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CIESM
16 Boulevard de Suisse, MC-98000, Monaco
Tél. : +377 93 30 38 79. Fax. : +377 92 16 11 95
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Sommaire

C-1. Géosciences marines
Session du comité 1

C- 2. Physique et climat de l'océan
Session du comité 77

C- 3. Biogéochimie marine
Session du comité 163

C- 4. Microbiologie marine
Session du comité 257

C- 5. Ressources vivantes et écosystèmes marins
Session du comité 301

C- 6. Ecosystèmes côtiers
Session du comité 467

Index alphabétique des auteurs 563

Comité

Géosciences marines

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ANALYSE DIACHRONIQUE (1949 À 2000) DE L'ÉVOLUTION DU TRAIT DE COTE DE PART ET D'AUTRE DE L'ESTUAIRE OUM ER RBIA (MAROC)

Abkhar Fatima [1] *, Bendahhou Zourarah [2], Carruesco Christian et M. Labraimi [4]

[1] Département de géographie, Faculté des Lettres et Sciences Humaines, Eljadida, Maroc - fatimaabkhar@yahoo.fr
[2] Département de Géologie Faculté des Sciences, Eljadida, Maroc
[3] Département de Géologie et Océanographie Université de Bordeaux I, France
[4] Laboratoire Géologie Marines, Faculté des Sciences, Rabat, Maroc

Résumé

L'analyse diachronique (entre 1949 et 2000), à partir de photo interprétation du trait de côte de part et d'autre l'estuaire de l'Oum-Er-Rbia, montre que ce littoral sableux présente un bilan sédimentaire négatif lié d'une part, à la conjonction de phénomènes naturels (hydrodynamisme, hydrologie), et d'autre part à l'action anthropique (aménagement du bassin versant, sur-exploitation des sables…)

Mots-clés : Maroc - Oum Er Rbia -Trait de côte - Aménagement- Erosion

Introduction

L'Oum Er Bia est le cours d'eau le plus régulier du Maroc. Son débit annuel moyen est de 117m^3/an. Son bassin versant a été aménagé depuis le début des années 20 et un certain nombre de barrages hydrauliques ont été construit le long de son cours. Les apports solides, estimés dans la station la plus en aval du cours, sont de l'ordre de 10.10^6 T/an (1). Une grande partie de ces apports est retenue dans les barrages en amont de l'estuaire et le transfert des sédiments vers le milieu marin est conditionné par les lâchés de ces barrages.

La zone d'étude est influencée par des vents de secteur Ouest à Sud-Ouest. Les houles dominantes sont WNW avec des coefficients de réfraction qui varient entre 1,38 et 1,62 (2). Les houles du Nord-Ouest peuvent déterminer une dérive inverse à la dérive générale qui est Nord -Sud dans l'embouchure. La marée est de type semi-diurne.

L'objectif de cette étude est de déterminer l'évolution du trait de côte de part et d'autre de l'estuaire en relation avec les facteurs environnementaux. Cette étude entre dans le cadre de la mise en place d'un plan d'aménagement durable du littoral de la région des Doukkala.

Matériel et méthodes

Deux types de documents ont été utilisés : des cartes topographiques 1/25 000 et des séries de photos aériennes verticales couvrant la période entre 1949 et 2000. Ces documents ont été comparés et analysés de manière à obtenir des taux moyens de recul et d'avancée de la ligne de rivage. Cette analyse s'appuie sur un traitement informatisé par l'intermédiaire de logiciel de type SIG.

Discussions et conclusion

L'étude de l'évolution du trait de côte a permis d'individualiser trois grands secteurs sédimentaires, dont les vitesses d'érosion et d'accrétion sont variables et influencées par les agents morphodynamiques et les actions anthropiques (Fig. 1):

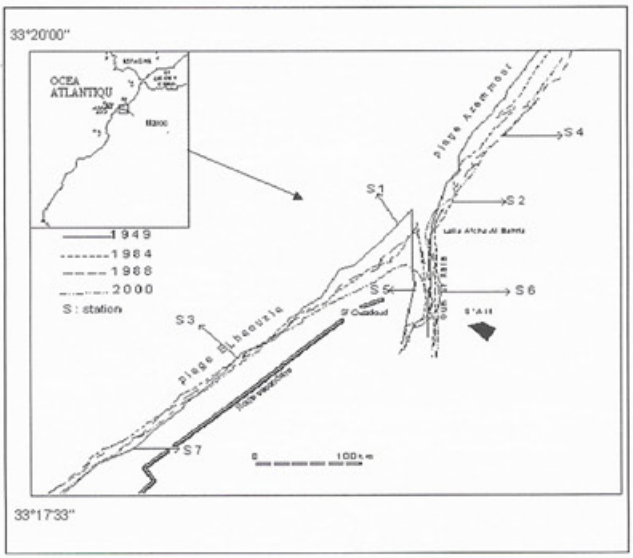

Fig. 1. Situation de la zone d'étude et évolution du trait de côte de part et d'autrede l'estuaire Oum Er Rbia entre 1949 et 2000.

1- Le secteur de l'estuaire, caractérisé par une dissymétrie avec un poulier sur la rive gauche. Ce poulier a connu un recul important de 4,6m /an entre 1949 et 2000 (Station 1). Cependant, durant cette période, le recul le plus important se situe entre 1984-1988 avec 21,25m/an. De même, entre 1984 et 2000, la flèche (Station 5) a connu une avancée spectaculaire (18,5 m/an entre 1984 et 1988) ce qui reflète la tendance à l'accumulation et la mise en place du crochet dans la partie interne de la flèche et le rétrécissement de l'entonnoir de l'embouchure de l'Oum Er Rbia de l'Ouest vers l'Est. Cependant, le musoir sur la rive droite a connu une érosion moyenne annuelle de 3m (Station 2), pendant ces cinquante années. Depuis 1984 la zone de musoir a présenté une tendance à l'accumulation.

2- Le secteur de la plage d'Elhaouzia (Station 7) est caractérisé par une accrétion reflétant une avancée de la ligne de côte, le taux de la moyenne annuelle entre 1949 et 2000 est de 0,3 m à 3,9 m. Cette accrétion est accentuée pendant la période 1984-1988 (14 m pour la satation 3 et 3,5m pour la station 7).

3- Le secteur de la plage d'Azemmour est marqué par une forte érosion, qui génère un recul du trait de côte d'une moyenne annuelle de 4 m. Cette dégradation s'est accrue dès 1984 avec un taux moyen annuel de 19,5 m (Station 4).

En effet, le secteur d'étude est caractérisé par une dérive littorale et un transit parallèle à la côte, de l'Est vers l'Ouest (3).

La variation du trait de côte est le résultat de la conjonction des facteurs naturels et /ou anthropiques. Les facteurs naturels sont en relation avec le réchauffement global et la fonte des glaces ; la valeur moyenne de recul des côtes à l'échelle mondiale est 1,5mm/an ce qui peut expliquer la tendance à l'érosion. L'action anthropique est en relation avec les aménagements du bassin versant ce qui a provoqué le piégeage des apports au niveau des barrages. La construction de la digue de Sidi Daoui en aval (1985) a provoqué une baisse importante des apports liquides et solides.

Actuellement, le littoral de la région est caractérisé par l'extraction abusive de matériaux, pour répondre aux besoins du secteur de la construction et des travaux publics, avec la croissance démographique et le développement socio-économique des deux agglomérations Azemmour et de Sidi Ali. Ce phénomène est venu aggraver le déséquilibre à la côte.

Bibliographie

1 - Snoussi M., 1986. Nature, estimation et comparaison des flux de matières issues des bassins versant de l'Adour (France), du Sebou, de l'Oum-Er-Rbia (Maroc). Impact du climat sur les apports fluviatiles à l'océan. Thèse De doctorat d'Etat Es Sciences, Université de Bordeaux I, 390 p.

2 - Chaibi M., 2003. Dynamique sédimentaire et morphogenèse actuelle du littoral d'El Jadida, Thèse de doctorat en géographie physique, Université de Aix Marseille, 235 p.

3 - Zourarah B., Carruesco C., Labraimi M., Rebouillon P., 2002. Evolution spatio-temporelle des teneurs en métaux lourds dans les sédiments fins de l'estuaire Oum-Er-Rbia (Maroc) : implications environnementales. Journal de Recherche Océanographique, Vol. 27, Fasc. 2.

SEDIMENT DRAINAGE PATTERN IN THE CATALAN MARGIN, WESTERN MEDITERRANEAN SEA: A VIEW FROM MULTIBEAM AND HIGH-RESOLUTION SEISMIC REFLECTION DATA

David Amblas [1], Miquel Canals [1] *, Roger Urgeles [1], Galderic Lastras [1] and John E. Hugues-Clarke [2]

[1] GRC Geociències Marines, Universitat de Barcelona, Martí i Franquès s/n, E-08028 Barcelona, Spain

[2] Ocean Mapping Group, University of New Brunswick, Fredericton, New Brunswick E3B 5A3, Canada

* miquel@natura.geo.ub.es

Abstract

New multibeam data from the Catalan margin, Western Mediterranean Sea, reveal with unprecedented detail its seafloor morphology. Debris flow deposits, canyon-channel and channel-levee systems on the slope and base of the slope, and a deep-sea channel parallel to the continental margin, are the main sediment-bypass structures in the study area. A fine description of these features based on swath bathymetry data, combined with the interpretation of high-resolution seismic reflection profiles, allows to improve the understanding of seascape evolution mechanisms, sediment transfer and depositional architecture.

Keywords: Submarine canyons, channel-levee systems, multibeam data, Catalan margin, Mediterranean Sea.

The detailed seafloor morphology of the entire outer Catalan continental margin, Western Mediterranean Sea, has been unveiled by new multibeam data. The data show a continental slope and base-of-slope dissected by several canyons deeply incised into the continental shelf. This canyon head morphology differs from the northern part of the Ebro margin, to the south, where canyons are shorter and restricted to the slope. Canyons in the Catalan margin, which generally evolve downslope to well-developed channel-levée systems, substantially differ in their morphology. Some (i.e. the Foix Canyon) are sinuous in their upper course and evolve to a more lineal morphology downslope, while others (i.e. the Blanes Canyon) start with a roughly lineal morphology that becomes sinuous downslope. In-between these end members there is a wide range of canyon morphologies and sizes.

At about 2.000 to 2.500 m water depth these canyon-channel systems are connected to a deep-sea channel known as the Valencia Channel. This deep-sea channel trends northeastwards following the Valencia Trough axis, an early Miocene-Pleistocene extensional basin (1) separating the Iberian margin to the west and the Balearic margin to the east. The Valencia Channel not only collects sediment transported from the canyons eroded into the Catalan margin but also from the Ebro turbidite system channels (2) and by large unconfined mass-wasting events. Among the later, the BIG'95 debris flow is the most prominent one, with a volume of ~26 km^3, released from the Ebro slope (3). Its subsequent deposit partially buried the uppermost course of the Valencia Channel. This deep-sea channel finally vanishes into the Valencia Fan 400 km away from its head.

The refined and systematic description of the sea-floor and subsea-floor character of the Catalan margin drainage pattern, based on the new multibeam and very high and high-resolution seismic reflection profiles, could provide necessary inputs for development of novel conceptual and numerical seascape evolution models from mid-latitude areas.

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References

1 - Clavell, E. and Berastegui, X., 1991. Petroleum geology of the Gulf of València. Pp. 355-368. *In:* A.M. Spencer (ed.), Generation, accumulation, and production of Europe's hydrocarbons, Sp. Publ. European Association of Petroleum Geoscientists, Oxford University Press.

2 - Canals, M., Casamor, J.L., Urgeles, R., Lastras, G., Calafat, A.M., De Batist, M., Masson, D., Berné, S., Alonso, B., Hughes-Clarke. J.E., 2000. The Ebro continental margin, Western Mediterranean Sea: Interplay between canyon-channel systems and mass wasting processes. GCSSEPM Foundation, 20th Annual Research Conference, Houston, Texas.

3 - Lastras, G., Canals, M., Hugues-Clarke, J.E., Moreno, A., De Batist, M., Masson, D.G., and Cochonat, P., 2002. Seafloor imagery from the BIG'95 debris flow, western Mediterranean. *Geology*, 30: 871-874.

MESOSCALE CIRCULATION CONTROL ON RIVER PLUME DISPERSAL OFFSHORE CATALONIA, NW MEDITERRANEAN SEA

Pedro Arnau * and Miquel Canals

GRC Geociències Marines, Universitat de Barcelona, Martí i Franquès s/n, E-08028 Barcelona, Spain
* antarnau@natura.geo.ub.es

Abstract

AVHRR, SeaWiFS, MODIS and ASTER satellite images collected during the last ten years have been examined to investigate the mesoscale circulation control on coastal currents and their influence over fluvial plume dispersal. The study focused on the Northwestern Mediterranean Sea, and the Catalan Margin in particular. The observed seasonal patterns have been compiled into a Geographical Information System which is inclusive of watershed properties, fine sediment sinks and interactions with coastal infrastructures.

Keywords: Satellite imagery, mesoscale, circulation, plume dispersal, Catalan margin.



Fig.1. Coalescing plumes along the Catalan coast, October 2003.

The study are included the Ebro shelf and the Catalan continental shelf north of the Ebro delta. The Ebro river basin is the largest (85362 km^2) of the Iberian Peninsula draining into the Mediterranean Sea. Rivers to the north are much shorter and carry much less water and sediment load. While the Ebro river receives tributaries from the western and central Pyrenees and the Iberian Massif, the rivers to the north originate either in the eastern Pyrenees or in the shoreline-parallel Catalan Coastal Ranges. The marine area offshore Catalonia is dominated by the permanent mesoscale Liguro Provençal Current (LPC) flowing southwestwards. Associated to the LPC, gyres form and propagate from north to south over the continental shelf throughout the year, thus influencing river plume spreading and transport. Satellite imagery along a 10 year period allows tracking and forecast recurrent coastal currents able to redirect river plumes. The same principle could be applied to sewage or pollutant releases. The wider the continental shelf is, the more difficult for the mesoscale-related gyres is to penetrate over the shelf. As in the Ebro shelf, this keeps the gyres further offshore and favors the development of a coastal circulation dominated by local factors.

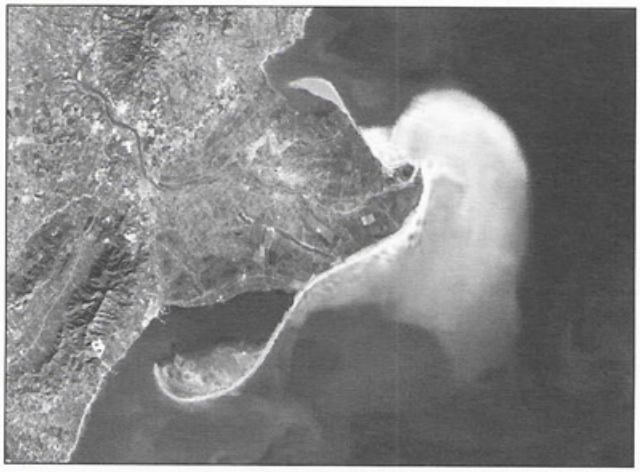


Fig. 2. Plume dispersal off the Ebro mouth, February 2003.

GEOLOGICAL HISTORY OF INNER SHELF QUATERNARY SUCCESSIONS FROM THE SOUTHEASTERN MEDITERRANEAN, ISRAEL

Avital A. [1, 2], Almogi-Labin A. [2 *], Benjamini C. [1]

[1] Department of Geological and Environmental Sciences, Ben-Gurion University of the Negev, Israel
[2] Geological Survey of Israel, Jerusalem 95501, Israel - * almogi@mail.gsi.gov.il

Abstract

The southeastern Mediterranean shelf located in the distal part of the Nile Delta was subjected to sea level oscillations during the Upper Quaternary. To study the history of this key area, two cores drilled offshore Ashqelon, southern Mediterranean coast of Israel in water depths of 9.5 and 25 m, were analyzed. TL, U-Th and ^{14}C dating techniques and some foraminiferal biomarkers enabled for the first time to correlate shallow water sedimentary successions representing the last 330,000 y with their deep-sea equivalents. Facies and faunal analyses indicate that most of the sediments were deposited in near-shore environments with only short intervals of continental episodes.

Key words: Southeastern Mediterranean, Nile delta, Upper Quaternary, Chronostratigraphy, Foraminifera

Introduction

The present-day sedimentological regime of the SE Mediterranean was established during the Pliocene. Clastic sediments derived from the delta of the Nile River have been accumulated on the inner shelf of southeastern Mediterranean, transforming it from a carbonate platform in the Miocene to a series of protruding deltas in the Plio-Pleistocene-Holocene. Late Quaternary climatic conditions severely altered both marine and coastal environments. Repeated shifts of the shoreline, caused by interglacial/glacial transgressions and regressions, were responsible for considerable facies oscillations. Lateral and horizontal discontinuities in inner shelf records were encountered, hampering an accurate regional correlation and environmental reconstruction. The aim of this study is to establish a multiple stratigraphic framework and to reconstruct the regional paleoenvironments during the last 330 kyr using continuous 83-100 m long cores from the SE Mediterranean shelf.

Material and methods

The region selected for this study is the off Ashqelon inner shelf area, southern Israel, which seems to represent more accurately the variability of the Nilotic cell. Two boreholes, 83 and 100 m long, taken 0.5 and 2.5 km off Ashqelon, at 9.5 and 25 m water depths, respectively were selected for this study. Data collected consists of sedimentology (grain size analysis, carbonate content, petrography of indurated horizons), and quantitative foraminiferal studies for reconstruction of the marine environments and correlation. Dating techniques included AMS ^{14}C, (TIMS) U-Th, and luminescence (1), enabling correlation to marine isotope stages (MIS) chronostratigraphy (2) and sea level oscillations (3).

Results and discussion

The inner shelf of the distal, easternmost end of the Nile River delta records in great detail the history of past climates and sea level changes. The Upper Quaternary sequence begins with carbonate-rich ~20 m thick silicicalstic unit, dated at ~335±24 to 231±9 kyr, which records the interglacial marine isotope stage (MIS) 9 and 7.3 and the intervening glacial MIS 8. Most of this period was arid. Low sedimentation rates of ~13 cm/ky and high carbonate content of up to 81% are accompanied by oligotrophy of the seafloor. Benthic foraminifera species richness is high (up to ~100 species, H(S) = ~3.6; Equitability = ~0.5) and the assemblages is composed of tropical-subtropical species including the symbiont bearing *Amphisorus hemprichii*, *Peneroplis* spp. and *Sorites orbiculus* (4). This indicates severe reduction or cut off of Nilotic input and establishment of a carbonate ramp on the southern continental shelf off Israel.

During the interval 223-175 kyr, silty-sandy marine sediments were deposited rapidly representing major increases in Nilotic input and near-shore marine productivity (5). Fresh water (6) and fluviatile input (7) into the eastern Mediterranean caused major changes. Sedimentation rates exceeding more than 50 cm/kyr, gradual reduction in carbonate content and the replacement of the symbiont-bearing larger foraminifera assemblage with opportunistic species responding to the increase in organic matter indicate transition to euotrohpy and that the carbonate ramp and its accompanying vegetation ceased to exist.

Sea level fell towards the end of the penultimate glacial, MIS 6.4-6.3, with the shoreline migrating westwards as demonstrated by intertidal beachrocks in the eastern core. Between 139±12 and 128 kyr continued cooling and sea level fall of ~-130 m is evidenced by the accumulation of loamy paleosol.

During the last interglacial MIS 5, between 128-70 kyr, resumption of Nile River activity is indicated by the accumulation of marine sands and silty sands. Sea levels were oscillated at a relatively high level, and the warm climate varied from humid to dry (6). During substages 5.5, 5.3 and 5.1 (~125, ~100, and ~80 kyr respectively) the shoreline was at least 5 km east of the present coastline (8). A break in the marine sedimentation occurred during MIS 5.4 (~110 kyr) when sand dunes formed 2 km west of the present coastline under arid conditions.

In the early part of the last glacial, ~70-~55 kyr, when sea level was at -60 to -55 m (3) marine sands and indurated sandstones accumulated in the west at a low rate, reflecting reduced Nile River contribution. Between ~50 and ~19 kyr, sea level gradually fell to –120 m. The entire shelf became exposed and a paleosol corresponding to the onshore Netanya Hamra developed (1). This paleosol formed under arid conditions; however intensive pedogenetic activity took place during the more humid interval, between 36-25 kyr (6), and subsequently during deglaciation.

As the early Holocene sea level rose, rates of sedimentation increased rapidly to ~400 cm/1000 y and sands and silty sands covered the entire pre-Holocene exposed shelf. Towards the east silty clays of a brackish/fresh water origin accumulated. This unit seems to be intimately linked to the rapid sea level rise, high rate of deposition, and humid climate conditions prevailing in the early part of the Holocene, and is known from various parts of the coastal plain.

References

1 - Porat N., Avital A., Frechen M., and Almogi-Labin A., 2003. Chronology of upper Quaternary offshore successions from the southeastern Mediterranean Sea, Israel. *Quat. Sci. Rev.* 22: 1191-1199.

2 - Imbrie J., Hays J.D., Martinson D.G., McIntyre A., Mix A.C., Morley J.J., Pisias N.G., Prell W.L., Shackleton N.J., 1984. The orbital theory of Pleistocene climate: support from a revised chronology of the marine $\delta^{18}O$ record, Pp. 269-305. *In:* Berger A., Imbrie J., Hays J., Kukla G., Saltzman B. (eds), Milankovitch and climate, Reidel Publishing Company.

3 - Waelbroeck C., Labeyrie L., Michel E., Duplessy J.C., McManus J.F., Lambeck K., Balbon E. and Labracherie M., 2002. Sea-level and deep water temperature changes derived from benthic foraminifera isotopic records. *Quat. Sci. Rev*, 21: 295-305.

4 - Langer M., and Hottinger, L., 2000. Biogeography of selected "larger" foraminifera. *Micropaleontology*, 46: 105-126.

5 - Rossignol-Strick M., 1985. Mediterranean Quaternary sapropels, an immediate response of the African monsoon to variation of insolation. *Palaeogeogr., Palaeoclimat., Palaeoecol.,*. 49: 237-263.

6 - Bar-Matthews M., Ayalon A., Gilmour M., Matthews A., and Hawkesworth C.J., 2003. Sea-land oxygen isotopic relationships from planktonic foraminifera and speleothems in the Eastern Mediterranean region and their implication for paleorainfall during interglacial intervals. *Geochim. Cosmochim. Acta,* 67: 3181-3199.

7 - Calvert S.E., and Fontugne M.R., 2001. On the late Pleistocene-Holocene sapropel record of climatic and oceanographic variability in the eastern Mediterranean. *Paleoceanography*, 16: 78-94.

8 - Reiss Z., and Issar A., 1961. Subsurface Quaternary correlation in the Tel Aviv region. *GSI Bull.* 32: 10-26.

QUATERNARY MARINE TERRACES IN THE ALBORAN INSULAR SHELF: TECTONICS *VERSUS* SEA LEVEL CHANGES

Bárcenas P. [1], Vázquez J.T. [1 *], Díaz del Río V. [2] and Fernández-Salas L.M. [2]

(1) Dpto. de Geología, Facultad de Ciencias del Mar, Universidad de Cádiz. CASEM, Campus Río San Pedro, E-11510 Puerto Real, Spain - * juan.vazquez@uca.es

(2) Instituto Español de Oceanografía. Centro Oceanográfico de Málaga. Puerto Pesquero s/n, E-29640 – Fuengirola, Spain

Abstract

On the basis of high-resolution seismic profiles and sonographic records supported by bathymetric data we propose a comprehensive description of the marine terraces evolution in the area surrounding the Alboran island, placed in the northeastern corner of the Alboran ridge, in relation to neotectonic activity and sea level changes during the Quaternary.

Keywords: Marine terraces, insular shelf, neotectonics, Alboran bank, Western Mediterranean Sea.

Introduction

The Alboran Sea is situated in the inner part of the western Alpine orogenic belt (Betic-Rifean ranges) between Eurasian and African plates. This region has an important oceanographic dynamic consequence of the Atlantic-Mediterranean water masses interchanges through the Strait of Gibraltar. The Alboran sea floor shows a very complex physiography constituted by sub-basins, structural highs and platforms as a consequence of the close relationship between geomorphology, tectonic, diapirism, volcanism and water deep circulation (1). The most important seamount located in the basin is the Alboran Ridge showing a NE-SW direction. The main feature of this basin is situated in the northeastern sector corresponding to the Alboran Island Bank. The main feature of this bank is the presence of an isolated insular shelf (2) surrounded by the slope domain and disconnected by the nearer continental areas.

Methodology

The data were obtained using a sub-bottom profiler (ORE 3.5 kHz) and echosounder (Furuno FUG 11), from 0 to 500 m depth, and also a side scan sonar (EG&G, 500 kHz) ranging from 0 to 60 m depth. Two oceanographic cruises (Coral 8209 and Alboran 9409 developped by IEO) were performed. From the study of these data we have obtained the detailed description and morphologic mapping of the Alboran Island Bank.

Morphologic characteristics of the Alboran insular shelf

The Alboran insular shelf is characterized by an irregular morphology. The maximum extension is 27.75 km and the mean width range between 5 and 6.5 km (Fig. 1). The longitudinal axis of the shelf follows a NE-SW main trend and the emerged area corresponding with the Alboran Island. The breakshelf appear in different depth with average values between 110 and 120 m and followed by a variable slope more abrupt in the southern flank (3). Nine morphological types have been described in the Alboran shelf related with the genesis processes: a) **erosive**: marine terraces, submarine scarps, depressions, channels and edges; b) **sedimentary**: sediment waves and sediment wave fields; c) **tectonic and/or inherent**: morphological highs and stepped shelf. The erosive processes are dominant in the shelf, followed by the tectonic process with are more developed in the southern sector (3). Marine terraces levels are the most relevant morphological type in this shelf and they are the issue of this communication.

Marine terraces

Three marine terraces types have been differenced in the Alboran shelf related to the eroded material and the presence of associated sedimentary bodies (Fig. 1): a) *marine terraces over hard ground or basement*, b) *marine terraces over sedimentary bottom* and c) *marine terraces with associated sedimentary body*. It has been observed 25 levels of marine terraces without associated sedimentary bodies, among 10 and 95 m in depth (3), presenting the highest frequency between 70-85 m depth and followed by the levels located in the 65-70 m. The marine terraces with associated sedimentary body have been located at 65, 68, 72, 78, 83, y 93 m depth, being more abundant between 85-90 m and 70-75 m.

Comparing the marine terraces steps in southern and northern flanks we point out the existence of steps at 10-15, 20, 24, 26, 28, 30-35, 38, 42, 44, 53, 65, 68, 70, 72, 75, 78, 89 and 95 placed on both flanks, whereas the remaining steps recorded are located in the southern shelf. These results are in agreement with those reported previously in the area flanked by Malaga and Gibraltar (4) and in the Mediterranean area (5), excluding the levels showed in the southern shelf, which have not been observed before by others authors. The marine terraces in the shelf have been related with short sea level stillstands during the last sea level rising (Flandrian transgression).

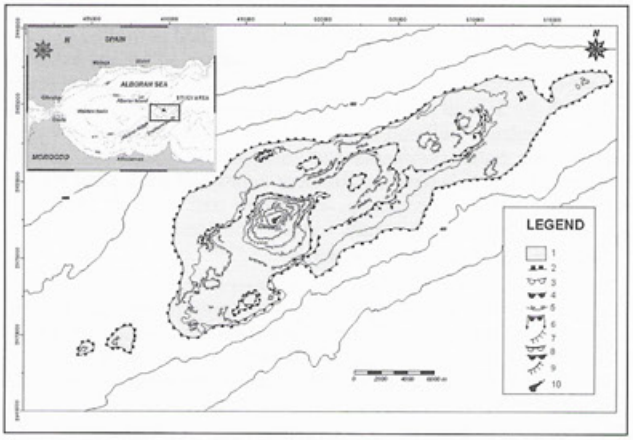


Fig. 1. Marine terraces levels distribution on the Alboran insular shelf. Legend: 1. Continental shelf, 2. Breakshelf, 3. Marine terraces over hard ground or basement, 4. Marine terraces sedimentary bottom, 5. Sedimentary body associated to marine terraces, 6. Tilted marine terraces, 7. Submarine scarps, 8. Marine terraces associated to fault, 9. Fault scarps and, 10. Alboran Island.

On the other hand, this area is characterised by an important seismic and tectonic activity (2), with tilted terraces and terraces associated to fault in the southern flank described in the area. In this way, the sea level change process should be the origin of the terraces steps. In the southern flank should be more likely a higher neotectonic origin than an high level process.

References

1 - Maldonado, A., Campillo, A.C., Mauffret, A., Alonso, B., Woodside, J. y Campos, J., 1992. Alboran Sea Late Cenozoic Tectonic and Stratigraphic Evolution. *Geo-Marine Letters*, 12: 179-186.

2 - Vázquez, J.T., 2001. Estructura del Margen Septentrional del Mar de Alborán. Tesis Doctoral, Universidad Complutense de Madrid, Madrid, 422 p.

3 - Bárcenas, P., 2002. Morfología submarina y evolución reciente del Banco de la isla de Alborán. Tesis de Licenciatura, Universidad de Cádiz, Cádiz, 234 p.

4 - Hernández Molina, F.J., Gracia, F.J., Somoza, L. y Rey, J., 1996. Distribución batimétrica de las terrazas submarinas en la plataforma continental de Málaga-Gibraltar. Implicaciones eustáticas durante el Cuaternario terminal. *Geogaceta*, 20(2): 416-419.

5 - Flemming, N.C., 1972. Relative chronology of sumerged pleistocene marine erosion features in the Western Mediterranean. *Journal of Geology*, 80: 633-662.

NEOGENE MUD DIAPIRISM, STRIKE-SLIP TECTONICS AND SEISMICITY IN NORTHEASTERN TUNISIAN MARGIN

Mourad Bédir *, Hakim Gabtni, Hamida Saidane and Sami Khomsi

Georesource Laboratory. Institut National de Recherche Scientifique et Technique, BP 95, 2050 Hammam-Lif, Tunisie
* Mourad.bedir@inrst.rnrt.tn

Abstract

Subsurface seismic and surface geologic studies conducted on northeastern Neogene series of Mediterranean Tunisian margin had permitted to highlight mud diapir, mud volcanoes and intrusives related to lithostatic pressions of Plio-Quaternary thick deposits and transtensive and transpressive movements of North-South and East-West flower fault corridors. Along the corridor fault borders took place historic and recent seismicity with deepseated faults epicentre location. The instrumental seismic magnitudes vary between 3 and 6 Richter degrees with some historic catastrophic events. This major seismic epicenter distributions seems to be related to strike-slip fault corridors where occurs a mudkinesis movements.

Key Words : Mud Diapirs, Strike-slip, Seismicity, Tunisia.

Introduction

Geologic and geophysic studies carried out on the Neogene deposits of the Eastern margin of Tunisia (1-5) and the north regions by seismic sequence stratigraphy and tectonics had permitted to recognize sequence and basin structuring accompanied by mud diapirs and intrusive structures with seismicity activities of deepseated faults (6, 7, 2, 3, 8). Several petroleum and high resolution seismic reflexion profils, petroleum well and historic and instrumental seismicity data covering the Sahel, Kéchabta and Medjerda Onshore and gulf of Hammamet and Pelagian sea Offshore zones had been used for the Neogene horizon correlations, isochrone and isopach mapping, seismic stratigraphy and seismic tectonic analyses.

Lithostratigraphic characteristics

In Northeastern Tunisia, Neogene deposits are composed by several hundred meters of alternating packages of clays, marls, Lignites and sandstones from Miocene, Pliocene and Quaternary series. These deposits show important changes in lithologic facies and thicknesses. They are very thick in the gulf of Hammamet, the Sahel (7), the Pelagian sea (4) and in the Northwest Medjerda and Kechabta basins (9, 10). Particularly, Miocene and Pliocene clays are very thick in the Eastern margin of the Cap Bon, the Sahel and the pelagian zones comprising Miocene sand Pliocene sandstone turbidite sequences outcropping in the Jebel Abderrahman (2) and in the coastal Nabeul and Hammamet regions (11).

Tectonic framework and kinematics

The Northeastern margin is structured by North-South and Est-West subsurface transtensive and transpressive strike-slip flower fault corridors that limit platform, graben, syncline and fold structures (6, 7). These corridors have been reactivated by Langhian-Serravallian distensive strains and Tortonian-Messinian and Quaternary compressive stress. Neogene sequence deposits are distributed around these structures where their thiknesses is very important in syndepositional subsiding zones of graben and synclines (7, 2). The main tectonic structures that constitute the background and the guide of the Neogene sequence deposit distribution. Vertical and lateral claykinesis movements are attested by depocenter migrations and inversions along fault corridors.

Mud diapirs, volcanoes and sequence structuring

Diapiric and intrusive seismic structures seems to be strongly associated to the faults that limit the graben, syncline and platform zones. Evidence of mud volcanoes structures is showed in the Sahel offshore Pelagian sea by high resolution seismic profils. The mud material come from Miocene sequences marked by Lower Miocene decollement level of Langhian limestone Ain Ghrab Formation. These features had been recognized in small outcrop scale in the Sahel and in the North Atlassic Miocene deposits of Medjerda and Kéchabta zones (3) in the Upper Miocene sequences showing metric to decametric lenticular intrusive shales and sands along kilometric strike-slip faults (1, 3, 11) and micro-sand and micro-clay volcanoes seismits. Seismic sequence deposits show around mud diapirs flanks high angle downlap prograding system tracts at the base, overlapped by aggradational and retrogradational onlap and toplap erosional unconformities and pinch outs.

Seismicity and basin modeling

The seismicity of eastern onshore and offshore Tunisian margin follow the master fault corridors oriented North-South, East-West and associated faulted dragfold structures oriented Northeast-southwest. The great seismic richter magnitudes situated between three and five richter degrees of epicenters are located along these fault corridors. This distribution relay subsurface mud diapirs, mud volcanoes, intrusives and fold structures. Therefore, there is a straight relationship between deepseated faults, seismicity and mud diapir structures. As a combination of these results, new structural, sequence stratigraphic and seismicity origin, basin model highlights mud diapirs distribution guided by the bordering faults of grabens, folds and syncline corridors.

The structuring of Northeast-Southwest en echelon folds and synclines inside and outside Est-West right lateral and North-South left lateral tectonic corridors indicates the strike-slip type of bordering faults and their seismogenic nature. Wrench fault movements induce mud diapirs and intrusive ascensions. This Neogene kinematic reconstruction highlights the neotectonic system inducing the actual seismicity on this margin.

References

1 - Bédir M., 1988. Géodynamique des bassins sédimentaires du Sahel de Mahdia (Tunisie orientale) de l'Aptien à l'Actuel. Sismo-stratigraphie, sismo-tectonique et structurale. Répercussions pétrolières, hydrologiques et sismiques. Thèse de Spécialité, Université de Tunis, *Revue des Sciences de la Terre* (Tunisie), 9 : 242.

2 - Bédir M., Tlig S., Bobier Cl. and Issaoui N., 1996. Sequence Stratigraphy, Basin dynamics and Petroleum geology of Miocene from the eastern Tunisia. *American Association of Petroleum Geologist Bulletin,* 80, 1: 63-81.

3 - Bédir M., El Manaa S., et M'ridekh, A., 1997. Subsurface Neogene Mud Diapirism and Basin Migration related to Strike-slip tectonics in the Eastern Margin of Tunisia. Mud rocks at the basin scale Meeting, Londres.

4 - Blandpied C., 1978. Structure et sédimentation superficielle en Mer Pélagienne (Côte orientale de la Tunisie). Thèse de 3ème Cycle. Univ. de Paris VI.

5 - Gaaloul N., 1995. Les environnements siliciclastiques du Néogène du Sahel de la Tunisie : Palynologie et Biosédimentologie, Thèse de Spécialité, Université de Tunis II, 265 p.

6 - Bédir M., Zargouni F., Tlig S., and Bobier CL., 1992. Subsurface geodynamics and petroleum geology of transform margin basins in the Sahel of Mahdia and El Jem (eastern Tunisia). *Amer. Assoc. Petro. Geology,* 76, 9: 1417-1442.

7 - Bédir M., 1995. Mécanismes Géodynamiques des bassins associés aux couloirs de coulissements de la marge Atlasique de la Tunisie, Seismo-stratigraphie, Seismo-tectonique et implications pétrolières. Thèse de Doctorat Es-Sciences, Université de Tunis II, 412 p.

8 - M'ridekh, M., Bédir M., et Tlig S., 1995. Contrôle tectonique et organisation séquentielle des séries plio-quaternaires du golfe de Hammamet (Tunisie Nord-orientale). 3e congrès National des Sciences de la Terre, Tunis, p.123.

9 - Biély A., Rakus M., Robinson P. and Salaj J., 1972. Essai de corrélation des formations Miocènes du Sud de la Dorsale tunisienne. *Notes du Service Géologique de Tunisie*, 38 : 73-92.

10 - Burollet P.F., 1956. Contribution à l'étude stratigraphique de la Tunisie centrale, *Annales Mines et Géologie*, 18 : 352.

11 - Derbal-Damak F. et Zaghbib-Turki D., 1995. Faunal characteristics of depositional sequences in Pliocene of Nabeul-Hammamet region (North-Eastern Tunisia). Réunion spécialisée, Faune et Flore et Stratigraphie séquentielle, Museum d'Histoire Naturelle, Paris : 10.

FORAMINIFERAL DISTRIBUTION IN THE MIDDLE ADRIATIC SEA

Danijela Bogner [1] *, Vlasta Ćosović [2], Mladen Juračić [2] and Ante Barić [1]

[1] Institute of Oceanography and Fisheries, Split, Croatia
[2] Department of Geology and Paleontology, Faculty of Science, University of Zagreb, Zagreb, Croatia
* bogner@izor.hr

Abstract

The distribution of foraminifera from the middle Adriatic Sea has been studied from ten surface sediment samples. Different water depth (from 52 m of water depth down to 262 m), different characters of the substrates (organic matter and carbonate content, granulometric properties) have affected foraminiferal diversity along Palagruža sill and Jabuka pit. However, among all listed factors, here, the organic matter content seems to be the most important.

Key words: middle Adriatic Sea, foraminifera, surface sediment

Introduction

Adriatic Sea is Epicontinental Sea. The middle part of the Adriatic Sea separates north shallow from deepest south part. In the middle part are located Jabuka pit and Palagruža sill. The aim was to investigate changes in foraminiferal associations along two profiles across Jabuka pit and Palagruža sill.

Methods

Surface sediment samples (from surface to 4 cm deep in sediment) were taken in June 2002 at ten stations in the middle Adriatic Sea (Fig. 1). Foraminifera were counted in the fraction larger than 63 µm, from the aliquots containing about 300 foraminiferal specimens. Multivariate cluster analysis, Fisher index and Shannon-Wiener index were done in order to define the foraminiferal diversity.

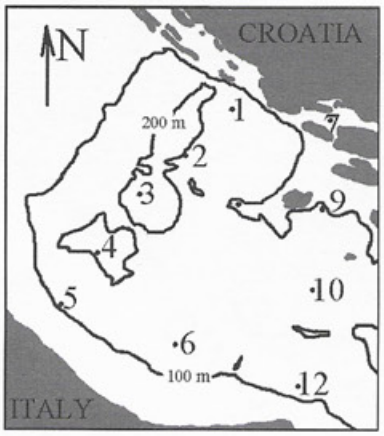


Fig. 1. Sampling locations in the middle Adriatic Sea.

Results and discussion

The 3762 foraminiferal specimens picked from the 10 samples were assigned to 52 genera and 72 species. Rotaliina are predominant (80-95 %). The most abundant are *Globigerina* sp, *Brizalina spathulata*, *Eponides* sp, *Cassidulina laevigata carinata*, *Nonion* sp., *Cribroelphidium decipiens* and *Textularia agglutinanas*. In investigated area fine grain sediments (< 63µm, muds) prevail, except at the station #9 (Table 1).

Cluster analysis on foraminiferal associations of the samples grouped split them into three clusters:

a) Stations #1, #2 and #10. The samples (about 180 m water depth), have carbonate content ranging from 30 to 36%, and organic matter between 4.51 to 7.08%. Foraminiferal diversity is moderate (Shannon-Wiener index 2.4-2.5, Fisher index 3.4 - 5.7). The most common foraminifera are *Globigerina* sp., *Brizalina* sp. and *Uvigerina mediterranea*.

b) Stations #3, #4, #5 and #6. These stations are located in west part of investigated area, starting at 114 m down to 262 m depth. Numbers of foraminifera per gram sediment is the lowest (under 1000), species diversity shows consistency in all stations; carbonate content between 26-27% in sediment, while organic matter content is highest. The most abundant foraminifera are *Globigerina* sp., *Brizalina* sp. and *Uvigerina mediterranea*.

c) Stations #7, #9 and #12. These stations are the shallowest, percentage of coarse grain fraction (>63µm) is the highest as the carbonate content (36-68%). The Diversity indexes show the largest variety of values (H(S) from 2.2 to 3.1; Fisher from 3.4 to 6) *Textularia agglutinans* and *Cribroelphidium decipeiens* are most abundant species.

Table 1. Water depth, granulometric properties, sediment type, organic matter and carbonate content, number of species and total foraminifera, Fisher index and Shannon-Wiener index (Mz - mean size, Sediment type according to Folk classification [1], S – number of species, N – total number of foraminifera per gram sediment, α – Fisher index, H(S) - Shannon-Wiener index)

Stations	Water depth (m)	Mz (µm)	Mud (%)	Sediment type	Organic matter (%)	Carbonates (%)	S	N	α	H(S)
1	170	2.05	96.3	mud	7.08	36	38	4270	5.7	2.4
2	187	1.7	96.9	mud	6.04	31	30	4326	4.3	2.4
3	262	1.27	98.2	mud	6.32	27	35	736	7.6	2.9
4	207	1.24	99	mud	6.79	26	27	900	5.2	2.4
5	114	1.64	98.9	mud	7.1	26	44	875	9.8	2.7
6	132	1.1	98.6	mud	7.03	26	31	635	6.8	2.6
7	52	2.12	94.8	mud	6.79	50	23	3116	3.4	2.2
9	102	38.03	43.4	gravelly mud	3.22	68	30	23167	3.4	2.9
10	172	2.67	95.8	mud	4.51	30	25	5186	3.4	2.5
12	112	3.03	92.5	slightly gravelly mud	5.47	36	43	7522	6.0	3.1

Different ecological conditions along Palagruža sill and Jabuka pit, seen through different water depth, differences in composition of substrate (organic matter content, carbonate content and granulometric composition), have resulted in differences in diversity of studied foraminiferal associations. The good relation occurs between organic matter content and Fisher index. The highest content of organic matter in station #5 follows the highest diversity Fisher index of 9.8, or the lowest organic matter content at station # 9 is characterized by the lowest Fisher index of about 3.4. It seems that quantity of organic matter at sea bottom is the most important factor determining benthic foraminiferal composition.

Palagruža sill stations are located near the coast (except station #10), consequently the content of coarse-grained particles is higher and the total numbers of foraminifera are the highest. However, percentage of planktonic foraminifera along this transect is the lowest (3.4-14.4 %) except at station #10 (37.5%).

References

1 - Folk, R.L. 1954: The distinction between grain size and mineral composition in sedimentary rock nomenclature. *J. Geol.*, 62:344-356.

FAST EVOLUTION OF A SUBMARINE VOLCANIC FLANK EXPERIENCING A LARGE-SCALE LANDSLIDE: THE CASE OF STROMBOLI, AEOLIAN ISLANDS

Bosman A. [1], Chiocci F.L. [1], Romagnoli C. [2 *], Tommasi P. [3]

[1] Dip. di Scienze della Terra, Università "La Sapienza", Roma
[2] Dip. di Scienze della Terra e Geologico-Ambientali, Università di Bologna
[3] Ist. Geologia ambientale e Geo-Ingegneria, CNR, Roma

Abstract

Repeated marine surveys were carried out offshore the Sciara del Fuoco slope (NW Stromboli) where, on December 2002, a large-scale landslide caused a tsunami. A detailed pre-landslide bathymetry allowed the early definition of the volumes involved in the submarine landslide and the recognition of features which possibly influenced the flank instability. Surveys also evidenced the fast evolution of the landslide scar, characterized by a gradual filling and by the progressive morphological re-adjustment of the flank. It follows that, on volcanic flanks, features related to instability phenomena have scarce possibility to survive the rapid evolutionary process starting after the failure event.

Keywords: submarine slope instability, Stromboli, multibeam bathymetry, morpho-sedimentary evolution.

On December 30, 2002 a major instability event occurred on the Sciara del Fuoco slope, on the western flank of Stromboli Island. Sciara del Fuoco is the most striking feature of Stromboli and represents the subaerial part of a partially filled sector-collapse scar that formed in the last of a series of major lateral collapses affecting the NW flank of the island in the last 13 ka (1). This sector of the volcanic cone has been the site of persistent volcanism during the last thousand years and acts as a channelway to the sea for most of the eruptive products and for loose materials (lava blocks and pyroclasts), moving gravitationally down the steep slope (up to 38°) of Sciara del Fuoco. Since the Sciara collapse scar extends offshore down to 700 m of depth, the slide debris reaching the sea is convoyed towards deeper waters (2).

The instability phenomena which affected on 30/12/2002 the northeastern portion of Sciara was preceded since 28/12/02 by a lava flow emission along the northern side of the Sciara scar. During the succession of instability events, a tsunami wave was generated and propagated around the whole island and in the surrounding sectors of the Aeolian archipelago, being felt as far as the Sicily coast.

Few days after the event, a multibeam survey was carried out in front of the Sciara del Fuoco slope. A detailed bathymetry down to a depth of 1000 m, collected ten months before in the framework of the Italian National Group for Volcanology research activities, enabled to compare the pre- and post-event settings and to point out that the submarine failure was wider than the subaerial one, and that it reasonably generated the tsunami wave (3; Fig. 1). In the coastal area and down to a depth of –350 m, the slide scar shows has a sub-circular composite shape, with a maximum depth up to 45 m with respect to the pre-landslide seabottom morphology. At greater depths, different elongated erosional lineaments have been followed down to over -1600 m of depth. The scar morphologies have been partly related to features observed before the landslide, which may have played a role in the landslide development. The total volume of rocks involved has been estimated to 28.5 millions of m^3, of which only about 8 millions are from the subaerial flank (4), while the other 20.5 for the submarine landslide represent a conservative estimate, limited to the first 1000 m of depth only. The bathymetric surveys also indicate that the submarine failure was followed by complete liquefaction of the deposits, which cancelled almost all landslide features.

The repetition of marine surveys (including multibeam, side scan sonar and seismic profiling, sea-bottom sampling), carried out in the framework of the Department for the Civil Defence activities, allowed to monitor the landslide scar and to follow its morpho-sedimentary evolution with time (5). The submarine morphology evolved rapidly after the event: immediately after the submarine failure, lava flows reached the sea and built a small lava-breccia delta at the shoreline, producing steam columns and minor phreatomagmatic blasts. Almost continuous detritic input, derived from the subaerial slope, contributed to the gradual infilling of the scar, which is still going on, accompanied by depocentres migration, although at gradually lower rates. The huge production of volcanogenic sediments on the Sciara, in fact, rapidly obliterated the original landslide morphologies, thus suggesting that similar events, occurred in the past, are likely to have been hidden by the fast morphological re-adjustment of the volcanic flank. These elements demonstrate that a complex inner structure should characterize the volcanoclastic depositional system, which is the result of frequent flank instability and subsequent slope rebuilding. The reconstruction of the flank evolution is further complicated by the coarse and loosened nature of the proximal facies, which prevents sampling and investigation of the internal structure of the deposit through seismic characterization.

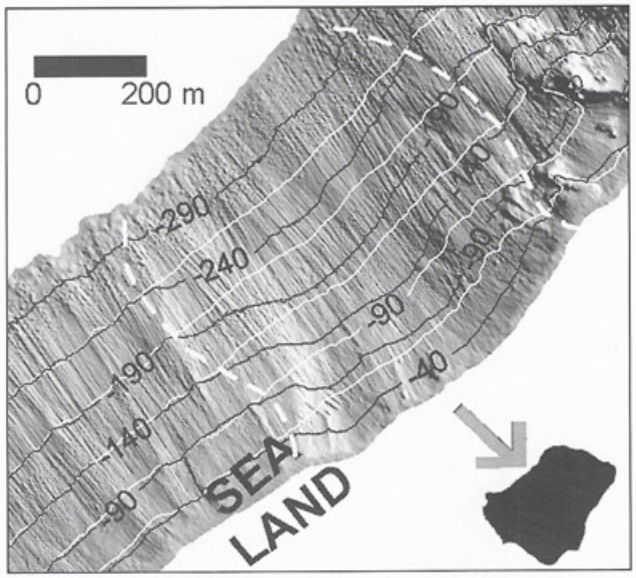


Fig. 1. Shaded relief image of the northeastern submarine Sciara extension with pre- (in white) and post-landslide (in black) contours. Dashed lines indicate the limits of the slided area.

References

1 - Tibaldi A., 2001. Multiple sector collapses at Stromboli volcano, Italy: how they work. *Bull. Volcanol.*, 63, 112-125.

2 - Kokelaar P.and Romagnoli C., 1995. Sector collapse, sedimentation and clast-population evolution at an active island-arc volcano: Stromboli, Italy. *Bull. Volcanol.*, 57, 240-262.

3 - Chiocci F.L., Bosman A., Romagnoli C., Tommasi P., De Alteris G., 2003. The December 2002 Sciara del Fuoco (Stromboli Island) submarine landslide: a first characterization. XXVIII General Assembly of the European Geophysical Society, Nizza, April 7-11, 2003.

4 - Marsella M. *et al.*, 2003, pers.comm.

5 - Bosman A., Chiocci F.L., Romagnoli C., Tommasi P., Abballe P., Bellino M., De Alteris G., d'Isanto C., Macelloni L., Tonielli R., 2003. Evoluzione morfologica e deposizionale del settore sommerso antistante la Sciara del Fuoco a partire dall'evento di maremoto del 30/12/2002: implicazioni per la comprensione dei fenomeni di instabilità gravitativa. Annual Assembly of the National Group for Volcanology, Roma, June 9-11, 2003.

NEW CLUES ABOUT THE CONTINENTAL ORIGIN OF DEEP SUBMERGED RELIEF IN THE MEDITERRANEAN SEA: THE TERRESTRIAL *IN SITU*-PRODUCED COSMONUCLIDES SIGNATURE OF ROCK SURFACES AND SCREE DEPOSITS ALONG THE SARDINIAN CHANNEL SCARPS

Gilles Brocard [1], Jean-Pierre Bouillin [2], Georges Mascle [2 *], Pierre Tricart [2], Didier Bourlès [3], Régis Braucher [3] & the SARCYA-SARTUCYA Scientific Team

[1] M2C, Université de Rouen, 76 821 Mont-Saint-Aignan, France
[2] LGCA, Université Joseph Fourier, 38 041 Grenoble, France
[3] CEREGE, Université Aix-Marseille 3, 13545 Aix-en-Provence, France

Abstract

The *in situ*-produced cosmonuclides are widely used for cosmic ray exposure dating of continental surfaces. Some recent works have investigated the ^{10}Be-^{26}Al system to assess the burial age of cave-deposited sediments. In the marine environment, the *in situ*-produced cosmonuclides can be also used as tracers of continental exposition before rapid and deep (>100m) submersion. The ^{10}Be-^{26}Al system may help to constrain the age of the submersion. Here, we have tested this method by measuring the ^{10}Be-^{26}Al signature of deeply submerged scarps in the Sardinia Channel regarded as fossil messinian erosion surfaces [1].

Keywords : Sardinia Channel, messinian environment, cosmogenic nuclides

Introduction

Many inactive canyons carved in cohesive rock series are found on the Mediterranean submarine scarps. Canyon formation is commonly ascribed to the repeated erosion of bedrock by turbidity currents along a single path, or by self-driven gravitational collapse. Many mediterranean scarps, however, have been exposed to atmospheric erosion during the messinian salinity crisis, and the canyons could be continental weathering features as well.

The messinian erosion surface can be used as a reference surface to discriminate pre-messinian and post-messinian evolution of the mediterranean relief. However, it is often difficult to date the scarp formation since sediments deposited onto the surfaces are periodically removed by sliding. We had to address this issue along the southern scarps of the Sardinian Channel which were explored with the Cyana submersible in 1994 and 1995.

In situ-produced cosmonuclides offer us the possibility do test, 1/ if the upper few meters of the present submarine surfaces have been previously exposed to cosmic rays, 2/ if this exposure took place during the messinian crisis.

Evolution of the Sardinian Channel structure and morphology from Tortonian to Present

The Sardinian Channel is a submerged rift located SE off Sardinia. Rifting and crust thinning during the early Miocene and then during Tortonian [2] led to the formation of this narrow channel. Tectonic activity dropped markedly and remained very low during the Pliocene and Quaternary. The channel was deeply flooded during the Pliocene owing both to the refilling of the Mediterranean sea after the messinian crisis and to a strong post-rifting subsidence.

Along the steepest slopes the pre-tortonian basement outcrops under below the Plio-Quaternary sedimentary cover. Five dives were devoted to the exploration of the scarps located south of the Cornaglia Terrace. The upper slopes (above -1500m) are blanketed with pelagic mud. According to the blocks found on the lower slopes, the rocks that underlain these mud belong to the tertiary sedimentary cover of the Internal Zones of Calabria Peloritan Mountains of Sicily and Kabylia (CPK). The lower slopes are sediment-free. Their basement is composed of paleozoic granitoïdes and metamorphic rocks of CPK origin [2]. Where they run parallel to the channel strike (NE-SW), their surface is roughly planar and the basement is covered extensively with scree deposits a few meters thick. The scree are composed of blocks from the CPK basement and its sedimentary cover. The lower slopes are cut by deep, narrow canyons carved into the basement rocks..

If the scree deposits and narrow canyons were Messinian in age, they could be used to ascribe a post-messinian age to the neotectonic ridges. However, both the scree deposits and the canyons could as well result from gravitational submarine reworking of the messinian scarps.

To test the messinian hypothesis, we have measured the ^{10}Be and ^{26}Al contents of the scree deposits and canyons walls.

The use terrestrial *in situ* cosmogenic nuclides for tracing and dating

Production within the terrestrial crust of cosmonuclides such as ^{26}Al and ^{10}Be, whose half-life are 710 and 1500 ky, respectively, is limited to the upper few meters of the Earth surface. Since in the ocean rocks are completely shielded from cosmic rays at depths of several tens of meters, the in situ-produced cosmonuclides can be used as tracers of previous exposure to cosmic rays at the Earth surface. If the submarine erosion of surface previously exposed onshore is low and the initial aerial exposure time is high, the in situ-produced cosmonuclide concentrations should indeed remain measurable.

Furthermore, the time elapsed since the inception of shielding can be inferred from the differential radioactive decay, of ^{26}Al and ^{10}Be [e.g.3]. It is thus possible to test if the exposure occurred during the Messinian.

Sampling strategy and preliminary results.

^{10}Be and ^{26}Al have been extracted from quartz crystals from five blocks sampled on the Cornaglia Terrace southern scarp. Three different settings were selected: the basement surface, its scree cover, and the canyons carved into the basement. Three samples are blocks coming from the scree deposits: a sandstone of the CPK basement cover, a pegmatite from the CPK basement, and a quartzite. The basement surface and canyon wall samples are granite slabs.

When writing this abstract, reliable ^{10}Be measurements have only been performed on the basement surface and on the sandstone from the overlying scree. However, these preliminary results are quite promising. The ^{10}Be concentrations are significantly higher than those of the processed blanks. This demonstrates that, outside the canyons, the submarine landscape did not evolved significantly since its exposure to atmospheric weathering. However, given the low concentration of ^{10}Be in both samples, the $^{26}Al/^{10}Be$ ratio will not be measurable if exposure took place during the Messinian.

We expect the other samples to help us 1/ to demonstrate, that the exposure is messinian in age and 2/ to determine whether the canyons are submarine or continental features. We also will try to confirm that the crystal cores have not been polluted by seawater ^{10}Be.

References

1 - Mascle G. and Tricart P., 2001. Le Canal de Sardaigne : les plongées Cyana. *Géologie Alpine. Mémoire HS*, 34, 166 p.

2 - G. Mascle, P. Tricart, L. Torrelli, J.P. Bouillin, R. Compagnoni, S. Depardon, J. Mascle, A. Pêcher, D. Peis, F. Rekhiss, F. Rolfo, H. Bellon, G. Brocard, H. Lapierre, P. Monié, G. Poupeau, 2004. Structure of the Sardinian Channel: crustal thinning and tardi-orogenic extension in the Apenninic-Maghrebian orogen: results of a diving survey using Cyana submersible (SARCYA and SARTUCYA). *Bull. Soc. Geol. France* (in press).

3 - Granger D.E. and Muzikar P.F., 2001. Dating burial with in-situ produced cosmogenic nuclides: theory, techniques, and limitations. *Earth and Planet. Sci. Letters,* 188, 269-281.

COASTAL EVOLUTION IN WESTERN ANATOLIA DURING THE LAST FIVE MILLENNIA

Helmut Brückner
Department of Geography, University of Marburg, D-35032 Marburg, Germany
h.brueckner@staff.uni-marburg.de

Abstract
The progradation of the Büyük Menderes delta and floodplain during the last 5000 years led to the total silting up of the former Latmian Gulf. By geoarchaeological means this delta growth is reconstructed in space and time, and the results then cross-checked with information from archaeological and (pre-) historical sciences. As synthesis, a scenario for the landscape evolution during the last five millennia is presented.

Keywords: Turkey, Büyük Menderes, Miletus, delta growth, geoarchaeology, Holocene.

The delta regions of western Anatolia witnessed the strongest coastline changes during the Holocene. In this paper this is exemplified for the Büyük Menderes (Maiandros) delta and floodplain. The impact of these processes on the former harbour cities Myous, Priene and Miletos are especially of interest since they lost their economic and strategic basis due to the siltation of their harbours. The relevant references for this topic are summarized in Brückner (1) and Brückner *et al.* (2). The new scenario of the landscape evolution, based on our geoarchaeological data, is presented in Fig. 1.

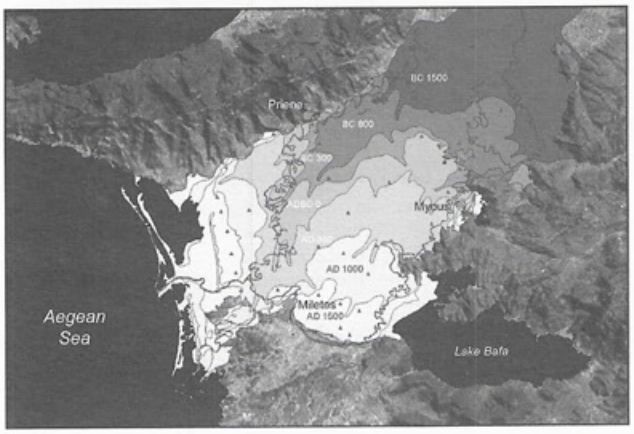


Fig. 1. Progradation of the Büyük Menderes delta during the past millennia.
Note that during the peak of the Holocene transgression ca. 5,000-6,000 years ago, the marine gulf extended much further eastward covering the whole area of the floodplain visible in this figure. In the figure, a given age refers to its nearest seaward coastline.

Potential Archaic to Classical Greek harbour sites were identified in the embayments west of the Myousian peninsula, i.e. between Castle hill and Settlement hill, and south of Settlement hill. In the vicinity of Myous, the transiton from marine to lacustrine facies must have occurred already in Hellenistic times. Lagoonal conditions prevailed in Hellenistic-Roman times. In the southwest, the lacustrine environment started in the 1st or 2nd century A.D. and partially prevailed until Modern times. In the east, the brackish and shallow Lake Azap is what remains of the former marine embayment.

Priene was founded anew in Late Classical time around 350 B.C. Under palaeogeographic perspective the most interesting question is that of the harbour site(s), a topic whereof the historic sources remain silent. Ceramic and ^{14}C stratigraphies of drill cores led to the following conclusions: In the eastern embayment, marine conditions prevailed at least until the 13th/12th century B.C. Thereafter, a slight regression can be proven by a peat dating from the second half of the 2nd millennium B.C. In the mid-4th century B.C, this embayment had already turned into a freshwater lake. For that time, a potential harbour site can be ascertained in the western embayment where water depth was still several metres and a lagoonal environment existed until the beginning of the Roman Imperial era. Definitely freshwater milieu did not exist before the 3rd century A.D. This embayment was filled with sediments more slowly than its eastern counterpart since it was sheltered from alluviation by the river due to the leeward position behind the promontory of the Priene rock.

During the peak of the Holocene transgression, the area of the later city of Miletos was composed of islands. One of them hosted the earliest settlement in the area of the later Athena Temple dating from the second half of the 4th millennium B.C. When the Minoan settlers arrived around 1900 B.C. this island topography is likely to have persisted; however, hints of an already existing connection with the adjacent mainland by a sandbar (tombolo) cannot be neglected. The palaeogeographic setting changed to a peninsula during the Minoan-Mycenaean occupation phase. The sediments were mobilized by coastal longshore drift and human-induced denudation from the adjacent slopes. It is at least since the Archaic period that the Milesian peninsula extending into the Latmian Gulf is known from literary sources and archaeologic evidence (city wall). The Roman time – and especially the Roman Imperial era – witnessed strong siltation processes around Miletos.

Tradition has it that the Milesian peninsula had four harbours, of which only the Lions' Harbour and the Theatre Harbour have been definitely identified to date. Our research in the Lions' Harbour showed an enormous increase in siltation between the 1st century B.C. and ca. A.D. 400. Corings within the Theatre Harbour unearthed no artifacts older than the Roman Imperial era; therefore, it must have been dredged in the 1st or 2nd century A.D. when also the theatre was renovated. The geoarchaeological approach also revealed that a good natural setting for the third harbour was given close to the earliest settlement near the later Athena Temple. Another potential harbour most likely existed to the east of the Milesian peninsula, in a leeward position to winds from the west.

The data set of archaeological and ^{14}C ages is suitable for the establishment of a locally valid sea level fluctuation curve for the Holocene. It seems to have a relative peak around 6-5 ka BP, after the strong late Pleistocene – Holocene sea level rise, and a relative low around 3 ka BP. This shape of this curve is similar to that of KAYAN (1995) established for the Troia (Troy) region. However, in our case this glacio-eustatic curve is shifted downward by the factor of 0.7 m/ka due to the ongoing subsidence of the Menderes graben. It is important to note that in several other regions of the Mediterranean, sea level reached its highest position during the Holocene only today and was definitely lower around 5 ka BP.

References

1 - Brückner H., 2003. Delta evolution and culture. Aspects of geoarchaeological research in Miletos and Priene. Pp. 121-144. *In*:., G.A. Wagner, E. Pernicka and H.P. Uerpmann (eds.), Troia and the Troad – Scientific approaches. Springer Series: Natural Science in Archaeology. Berlin, Heidelberg, New York.
2 - Brückner H., Müllenhoff M., Handl M. and van der Borg K., 2002. Holocene landscape evolution of the Büyük Menderes alluvial plain in the environs of Myous and Priene (Western Anatolia, Turkey). *Z. Geomorph. N. F.*, Suppl.-Bd. 127: 47-65, Berlin, Stuttgart.
3 - Kayan I., 1995. The Troia Bay and supposed harbour sites in the Bronze Age. *Studia Troica*, 5: 211-235.

DEEP STRUCTURES OF THE NILE CONTINENTAL MARGIN AS DEDUCED FROM COMBINED MULTI-CHANEL SEISMIC REFLECTION AND GRAVIMETRY DATA

Laurent Camera [1] *, Nicolas Chamot-Rooke [2], Françoise Sage [1], Jean Mascle [1] and Medisis Scientific party

[1] Geosciences Azur, UMR 6526, BP 48, 06235 Villefranche-sur-Mer, France

[2] Laboratoire de Geologie, CNRS-UMR 8538, ENS, 24 rue Lhomond, 75231 Paris, Cedex 05, France

Abstract

The Egytian continental margin sedimentary cover include at least three main contrasted sequences. From top to bottom : a post Miocene, 2/3km thick on average, blanket which constitutes most of the Nile deep sea fan; a Messinian unit made of massive evaporites locally more than 2km thick, and submitted to important gravity gliding, and finally, a pre-mesinian, poorly known Mesozoic to Cenozoic cover which represents the pre, syn and most of the post-rift sequences of this segment of the african passive margin of Mesogea. Our results based on MCS and gravity data are a preliminary attempt to investigate this deep sedimentary and crustal sections of the Egytian margin.

Key words: Eastern Mediterranean/ Nile deep margin/ seismic-gravity

Most of the Egyptian continental margin is presently covered by the Nile deep-sea fan, a huge terrigenous construction of upper Cenozoic age resting on various Messinian deposits, including thick evaporites, themselves submitted to regional gravity tectonics [1]. It is generally agreed that the Egyptian continental margin represents a segment of a passive margin, the Mesogean margin of Africa, believed to have initiated in Mesozoic times (Jurassic to early Cretaceous, depending of the authors) in response to rifting processes leading to the opening of an oceanic space, whose remnants (the deep Eastern Mediterranean sea basins) [2, 3, 4] are now almost entirely consumed at the level of the Hellenic/Cyprus subduction zones. Despite considerable sets of geophysical data obtained by oil companies, but not yet available, little is still known on the deep structures of this passive margin which, moreover, may have been partly re-activated in Miocene times as a consequence of the the Red Sea/Gulf of Suez rifting. For example, the exact location of the transition zone between continental and oceanic crusts, or the tectonic fabrics, inherited from rifting and now deeply buried, are still pending questions. To our knowledge no seismic refraction data are yet available within this area of the Eastern Mediterranean, with the exception of an expanded seismic experiment recorded more than 10 year ago across the Herodotus abyssal plain [5]; Moreover the presence of massive, and unstable, Messinian evaporite layers [1], locally as thick as 3 km, and characterized by high seismic velocities, has considerably restricted sesimic imaging from academic seismic reflection surveys

This work is a preliminary attempt to better image, and constraint, the deep structures (sedimentary and crustal) of this passive margin segment. It is based on a combination of two sets of data: (1) Recently (2002) recorded deep penetrating (MCS) data [6]; (2) Marine gravity data, previously (1998) recorded on the entire deep sea fan, and themselves completed by Seasat derived data (Sandwell; 10).

In July 2002 about 1600 km of MCS data, using an array of 8 guns and a 5km long, 360 channels, digital streamer, have been recorded along seven regional lines, either perpendicular or parallel, to the present slope general trend (see Fig. 1). The use of standard processing packages (Geovecteur) has already allowed to better image several characteristics of the deep structures of the margin [6] and has particularly shown that, below spectacular thin-skin salt-related shallow structures (particularly well-expressed in the Eastern margin area), deeply sedimented basins exist. These basins contain strong and well-layered, reflector sequences detected up to 10 stwt (see Fig. 2) and interpreted as indicative of Mesozoic and subsequent deposits [7]. Locally, deep reflectors (around 11/12 stwt) may indicate transitional zone to thin layered lower continental crust, or even to the Moho. Below the Herodotus abyssal plain, reflectors well correlated with ESP data [5]. are from top to bottom identified as indicative of the Plio-Quaternary cover, the thickened evaporites, the mesozoic to cenozoic sediments, the top of the oceanic crust and even the Moho. Different tests of pre-stack depth migration have been succesively performed on one of the MCS lines (Line MD 06) to better asses the sedimentary thickness and to better image the deep margin architecture.

The seismic data have then been used to constrain preliminary crustal models for the Egyptian margin based on gravimetry data.

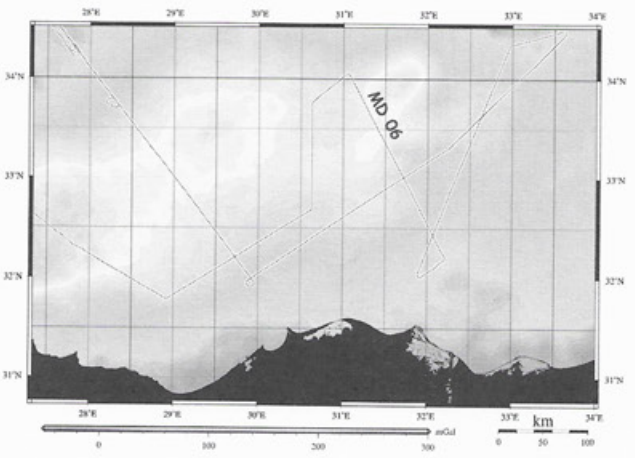


Fig. 1. Track line of Medisis survey over a Bouguer anomaly compilation.



Fig. 2. Tracing of MD 06 line from preliminary Geovector processing. Below thin-skin salt-related tectonic features, deep sedimentary basins, characterized by strong and well-layered reflector packages (interpreted as Mesozoic to early Cenozoic sediments), are detected up to 10 stwt.

References

1 - Loncke, L., 2002. Le delta profond du Nil : structure et évolution depuis le Messinien (Miocène terminal), Thèse de doctorat de l'Université Pierre et Marie Curie, Observatoire Océanologique de Villefranche-sur-Mer, Geosciences Azur, 404 p.

2 - Biju-Duval, B., Letouzey, J., and Montadert, L., 1978. Variety of margins and deep basins in the Mediterranean. *AAPG bulletin*: 293-317.

3 - Geiss, E., 1987. A new compilation of crustal thickness data for Mediterranean area. *Annales Geophysica*, 5B: 623-630.

4 - Hirsch, F., Flexer, A., Rosenfield A. and Yellin-Dror, A, 1995. Palinspatic and crustal setting of the Eastern Mediterranean. *Journal of Geology*, 18: 149-170.

5 - De Voogd, B., Truffert, C., Chamot-Rooke, N., Huchon, P., Lallemand, S. and Le Pichon, X., 1992. Two-ship deep seismic sounding in the basins of the Eastern Mediterranean Sea (Pasiphae cruise). *Geophysical Journal International,* 109: 536-552.

6 - Mascle J., Camera L., Chamot-Rooke N, *et al.* 2003. New constraints on the deep structure of the eastern mediterranean sea from new mcs seismic reflection data. *Geophysical Research Abstracts*, 5/ 09172-2003.

7 - Aal, A.-A., El Barkooky, A., Gerrits, M., Meyer, H.-J., Schwander, M. and Zaki, H., 2001. Tectonic evolution of the Eastern Mediterranean basin and its significance for the hydrocarbon prospectivity of the Nile delta deepwater area. *GeoArabia,* 6, 3: 363-384.

FLUID EMISSIONS AND MUD VOLCANOES IN THE UPLIFTING NORTHERN APENNINES: LEAKAGE THROUGH DEEP ROOTED NORMAL FAULTS IN A COMPRESSIVE SCENARIO

Rossella Capozzi * and Vincenzo Picotti

[1] Dipartimento di Scienze della Terra e Geologico-Ambientali, University of Bologna, Via Zamboni 67, 40126 Bologna, Italy
* capozzi@geomin.unibo.it

Abstract

In the Northern Apennines, spontaneous seepages are aligned in two belts, stretching the main divide and the foothills. Studied seepages, belonging to foothills belt, display two main patterns of fluid migration up to the surface. Geochemical and isotopic characters of saline waters and gas allowed distinguishing various depth of sources and reservoirs and to relate the leakage to deep-rooted normal faults or to up dip carrier beds which supply permeable shallow layers. The dominance of normal faults as migration pathway indicates the presence of an extensional state of stress in the uplifting Northern Apennine belt.

Keywords: mud volcano, geochemistry, normal fault, uplift.

Spontaneous fluid emissions and associated mud volcanoes occur in the Northern Apennines approximately along two belts striking near parallel to the main divide and to the foothills respectively (1). Along the foothill belt, we have studied some of these emissions belonging to different surface geological setting of the Northern Apennines. The study was addressed to mud volcanoes and seeps located in two geological setting, 1) topping the upper tectonic nappe of the chain (2) (the Ligurian unit), and 2) leaking through the foredeep units, where the Ligurian unit is absent. The study has been carried out by sampling, over a time spanning some months, the various components of fluid including saline waters and gas and by analysing their geochemical and isotopic characters. The definition of these characters integrated with data deriving from seismic profiles and the surface geology allows defining mechanisms of fluid leakage to the surface.

In particular, we would stress the importance of geochemical analysis on water emissions which allows reconstructing the migration through different carrier beds and steps in the migration pathway.

Geochemical and isotopic studies provided indication about the depth of gas sources. It resulted up to 6000 m in case of thermogenic gas migrating through deep-rooted normal fault and from below the Ligurian nappe, and typically biogenic when Neogene units can be identified as the main productive sedimentary body. This information is essential to confirm geological reconstruction also because testifies the presence of deep sources and permeable horizons down to 6-7 km under the surface.

The mud volcanoes of the studied region are caused by normal faults draining down to the lower tectonic foredeep unit, whereas, in the case of absent Ligurian, seepages are associated to shallow permeable carrier beds sealed by mudstones.

In the Northern Apennines, commonly interpreted as active compressive chain, the foothills records diffuse extensional features (3, 4), which are very effective pathways for the observed seepages. The presence of an extensional state of stress in the uplifting belt documents permutation of the stress axes in the late Quaternary, whereas, as a whole, the Adriatic plate still records a compressive state of stress.

References

1 - Borgia G.C., Elmi C. and Martelli G.,1986. Hydrocarbons in the Tuscan-Emilian Apennines: origin and characters of mineralization. *Mem. Soc. Geol. It.,* 31: 255-266.

2 - Capozzi R., and Picotti V., 2002. Fluid migration and origin of a mud volcano in the Northern
Apennines (Italy): the role of deeply rooted normal faults. *Terra Nova,* 14: 363-370.

3 - Bertotti G., Capozzi R., and Picotti V., 1997. Extension controls Quaternary tectonics, geomorphology and sedimentation of the N-Apennines foothills and adjacent Po Plain (Italy). *Tectonophysics*, 282: 291-301.

4 - Antonellini M., and Mollema P., 2002. Cataclastic faults in the Loiano Sandstones; Northern Apennines, Italy. *Boll. Soc. Geol. It.,* 121: 163-178.

PHYSICAL PROPERTIES AND THEIR RELATIONSHIP TO TEXTURE AND CONSOLIDATION EFFECTS IN SEDIMENTS FROM MUD VOLCANOES IN THE ANAXIMANDER MOUNTAINS (EASTERN MEDITERRANEAN)

David Casas [1] *, Gemma Ercilla [1], Vasilis Lykousis [2], Panos Georgiou [2], Grigoris Roussakis [2]

[1] Institut de Ciències del Mar-CSIC. Passeig Marítim de la Barceloneta. 37-49. Barcelona. Spain - * davidc@icm.csic.es

[2] National Centre for Marine Research- NCMR. Ag. Kosmas, Elliniko, 16604 Athens. Greece

Abstract

This research is focussed on the mud volcanoes Amsterdam, Kazan and Kula located in Anaximander Mountains. These volcanoes, characterized by the presence of sediments containing gas and gas hydrate, have been sampled, recovering four gravity cores. For those sediment located inside the mud volcanoes the physical properties are controlled by lithology and volcanic processes rather than degree of compaction. This could suggest the possible present volcanic activity. Contrasting, the core located outside the Kula mud volcano displays physical properties mostly related to consolidation effects and to the type of sediment at a detailed scale, as it occurs typically in deep sea fine grained sediments. This suggests a restricted influence of volcanic processes outside the crater.

Keywords: Mud volcano, Gas Hydrate, Physical properties, Texture, Consolidation.

Physical properties of marine sediments are important variables to understand geological events of marine environments. Several studies have been conducted to examine the relationship between physical and sedimentological parameters of marine sediments (1-4). The aim of this work is to determine the effects of sedimentologic changes on the physical properties of sediments containing gas hydrate recovered on the Anaximander Mountains, offshore in the southwest Turkey. The research is focussed on the known mud volcanoes Amsterdam, Kazan and Kula, which are characterized by the presence of sediments containing gas and gas hydrate (5, 6). These volcanoes have been sampled recently with a gravity corer system, recovering four cores; An05GC1 in Amsterdam, An07GC4 in Kazan and An14GC1 and An13GC1 in Kula mud volcanoes.

The Anaximander Mountains are located in one of the most rapidly subsiding sections of the Mediterranean (7). At least, seven mud volcanoes have been identified in the area. The origin of these volcanoes is associated to the structural situation characterized by a compression zone that favours the expulsion of overpressured fluids at the surface. There are several acoustic evidences in the area suggesting the presence of gas in the sediments, such as acoustic turbidity, acoustic wipe-outs and pockmarks. Likewise, sediment containing interstitial free gas, gas hydrate, and carbonate crusts have been recovered on the volcanoes (5, 6).

The studied cores were analysed in order to know the physical (magnetic susceptibility, acoustic velocity, and bulk density) and index properties (e.g. water content, grain density, and shear strength), texture and composition of the types of sediments. The physical properties comprise continuous measurements with a multi sensor core logger, whereas the index properties and textural analysis were made on discrete samples.

Two different types of sediments have been defined, mud breccia and hemipelagic mud. Mud breccia is characterized by a high content of clay and silt ranging between 67-56 % and 19-30%, with percentage of sand and gravel of about 14 %. Hemipelagic mud is characterized by a high content of clay and silt and only a little percentage of sand (3%). The stratigraphy of cores An05GC1, An07GC4, An14GC1 comprises the vertical stacking of mud breccia, whereas the core An013GC1 is defined by mud breccia that toward the top passes to hemipelagic mud; the contact between both types of sediment is sharp.

Some differences between cores have been identified from the statistical correlation of the different studied parameters. For cores An05GC1, An07GC4, An14GC1 the physical properties are mainly controlled by lithology; in fact, only positive correlations between sand and density (R=0.47), and silt and density (R=0.69) have been observed. The physical properties of the core An013GC1 are mostly related to compactation (consolidation by overburden), but at detail scale shows variations related to variations in defined texture (hemipelagic mud versus mud breccia). In this sense, we have observed the following positive relationships: density and P-wave (R=0.47), sand and density (R=0.58), density and core depth of the sample (R=0.72), magnetic susceptibility and carbonate (R=0.73), and magnetic susceptibility and sand (R=-0.58).

Likewise, the statistical correlation indicates that carbonate content does not correlate with changes in porosity and grain density in the four cores. This may suggest that carbonate content does not show any particular effect on the physical properties of the sediments. Shear strength and water content have mostly a very low correlation to null with sample depth in the core. A negative correlation is observed between shear strength and water correlation in cores An07GC1 (R=0.79) and An13Gc1 (R=0.7). For the rest of the cores, the shear strength could be controlled by the effect of sediment fabric disruption resulting from the depressurisation after collection of samples containing gas hydrate and/or by changes in the cohesive forces developed in the clayey-rich sediment (8).



Fig. 1. Bathymetric map displaying the location of Amsterdam, Kazan and Kula mud volcanoes, in the southwest Turkey (eastern Mediterranean).

The stratigraphy and the above mentioned correlations suggest that for those sediment cores located inside the mud volcanoes (An05 GC1, An07GC4 and An14GC1) the physical properties are controlled by lithology and volcanic processes rather than degree of compaction. This could suggest recent fluid circulation, and then the possible present volcanic activity in the studied volcanoes. Contrasting, the core located outside the Kula mud volcano (An13GC1) displays physical properties mostly related to consolidation effects and to the type of sediment at a detailed scale, as it occurs typically in deep sea fine grained sediments. This suggests a restricted influence of volcanic processes outside the crater.

References

1 - Hamilton, E.L., Bachman, R.T., 1982. Sound velocity and related properties of marine sediments. *J. Acoust. Soc. Am.*, 72: 1891-1904.

2 - Orsi, T.H., Dun, D.A., 1991. Correlations between sound velocity and related properties of glacio-marine sediments: Barents Sea. *Geo-Mar Lett.*, 11: 79-83.

3 - Weber, M., Niessen, F., Kuhn, G., Wiedicke, M., 1997. Calibration and application of marine sedimentary physical properties using a multi-sensor core logger. *Mar. Geol.*, 136: 151-172.

4 - Kim, D. C., Sung, J. Y., Park, S. C., Lee, G. H., Choi, J. H., Kim, G. Y., Seo, Y. K., Kim. J. C., 2001. Physical and acoustic properties of shelf sediments, the South Sea of Korea. *Mar. Geol.*, 179: 39-50.

5 - Woodside, J.M., Ivanov, M.K., Limonov, A.F., 1998. Shallow gas and gas hydrates in the Anaximander Mountains region, eastern Mediterranean Sea. *In*: Henriet, J.-P. & Mienert, J. (eds.) Gas Hydrates: Relevance to World Margin Stability and Climate Change. Geological Society, London, Special Publications, 137: 177-193.

6 - Lykousis, V., Woodside, J., De Lange, et al., 2003. Mud volcanoes and related gas hydrates in Anaximander mountains (Eastern Mediterranean). New discoveries from the 01/May 03 cruise of R/V Aegaeo (Anaximander Project). Ocean Margin Research Conference. Paris, 15-17 September.

7 - Fleming, N. 1972. Eustatic and tectonic factors in the relative vertical displacement of the Aegean coast. Pp. 189-201. *In*: Stanley, D. (ed.) The Mediterranean Sea. Dowden, Hutchinson & Ross, Stroudsberg.

8 - Scmincke, H.U. Ewaver, P.P.E., Firth, J.V. et al., 1995. Proc. ODP, Int. Repts., 116: College Station TX.

DISCOVERY OF WIDESPREAD SUBMARINE SLIDES REWORKED BY BOTTOM CURRENTS ON THE SOUTHERN ADRIATIC CONTINENTAL SLOPE

Cattaneo A. [1] *, Minisini D. [1], Trincardi F. [1], Verdicchio G. [1], Asioli A. [2] and TOBI team [3]
[1] ISMAR (CNR), v. Gobetti 101, 40125 Bologna, Italy - * antonio.cattaneo@bo.ismar.cnr.it
[2] IGG (CNR), Padova, Italy
[3] SOC, Southampton SO14 3ZH, UK

Abstract
A recently acquired TOBI side-scan sonar mosaic shows evidence of widespread collapsing of the South Adriatic continental slope. The new seafloor images, accompanied by VHR Chirp sonar profiles, reveal: 1) multiple overlapping slide scars affecting Pleistocene regressive shelf-margin deposits below the shelf edge; 2) extensive blocky slides on the lower slope; 3) evidence of strong bottom currents (presence of sediment drifts and furrows); and 4) a basin wide acoustically-transparent deposit up to 40 m thick, buried under a late-Pleistocene-Holocene mud section, in water depths greater than 1000 m.

Keywords : TOBI, Adriatic Sea, submarine slides, sediment drifts

The southwestern Adriatic slope was investigated to improve the understanding of sediment transport from the north and across the slope area. Little was known on the complex morphology of this area, but several published cores reported high, though not uniform nor steady, sediment accumulation rates throughout the last ca. 30 kyr [1].

The southwestern Adriatic Sea is characterised by high gradients (1-4%) and the presence of tectonic features (Gondola fault, Dauno Seamount) and several incisions, locally breaching the shelf edge and considered active during glacial lowstands, as the Bari canyon [2]. Seismic-stratigraphic correlations indicate that the Bari canyon was downcut repeatedly during the last few eustatic falls. In particular, the recent-most regressive sequence recording the interval from Oxygen Isotope stages 5 to 2 is downcut by the multiple heads of this complex sediment conduit [2]. Preliminary surveys showed evidence of sediment instability affecting lowstand shelf-margin deposits and thick graded turbidite beds at the base of the slope [3]. The TOBI survey, undertaken during the SAGA2003 cruise onboard R/V *Urania* within the Eurostrataform project (EC Contract EVK3-CT-2002-00079), first showed large-scale submarine slides, the 3-dimensional shape of large along-slope sediment drifts, the morphology of the Bari canyon, and helped understanding the extent and nature of mass-failure deposits and the complex relation between mass wasting and sediment deposition by bottom currents.

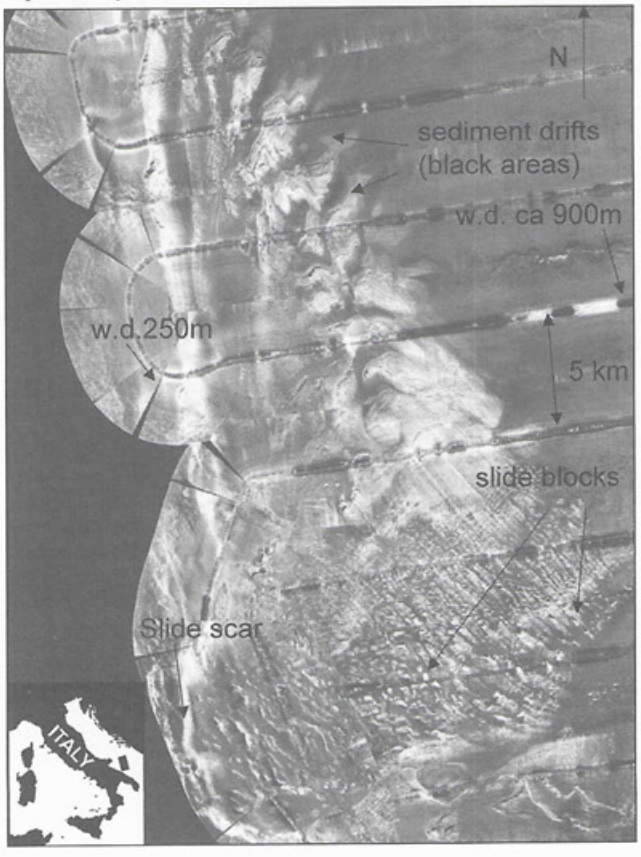


Figure 1 represent part of the TOBI survey with extensive slide scars on the upper slope (left) and relatively recent mass-failure deposits transported to NE on the lower slope and in the adjacent basin. Slide blocks are acoustically-transparent deposits (in seismic lines) with no internal bedding and size up to 200x500 m. Lateral variations in internal seismic-reflector geometry and seafloor morphology of the mass-transport deposits reflects, likely, along margin differences in sediment composition and thickness of the failed section as well as highly variable runout of the failed materials (exceeding at times 40 km). TOBI data show that the entire slope area is swept by bottom currents generating: furrowed areas extending up to 10s of km^2; moats or scours on the downdrift side of seafloor irregularities (slide blocks); and preferential sediment deposition on the inferred updrift side of the same irregularities. The NW-SE pattern of furrows is consistent with the growth of sediment drifts located in 400-600 m w.d. to the north.

Relative sea-level fall has long been considered as a possible predisposing or triggering mechanism for sediment failure. While the evidence of mass-failure events during falling sea level and lowstand is common, the occurrence of mass-failure during the late-Quaternary sea-level rise is increasingly being recognized [4]. Preliminary correlation to published cores in the area indicates that the main mass transport deposit reached the basin floor during the Last Glacial Maximum, but younger failures of smaller size may have affected the slope more recently. Future work will focus on the definition of intervals of growth vs. quiescence of the sediment drifts and their possible relation to paleoceanographic reconfigurations and timing of sediment failure.

References

1 - Jorissen F.J., Asioli A., Borsetti A.M., Capotondi L., De Visser J.P., Hilgen F.J., Rohling E.J., Van De Borg K., Vergnaud-Grazzini C., Zachariasse W.J., 1993. Late Quaternary central Mediterranenan biochronology. *Mar. Micropal.*, 21: 169-189.

2 - Ridente D., Trincardi F., 2002. Eustatic and tectonic control on deposition and lateral variability of Quaternary regressive sequences in the Adriatic basin. *Mar. Geol.*, 184: 273-293.

3 - Cattaneo A., Correggiari A., Trincardi F., 2002. Recognition of turbidite elements in the late-Quaternary Adriatic basin: where are they and what do they tell us? *CIESM Workshop Series*, n.17: 23-28.

4 - Trincardi F., Cattaneo A., Correggiari A., Mongardi S., Breda A., Asioli A., 2003. Submarine slides during relative sea level rise: two examples from the eastern Tyrrhenian margin. Pp. 469-478. *In*: Locat J., Mienert J. (eds.), Submarine Mass Movements and their Consequences. Kluwer, Amsterdam.

DISPONIBLE SÉDIMENTAIRE ET MODÈLES CONCEPTUELS D'ÉVOLUTION MORPHODYNAMIQUE DES BARRES SÉDIMENTAIRES D'UNE PLAGE MICROTIDALE (SÈTE, FRANCE)

R. Certain, J-P. Barusseau *

Université de Perpignan, Faculté des Sciences, LEGEM, 52 Avenue Paul Alduy, 66860 Perpignan Cedex, France

Résumé

Dans un environnement littoral sableux microtidal (Sète, France), la quantité de sédiment présent sur l'avant-côte (ou disponible sédimentaire) a été définie et les modèles conceptuels de la morphodynamique du système de barres sédimentaires ont été établis. Il semble que la disponibilité en sédiment influence ces modèles évolutifs et puisse être un critère pour définir le niveau de vulnérabilité d'une plage.

Mots-clés: Morphodynamique / plages sableuses / barres sédimentaires / modélisation conceptuelle / disponible sédimentaire / sismique THR

Le littoral sableux de Sète (France), avec son avant-côte à barres sédimentaires, est un des trois sites d'étude de l'Action de Recherche Thématique 7 du Programme National d'Environnement Côtier (PNEC). Ce site a été choisi en raison de son caractère microtidal dominé par la houle et des longues séries temporelles de données disponibles. Le caractère dissipatif de la plage et rectiligne des barres est en concordance avec les classifications usuelles des plages de type dominé par la houle [1, 2], en fonction de la granulométrie, de la pente et des hauteurs de houle enregistrées sur le secteur.

Sur ce site, deux démarches ont été suivies : une quantification des volumes de sédiments sableux présents sur l'avant-côte à partir de prospection sismique THR [3] et la caractérisation de modèles évolutifs conceptuels relatifs à la morphodynamique des barres.

Les volumes sableux sur l'avant-côte ont été estimés en trois secteurs du lido de la lagune de Thau à Sète afin d'appréhender leur répartition et le lien éventuel qui pourrait exister avec le transport de dérive littorale, estimé à plusieurs dizaines de milliers de m^3 par an. Ainsi, un site amont-transit, un site aval-transit et un site en position intermédiaire ont été prospectés. En amont-transit, à Sète, là où l'érosion est la plus forte avec un recul du trait de côte de 50 m en 50 ans, le volume sableux contenu sur l'avant-côte du site est le plus faible (200 000 m^3) [4]; Ce volume augmente dans le sens de la dérive littorale pour devenir maximum (500 000 m^3) en aval transit, à Marseillan, où le trait de côte progade [5]. Il semblerait qu'on puisse mettre en relation la quantité de sédiment présent sur l'avant-côte, ou disponible sédimentaire, et les tendances évolutives des plages. Là où le réservoir sableux est appauvri, la tendance évolutive des plages est négative et, à l'opposé, les plages associées à des réservoirs importants ne semblent pas souffrir de l'érosion.

Les principaux résultats morphodynamiques obtenus montrent l'existence de 2 modèles conceptuels d'évolution des barres sédimentaires en réaction à la variabilité météo-marine.

(1) Le modèle d' *«oscillation autour d'une position d'équilibre»* (O.P.E) traduit le régime ordinaire du comportement des barres, avec des reculs et des avancées successifs [6]. Les barres migrent vers le large lors des tempêtes et vers la côte lorsque les conditions énergétiques diminuent. Cette oscillation s'exprime à plusieurs rythmes: (i) à l'échelle des grandes phases évolutives des barres, qui sont de longues périodes durant lesquelles les barres présentent les mêmes caractères géométriques. Le passage de l'une à l'autre de ces phases se produit lorsque survient une tempête dont la hauteur significative excède 4 m; (ii) à l'échelle saisonnière, ce qui est bien illustré par le comportement de la barre interne : durant l'été, lorsque les conditions d'agitation sont faibles, la barre vient s'accoler ponctuellement au rivage ; quand les conditions d'agitation augmentent en automne, la barre interne se reforme et recule vers le large.

(2) Le modèle de "*net offshore migration*" (N.O.M) pointe la tendance à un recul des barres sous l'effet d'évènements paroxystiques (tempêtes de probabilité vingtennale à cinquentennale) préludant à leur dégénérescence [7-10]. A partir de la position d'équilibre, la barre externe recule fortement et s'abaisse suite au coup de mer. Au lieu de revenir à la côte (modèle OPE), la barre externe perd du matériel au profit de la barre interne et dégénère. La barre interne, exposée à la houle, se met alors à reculer pour remplacer l'ancienne barre externe, une nouvelle barre interne étant créée à la côte. En quelques années après l'événement déclencheur, la disposition standard est restaurée.

A partir de ces deux approches, il semble qu'on puisse affiner la notion de disponible sédimentaire. Le disponible sédimentaire représente la quantité de sédiment accumulé sur l'avant-côte à l'échelle séculaire. Une partie de ce stock peut être remobilisé lors des grandes phases évolutives du système de barres à l'échelle pluriannuelle (décrites précédemment), c'est le sédiment mobilisable. A l'échelle des coups de mer, des quantités moins importantes de sédiment peuvent aussi être déplacées, le sédiment mobile. Ces notions sont importantes à l'heure d'établir un diagnostic sur l'état de santé d'une plage. Pour les sites en forte érosion, comme le littoral du nord de la lagune de Thau, les notions de disponible sédimentaire et de sédiment mobilisable sont confondues, ce qui signifie que la totalité du stock sableux peut être remobilisée lors des grandes phases évolutives des barres. Il semble qu'on dispose là d'une nouvelle méthode de détermination du niveau de vulnérabilité d'une plage. De plus, il semble que lorsque le disponible sédimentaire n'est pas suffisant, les modèles évolutifs eux-mêmes peuvent être perturbés.

Références

1 - Short, A.D., 1999. Wave-dominated beaches. *In :* A.D. Short, ed., Handbook of beach and shoreface morphodynamics, John Wiley and sons Ltd, 7, 174-203.

2 - Short, A.D., & Aagard, T. 1993. Single and multi-bar beach change models. *Journal of Coastal Research*, Special Issue, 15: 141-157.

3 - Simpkin, P.G., & Davis, A., 1993. For Seismic profiling in very shallow water, a novel receiver. *Sea Technology*, 34, 5 p.

4 - Tessier, B., Certain, R., Barusseau, J.P., & Henriet, J.P., 2000. Evolution historique du prisme littoral du lido de l'étang de Thau (Sète, SE France). Mise en évidence par sismique réflexion très haute résolution *C.R. Ac. Sci. Paris,* 331: 709-716.

5 - Certain, R., Tessier, B., Barusseau, J-P., Courp, T. and Pauc, H. Sedimentary balance and stock availability along a littoral system. The case of the western Gulf of Lions littoral prism (France) investigated by very high resolution seismic. *Marine and Petroleum Geology* (in press).

6 - Certain, R., 2002. Morphodynamique d'une côte sableuse microtidale à barres : le golfe du Lion (Languedoc – Roussillon). Unpublished thesis, Univ. Perpignan, 209 p., ann.

7 - Ruessink, B.G., & Kroon, A.,1994. The behaviour of a multiple bar system in the nearshore zone of Therschelling, The Netherlands 1965-1993. *Marine Geology*, vol. 121: 187-197.

8 - Winjberg, K.M., 1995. Morphologic behaviour of a barred coast over a period of decades, unpublished thesis, Univ. of Utrecht, 215 p.

9 - Lippman, T.C., Holman, R.A., Hataway, K.K., 1993. Episodic, nonstationnary behaviour of double bar system at Duck, N.C., U.S.A., 1986-1991. *Journal of Coastal Research,* 15(SI): 49-75.

10 - Shand, R.D., 2003. Relationships between episodes of bar switching, cross-shore bar migration and outer bar degeneration at Wanganui, New Zealand. *Journal of Coastal Research*, 19, 1: 157-170.

STRATIGRAPHY AND SEDIMENTARY FACIES OF THE LLOBREGAT DELTA FROM GEOTECHNICAL MEASUREMENTS

S. Colàs [1] *, J.L. Casamor [1], M. Canals [1], J.M. Devincenzi [2]

[1] GRC Geociències Marines, Dept. d'Estratigrafia, P. i Geociències Marines, Universitat de Barcelona, E-08028, Spain
[2] IGEOTEST, E-17600, Spain

Abstract

A 3D model of the Llobregat Delta has been constructed from CPT and CPTU measurements. This model shows the spatial distribution of sedimentary facies including beach sands, floodplain silts and clays, delta front sands and silts, and prodelta silts and clays. Each facies is described in terms of mechanical properties namely cone tip resistance (q_c) and friction ratio (FR%). Groundtruthing of lithologies is provided by continuous cores in control boreholes. Moreover, key surfaces for sequence stratigraphic interpretation, like transgressive and maximum flooding surfaces, have been identified.

Keywords: Geotechnical measurements, stratigraphy, sediment facies, Llobregat Delta

The present study is based on Cone Penetration Tests (CPT) and piezocone tests (CPTU) from a geotechnical study carried out prior to the construction of a new sewage treatment plant (EDAR) on the delta plain of the Llobregat River. 70 CPT/CPTU tests and 20 boreholes with continuous core recovery were performed within a 1.2 x 0.25 km^2 area. Despite of its small size, the study area is considered to be representative of the deltaic system because of its location near the current river mouth and orientation parallel to the river lowermost course. Both methods provide a high measurement rate of the soil resistance (q_c) and friction (f_s) recovered every 1 to 2 cm. CPT/CPTU data combined with continuous cores are widely used for the geotechnical and sedimentological characterization of soft soils [1].

The data set has been used to construct a 3-D model using the minimum tension gridding (MTG) method. This technique has the advantages of its simplicity. In addition, it does not require large calculation times. The modelling results unveil the internal structure of the delta by illustrating the spatial distribution of sedimentary units and q_c trends. The results obtained through the MTG method are supported by previous results from the same study area using kriging algorithms [2].

Within the general architectural frame, our study allows differentiating fluvial channel sands, beach ridge sands, crevasse sands, delta front sands, silts and clays, and prodelta silts and clays. Each facies is described in terms of its mechanical properties, namely q_c and FR%. Groundtruthing of sediment facies is obtained from continuous cores in control boreholes (Fig. 1). Plotting q_c *versus* FR% on Robertson's *et al.* chart [3] with inclusion of sediment facies allows establishing q_c-sediment facies correlation.

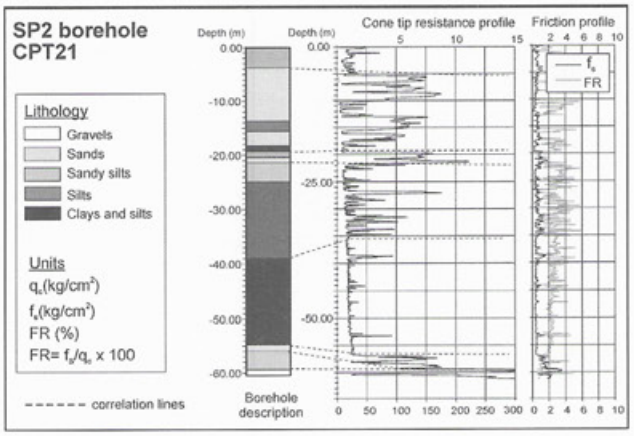


Fig. 1. CPT21 results plotted in parallel with the sediment log from a close borehole SP2. The correlation between soil resistance (q_c) values and the borehole lithological description becomes evident. The friction ration curve is also provided, since it is used jointly with q_c to develop the q_c-sediment facies correlation. The tree main sedimentary units are correlated: an upper sandy level between 5 and 20 m of depth, an intermediate level made of silts and clays with about 30 m of thikness, and a lower coarse level. This stratigraphic sequence represents the generally assumed deltaic coarsening-upwards sequence of prodelta and delta-front facies overlain by fine sediment attributed to the floodplain.

Relative sea-level stillstands have been identified from the location of landwards stepping beach ridge sands in the 3D model at 7, 13, 18 and 25 m of depth below the current sea-level. Their distribution can be attributed to retrogradational deltaic sequences formed during periods of relative stillstand within the transgressive systems tract related to the last post-glacial sea-level rise and subsequent shoreline migration. This fact allows to infer four relative sea-level stages associated to the upper part of the Versilian transgression, likely from about 11000 to 6000 yBP. Two additional, seaward shifted, uppermost beach ridge sands have been interpreted as representing two progradational phases associated to the highstand systems tract. This corresponds to a sustained delta growth and shoreline advance phase favored by a estabilization of the sea-level since 6000 yBP onwards.

References

[1] - Amorosi, A. and Marchi, N., 1999. High-reslution sequence stratigraphy from piezocone test: An example from the late Quaternary deposits of the southeastern Po plain. *Sedimentary Geology*, 128: 67-81.

[2] - Devincenci, J.M., Colàs, S., Falivene, O., Canals, M. and Busquets, P., 2003. Aplicación del piezocono para el estudio sedimentológico de detalle de los sedimentos cuaternarios del Delta del Llobregat, Barcelona. *Proceedings III Congreso Andaluz de Carreteras, Sevilla, España,* Octubre 2003.

[3] - Robertson, P.K., Campanella, R.G., Gillespie, D. and Greig, J., 1986. Use of piezometer cone data. Proceedings of the ASCE Special Conference in situ '86: Use of *in situ* tests in geotechnical engineering, Blacksburg, 1263-80, American Society of Engineers (ASCE).

PALÉOGEOGRAPHIE ALPINE ET ORIGINE DES BASSINS DE LA MÉDITERRANÉE OCCIDENTALE

Alain Coutelle

UBO, Département des Sciences de la Terre (UMR 6538), CS 93837 - Brest Cedex 3 France - coutelle@univ-brest.fr

Résumé

L'assimilation de la dynamique de la Chaîne Alpine de la Méditerranée Occidentale à celle d'un système d'arc insulaire, pose problème. Ainsi, un réexamen de la signification du volcanisme néogène de l'Afrique du Nord, amène à lui retirer sa qualité supposée de volcanisme d'arc. Cet acquis incite à revoir d'autres points du modèle et en particulier, la paléogéographie qu'il sous-entend. En se référant aux seules affinités stratigraphiques, on est ainsi conduit à rattacher l'"arc" du modèle non pas à l'Ibérie-Europe, mais à l'Afrique-Apulie, ce qui n'est pas non plus favorable au modèle.

Mots clés: tectonics, palaeogeography, Western Mediterranean

Introduction

De nombreuses hypothèses ont été proposées pour expliquer la formation des bassins de la Méditerranée Occidentale. Parmi ces propositions, la plus en vogue, assimile les bassins marins actuels à un bassin d'arrière-arc insulaire et la chaîne alpine à un prisme d'accrétion d'avant-arc. Le rôle de la fosse avant-arc serait tenu par les anciens bassins de flyschs dont la disparition par subduction de leur soubassement océanique, aurait permis l'ouverture des bassins actuels.

Une publication récente (1) a montré que l'un des argument majeurs pour ce type de modélisation ne tenait pas. Le volcanisme littoral d'Afrique du Nord supposé caractériser l'arc insulaire alpin, donc la plaque supérieure, est en fait le produit de fusions ponctuelles de la plaque africaine, c'est-à-dire de la plaque inférieure. D'autres arguments, structuraux, chronologiques, etc., peuvent être opposés à ce type de modèle. En particulier, il implique une paléogéographie qui n'est pas la plus probable. C'est cet aspect qui va nous retenir maintenant.

Paléogéographie "plaquiste" de la Méditerranée occidentale

Ce modèle, que j'appellerai "plaquiste" pour faire simple, admet qu'avant les rapprochements cénozoïques, la paléogéographie de la Méditerranée occidentale, s'organisait de la manière suivante:

- du coté européen, et selon une direction grossièrement NE-SW, s'étendaient les domaines ibérique, baléare, corso-sarde, briançonnais;
- à ces territoires s'accolaient, au SE, un domaine médian, qui comprenait les domaines à socle continental et couverture carbonatée, bético-rifain, kabyle, péloritain, calabrais et prépiémontais;
- cette lanière était elle-même bordée par une fosse de flyschs, rifo-bétiques au SW, puis kabyles, péloritains, calabrais, ligures et enfin piémontais vers le NE;
- la bordure méridionale de ce sillon était formée par les marges continentales de l'Afrique et de l'Apulie.

A la fin du Crétacé, ce dispositif soumis à un serrage N-S, s'adapte aux nouvelles contraintes grâce à une subduction à pendage nord, apparue à la jonction entre la sillon des flyschs et le domaine médian. Par la suite, à partir de l'Oligocène, le renforcement de cette subduction amène la résorption complète du sillon des flyschs et l'apparition de nouveaux bassins à fond océanique entre le domaine européen et le domaine médian, devenu un arc insulaire.

Cette paléogéographie s'accorde avec celle proposée par certains auteurs travaillant en Afrique du Nord, pour qui tous les flyschs maghrébins s.l. se sont déposés dans un même bassin, "externe" par rapport aux domaines à socle et couverture calcaire. En Algérie cette origine est dite "citra-kabyle".

Une autre paléogéographie est possible.

Plus ancienne, l'idée que certains flyschs aient une origine "ultra-kabyle", ou encore "interne", procède d'une autre démarche. Il existe en effet, sur toutes les unités à socle et couverture calcaire, une couverture tectonique de flyschs bien particuliers avec un Crétacé disloqué à faciès chaotique dit "argille scagliose" en Italie et un Cénozoïque à faciès de pélites bariolées et grès micacés, connus de Gibraltar à la Ligurie. La vergence générale vers l'Afrique des nappes néogènes, impose l'origine "interne" ou "ultra-domaine médian" de ces flyschs. Dans l'autre cas de figure, on est obligé d'admettre que ces unités hautes de flyschs se sont mises en place du S vers le N, contrairement à toutes les autres unités et ceci, sans aucune preuve tectonique. D'autre part, cette paléogéographie pose problème pour le raccordement à la fosse des flyschs alpins, obligeant à un relais transversal mal argumenté. En outre, l'alimentation de la fosse des flyschs en matériel provenant des socles et de leur couverture est difficile, les détritus devant traverser des zones à sédimentation exclusivement pélagique. Enfin, cette paléogéographie solidarise l'Apulie et l'Afrique, alors que cela ne doit pas être car le décalage latéral de l'Afrique admis par les cinématiciens, de l'ordre du millier de kilomètres, conduirait à donner à l'océan alpin une largeur excessive, tout en situant l'Apulie beaucoup trop à l'E par rapport à l'Europe. Un article, assez ancien (2) a fait le point sur ces débats sans que les choses aient beaucoup bougé depuis.

Dans le contexte d'une reprise de la discussion sur ces questions, suite aux travaux récents portant sur la signification du volcanisme d'Afrique du Nord, il est apparu nécessaire de reprendre le dossier de la stratigraphie des séries de la couverture carbonatée du domaine médian ainsi que la question de l'alimentation des flyschs.

1 - Les séries les plus typiques du domaine médian, à matériel pélagique méso-cénozoïque, présentent des caractères stratigraphiques qui les rapprochent des séries telliennes internes, mais qui, surtout, les identifient presque aux séries de la nappe toscane. Elles n'ont, par contre, pas grand'chose de commun avec les séries bétiques et sardes. Sur ces critères, on doit donc logiquement rattacher le domaine médian à la bordure nord-ouest de l'Apulie. D'autres unités, généralement en écailles tectoniques au S, et sous, les unités à matériel pélagique, ont une stratigraphie très différente. En effet, du Jurassique moyen à l'Eocène, tous les étages sont détritiques, ce qui les rapproche des flyschs. Elles présentent parfois des dispositifs structuraux particuliers "en fleur" et portent souvent la marque d'un faible métamorphisme. De telles unités, sont de bonnes candidates pour provenir de la zone de décrochement entre l'Afrique et l'Apulie.

2- S'agissant des flyschs, le rattachement du domaine médian à l'Apulie, permet de localiser le bassin des flyschs "internes" dans le prolongement direct, vers le SW, du sillon des flyschs liguro-piémontais. A sa terminaison sud, ce bassin se raccordait obliquement à un autre sillon, orienté E-W, qui correspondait à la zone de contact coulissante de l'Afrique avec les autres domaines plus septentrionaux. C'est le sillon "externe". Une telle disposition règle les difficultés d'alimentation et d'indentation de faciès entre flyschs.

Conclusion

Naturellement, cette paléogéographie ne s'accorde pas du tout avec celle qui convient au modèle "plaquiste". On a vu qu'il en allait de même pour le volcanisme d'Afrique du Nord. Ce modèle est donc à revoir.

Références

1 - Maury R.C., Fourcade S., Coulon C., El Azzouzi M., Bellon H., Coutelle A., Ouabadi A., Semroud B., Megartsi M., Cotten J., Belanteur O., Louni-Hacini A., Piqué A., Capdevilla R., Hernandez J. et Réhault J.P., 2000. Post-collisional neogene magmatism of the Maghreb margin: a consequence of slab breakoff. *C. R. Acad. Sc.*, Paris, t. 331, sér. IIa: 159-173.

2 - Coutelle A. et Delteil J., 1989. La suture alpine en Méditerrannée occidentale. Remarques sur une synthèse récente et rappel d'une autre conception, et Bouillin J.P., 1989. Réponse au commentaire de A. Coutelle et J. Delteil "La suture alpine en Méditerrannée occidentale. Remarques sur une synthèse récente et rappel d'une autre conception". *Bull. Soc. géol. France*, 8° sér., t.V: 859-867.

CONTENT OF THE ^{40}K, ^{232}TH, ^{226}RA, ^{238}U & ^{137}CS IN THE RECENT SEDIMENTS OF THE KRKA RIVER ESTUARY

Neven Cukrov *, Delko Barišić, Marko Branica
Institut Rudjer Boskovic, Zagreb, Croatia - * ncukrov@irb.hr

Abstract

A spatial radionuclide distribution in recent estuarine sediments in the Krka River Estuary was studied. Human activities affected a natural geochemical equilibrium of radionuclides in the area studied. The sediment samples have been analysed during the past two years and the activities of ^{40}K, ^{232}Th, ^{226}Ra, ^{238}U and ^{137}Cs were determined by a gamma-spectrometry method. The radionuclide distribution data indicate a different sedimentation rates of the marine and/or terrigenous origin. A difference in the transport rates of the dissolved and suspended material is clearly indicated by the ^{137}Cs and ^{40}K contents in the sediments at the upper estuary.

Keywords: the Krka River Estuary, sediments, radionuclide distribution, gamma-spectrometry

Introduction



A clastic material input into the eastern Adriatic Sea (the Croatian coast) is much smaller than that in the western side of the Adriatic Sea (the Italian coast), which can be attributed to the prevailing karstic character of the Croatian coast. There are no large rivers draining these terrains, and a relatively small quantities of the material carried by the eastern Adriatic rivers (Mirna, Raša, Zrmanja, Krka), are deposited in their estuaries. The Cetina and Neretva Rivers carry a significant quantities of the material, but due to the semi-closed nature of the Adriatic Sea, a recent sedimentation of the terrigenous material is restricted to a relatively small delta (the Neretva River) or an estuary (the Cetina River) sedimentation area. The content of naturally occurring radionuclides in the different types of a recent Adriatic Sea sediments has not been systematically studied, but some data were published elsewhere (1, 2).

Sampling and methods

The bottom sediment samples (the upper 5 cm of a sediment) were collected by a scuba diver using a hand-driven plexyglas corers, during the past two years at 12 locations in the Krka River Estuary. The samples were frozen at –18°C and kept until analyses. Prior to the gamma-spectrometry measurements, the sediment samples were thawed at room temperature and dried at 106°C during 24 hours, counted in a special vessels, sealed and stored for at least 4 weeks in order to allow a radioactivity disintegration of a gaseous ^{222}Rn. The samples were counted on a HPGe detector with a 8192 channel analyser. The system was calibrated using the standards supplied by Amersham International, IAEA-306 and IAEA-314. The spectra recoreded (80,000 seconds) were processed on a PC using a GENIE 2000 software. The activities of ^{40}K (1460.75 keV-peak), ^{137}Cs (661.6 keV-peak), ^{226}Ra (609.3 keV-peak of its ^{214}Bi progeny), ^{232}Th (911.1 keV-peak of its ^{228}Ac progeny) and ^{235}U (186 keV-peak (after the subtraction of the overlapping ^{226}Ra peak)) were calculated. The activities of ^{238}U were calculated from the ^{235}U activity assuming the ^{235}U/^{238}U activity ratio of 0.046.

Results and discussion

The lowest concentrations of all naturally occurring radionuclides (^{40}K, ^{232}Th, ^{238}U and ^{226}Ra) as well as an anthropogenic radionucleide (^{137}Cs) were obtained at the station KR-1. These activities correspond to the sand and the silts which are mostly spread along the Croatian coast and represent a typical values for the marine carbonate sedimentation (1, 2). The activities of ^{40}K are found to be elevated towards the Skradinski Buk waterfalls. However, the highest activities were found at the station KR-10 (the Prokljan Lake), which decreased towards the station KR-12 (Skradin). The distribution of ^{232}Th mostly follows that of ^{40}K. The distribution of ^{40}K and ^{232}Th indicates that the main input of the terrigenuous material in the Krka River Estuary originates from a very small Guduča River inflowing into the Prokljan Lake downstream the Krka River. The Krka River contains larger quantities of a fresh-water (an average of 55 m^2/sec) than the Guduča River (average <1m^2/sec). However, a number of waterfalls along the Krka River, upstream the town of Skradin, significantly reduce the transport of the suspended material. A constant rise of the ^{137}Cs activities from the station KR-1 to the station Kr-12 indicates this, because ^{137}Cs dissolves in the water and its transportation is unobstructed by the waterfalls.

The distribution of ^{238}U and ^{226}Ra shows the same pattern as ^{40}K and ^{232}Th, but with some exceptions, probably as a result of human activities in the Estuary. Future investigation will focus on these activities.

Since the Krka River Estuary functions as a large "water pump" (a flow of a fresh-water on the surface towards the sea, and an opposite flow of a salt-water in the Estuary), the sediment transport is mostly opposite to the river flow. As a result, the marine sedimentation is still predominant at the location KR-5 (2.3 km from the sea).

The results also indicate different relations of the studied elements on the left (KR-4,8) and the right (KR-5,6,7,9) banks of the Krka River Estuary.

	^{40}K	^{232}Th	^{137}Cs	^{226}Ra	^{238}U	depth
	Bq/kg dry weight					m
KR-1	20,5	3,5	0,3	4,3	6,7	33
KR-2	90,3	5,7	2,4	8,5	13,1	38
KR-3	41,8	4,2	0,7	9,8	14,1	32
KR-4	70,4	4,8	2,1	9,5	10,3	25
KR-5	110,3	8,2	2,6	28,7	25,9	27
KR-6	207,9	10,9	4,3	36,4	35,9	29
KR-7	295,2	17,1	7,9	23,5	25,5	24
KR-8	204,9	11,0	5,6	18,7	14,7	29
KR-9	244,1	12,0	8,1	22,7	21,8	24
KR-10	337,3	17,4	10,4	17,1	25,9	25
KR-11	308,6	15,9	15,4	16,9	29,1	14
KR-12	238,8	10,9	22,5	16,6	16,7	8

References

1 - Barišić, D. *et al.*, 1996. Radiological characteristics of recent marine sediments of the Adriatic sea. International Seminar on the Use of Isotope Techniques in Marine Environmental Studies. Athens, Greece. IAEA-SR-194/8

2 - Barišić, D *et al.*, R 1998. Natural radionucleides in recent marine sediments of the Adriatic Sea. *Rapp. Comm. int. Mer. Médit.*, 35: 228-229.

PREMIER EXAMEN DÉTAILLÉ DE LA MORPHOLOGIE ET LA STRUCTURE SUPERFICIELLE SOUS-MARINE DE LA MARGE OUEST-ALGÉRIENNE : CAMPAGNE MARADJA

J. Déverchère [1] *, K. Yelles [2], B. Mercier de Lépinay [3], J-P. Bouillin [4], V. Gaullier [5], H. Pauc [5], B. Savoye [6], E. Calais [7], A. Domzig [1], P. Le Roy [1], R. Bracène [8], A. Kherroubi [2]

[1] UMR6538, UBO-IUEM, Place N. Copernic, 29280 Plouzané, France - * jacdev@univ-brest.fr
[2] CRAAG, Bouzareah, Alger, Algérie
[3] UMR6538 Géosciences Azur, Valbonne, France
[4] LGCA, UJF, Grenoble, France5LEGEM, Univ. Perpignan, France
[6] IFREMER, Plouzané, France
[7] EAS, Univ. Purdue, Etats-Unis
[8] SONATRACH, Dpt . Exploration, Boumerdès, Algérie

Résumé

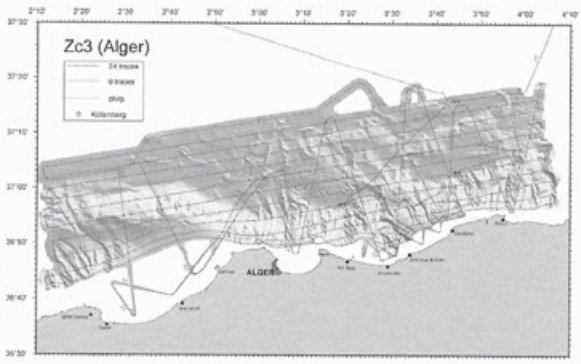
Nous tentons d'apporter des réponses sur l'aléa sismique, gravitaire et de tsunami au large de l'Algérie. Il s'appuie sur l'exploitation d'une importante base de données bathymétrique, de réflectivité, sismique, magnétique, gravimétrique, de sondeur, et de carottages, acquise en août-septembre 2003 au cours de la campagne MARADJA. Cette mission a notamment couverte la zone de rupture de Boumerdès (21 mai 2003, Mw 6.8). Nous montrons l'existence d'une succession de failles actives sur rampes à pendage sud qui affectent la marge et le bassin et s'associent à un intense diapirisme salifère et à des instabilités sédimentaires.

Mots clés : Risque sismique, failles actives sous-marines, instabilités sédimentaires, géodynamique, Algérie

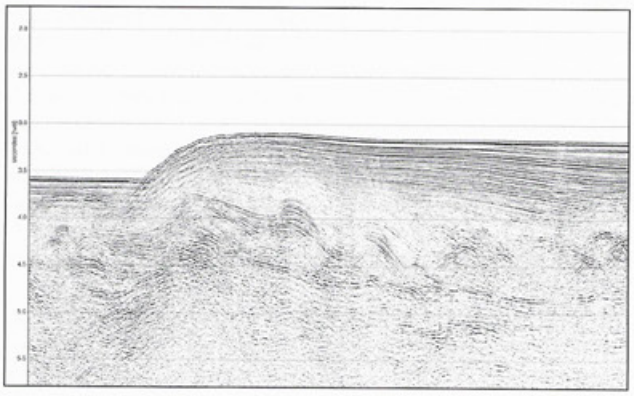
La campagne MARADJA ("Marge Active Djazaïr") s'est déroulée du 21 août au 18 septembre 2003 à bord du N/O *Le Suroît* de l'IFREMER. Elle avait été programmée avant le séisme catastrophique de Boumerdès (21 mai 2003) pour imager les structures actives (failles et glissements) sur la pente et le bassin ouest-algérien, suite aux nombreux indices de séismes sous-marins et d'avalanches sous-marines dans ce secteur.

En raison de l'absence de données bathymétriques précises, un prérequis à toute évaluation sismotectonique était d'établir une couverture par multifaisceau type EM300 sur les zones de pente et de pied de marge des grandes villes côtières. C'est donc l'accès à des données totalement nouvelles et très importantes du point de vue de l'évaluation du risque que nous offre l'acquisition réalisée pendant cette campagne. L'équipe scientifique réunissait plusieurs équipes françaises (Brest, Grenoble, Nice, Perpignan), le CRAAG (Alger), organisme responsable de la surveillance sismique et de l'évaluation du risque en Algérie, et un représentant de la société algérienne Sonatrach.

Suite au séisme de Boumerdès, les travaux du N/O Le Suroît se sont d'abord concentrés lors du premier Leg (21 août-3 septembre) à la zone sous-marine autour d'Alger, en élargissant la zone d'étude initialement prévue de 3,5°E à 4°E. Nous présentons seulement cette zone d'Alger ici. Nous avons réalisé une couverture bathymétrique à partir de 25 milles de la côte par des profondeurs d'eau de l'ordre de 2700 m, jusqu'au rebord du plateau, ce qui a représenté environ 2800 km de profils (Fig. 1, Tab. 1).



La zone cartographiée révèle plusieurs grands segments de failles actives, à la géométrie complexe, qui sont des escarpements cumulés de faille. Deux de ces segments (environ 30 km de longueur chacun) pourraient être en relation avec la rupture de Boumerdès du fait de leur position par rapport aux répliques et de leur longueur et "fraîcheur". Cette première interprétation est confirmée par les profils 6 traces et par 2 grands profils multitraces coupant la faille. Néanmoins, il existe d'autres structures sur le fond qui sont reliées à des bombements du socle sous le sel messinien, ainsi que d'étroits ou larges éventails sédimentaires en amont de ces structures (Fig. 2) qui témoignent de l'existence d'autres chevauchements aveugles en rampe, à l'origine de ces bassins suspendus, visiblement actifs, qui sont soit des bassins en « piggy-back » (Fig. 2) soit des systèmes disposés sur des plis en roll-over. Etant donné la profondeur probable du séisme de Boumerdès (5-10 km), la trace du déplacement lié au séisme n'est donc peut-être pas détectable en surface, ou bien alors passe sur d'autres escarpements plus petits.



Par ailleurs, nous avons identifié de grands canyons sous-marins sur les pentes, et de nombreuses preuves de glissements gravitaires, dont notamment des figures de "debris flows" et "slumps". Nous avons aussi tenté et réussi 4 carottages importants (Fig. 1), qui atteignent 8 mètres de longueur. Trois carottes (KMDJ01, 02 et 03) ont été prélevées dans des séries qui résultent vraisemblablement de phénomènes gravitaires d'accumulation de bas de pente à la sortie de trois canyons, respectivement du Sébaou, de l'Isser et de Zemmouri-Alger. La pénétration s'est arrêtée sur un niveau de vase extrêmement cohésive surmonté par une ou plusieurs formations de vase plus fluide vers le sommet. La carotte KMDJ04, nettement plus au large, a échantillonné une ou plusieurs turbidites : elle recoupe des niveaux alternativement grossiers et fins, apparemment rythmés. Elle correspond à une zone d'accumulation dans un mini-bassin créé par les diapirs de sel.

A l'Ouest d'Alger, l'escarpement de Khair Al Din apparaît comme étant actif à sa base sur toute sa longueur : on y observe un bourrelet compressif très net affectant la sédimentation la plus récente. Il s'agit de la structure active continue la plus importante repérée sur nos données (environ 100 km de longueur), qui confirme l'importance d'examiner d'autres secteurs que celui de Boumerdès seul dans ce projet.

Ces résultats préliminaires seront détaillés et mettront en évidence les relations entre tectonique *sensu stricto*, tectonique salifère, et phénomènes gravitaires sur pente.

Tableau. Bilan des données acquises au cours de la campagne MARADJA (21 août – 18 septembre 2003).

Nature	Nombre	Remarques
Profils sismiques 6 traces	4169 km	93 000 tirs réalisés à la cadence de 12 sec.
Profils sismiques 24 traces	802 km	62 000 tirs réalisés à la cadence de 5 sec.
Sondeur MF EM300 et sondeur de sédiments CHIRP	En continu	1517 km en acquisition sans sismique, 4971 km avec : Total 6500 km environ
Sondeur MF EM1000	10 profils	Utilisation combinée avec EM300 seulement sur plateau continental
Mesures gravimétriques et magnétiques	En continu	Sauf magnétisme, interrompu dans les girations
Mesures de température (Sippican)	54	
Carottages	8	Longueur totale 56 mètres

VERY HIGH RESOLUTION SEISMIC SIGNATURE OF THE HOLOCENE FOIX DELTA SYSTEM (NE IBERIAN PENINSULA, WESTERN MEDITERRANEAN)

V. Díaz-del-Río [1] *, L.M. Fernández-Salas [1], J.L. Sanz [2] and O. Tello [2]

[1] Instituto Español de Oceanografía. Puerto Pesquero, s/nº, E-29640 Fuengirola
[2] Instituto Español de Oceanografía. C/ Corazón de María, nº 8, E-28002 Madrid
* diazdelrio@ma.ieo.es

Abstract

Analysis of very high-resolution (Konsberg Simrad Topas) seismic profiles and multi beam bathymetry data (Konsberg Simrad EM-3000) from the northeastern continental shelf of the Iberian Peninsula (Catalonian margin), reveals that the sedimentary sequence developed above the acoustic basement consists in a highstand system tract of the last depositional sequence.

Keywords: Western Mediterranean, Holocene deltaic bodies, sea-level changes, very high resolution seismic sections.

The geological setting is dominated by a set of deltaic Holocene systems performed from North to South developed in relation to Llobregat, Besós and Foix rivers. The morphological sketch shows a narrow shelf of 12 km in width, with two well-defined shelfbreaks at 120 m and 180 m. The most northern sector is characterised by a relatively wider shelf, close to 16 km in width, and localised bathymetric irregularities that are the expression of a set of sand ridges are developed over a restricted area in the inner and middle shelf (between 25 and 80 metres) and represent a shore-subparallel reliefs formed on a high-energy environment dominated by storm events near the shoreface during a sea level standing. The shelfbreak is mostly abrupt due to the existence of four incised canyon heads performed in relation to river Foix and other tributaries that seems to have an active role in the transport of sediments from shore to deep basin (1).

Several authors (2, 3) have pointed out the particular stacking pattern of the delta system based on high and medium resolution seismic profiles. A strongly reflective basal surface, composed by superimposition of various bodies differents in age, is mainly erosional and it is related to the well-known transgresive surface.

Under the deltaic deposits there are two units, representing a coastal lagoon environment, consist of paralic sediments and littoral bodies preserved from shoreface erosion and also by a rapid sea level rise.

The distal facies of coastal deposits are represented seaward. The sequence preserved is interpreted as highstand deltaic complex transported mainly by the Foix river and deposited under various conditions.

The deltaic system include two units separated by regional non-erosional surfaces, formed during periods of possible reduced deposition, in a prograding sigmoid estuarine/deltaic complex. The last two units shows opaque seismic facies with acoustic maskings in the proximal prodelta due to existence of gas and organic matter accumulated in the sediments. The presence of gas is not only infered from masking but also from deformed structures in the reflectors caused by the gas fluid interbedding and the subsequent expansion in some particular direction. These observations imply new considerations on the importance of gas fluid as an active role on the resulting non-tectonic structures.

The most recent unit of the highstand systems tract is composed of a distal mud patch derived from the Foix, Llobregat and Besós rivers. Dispersal and deposition of this modern mud sheet are largely controlled by the regional circulation pattern and sediment supply.

References

1 - Puig, P. and Palanques, A., 1996. Flujos de partículas en el margen continental de Barcelona: El control de los cañones submarinos en la transferencia plataforma-talud. *Geogaceta*, vol. 20(2): 367-369.

2 - Serra, J. and Verdaguer, A, 1983. La sedimentación holocena en el delta del Lobregat. X Congreso Nacional de Sedimentología. A. Obrador Ed., pp. 249-2.51.

3 - Checa, A., Díaz, J.I., Farrán, M. and Maldonado, A., 1988. Sistemas deltaicos holocenos de los ríos Llobregat, Besós y Foix: modelos evolutivos transgresivos. *Acta Geológica Hispánica*, vol. 23: 241-255.

COMPLEX TRACE ANALYSIS APPLICATIONS TO THE SOROKHIN TROUGH SEISMIC DATA, THE NORTHERN BLACK SEA

Derman Dondurur [1], Mustafa Ergün [2 *] and Günay Çifçi [3]

[1] Dokuz Eylül University, Department of Geophysics, Buca-Izmir, Turkey
[2] Yasar University, Alsancak, Izmir, Turkey - * mustafa.ergun@yasar.edu.tr
[3] Dokuz Eylül University, Institute of Marine Sciences and Technology, Izmir, Turkey

Abstract

Complex trace attribute analysis was used to determine the acoustic anomalies from gas accumulations on the high resolution seismic data from Sorokhin Trough in the Northern Black Sea. In bright spot zones, envelope of the single channel seismic data shows strong acoustic anomalies. Phase and polarity reversals are observed on instantaneous phase and polarity sections, and the gas saturated zones are observed to have much lower frequencies on the instantaneous frequency sections.

Key Words: Single Channel Seismic, Integrated Instantaneous Attributes, Gas Accumulation.

Introduction

The Sorokhin Trough, the western submarine termination of the Great Caucasus is situated within the eastern Black Sea basin on the continental slope and rise. The basin is mainly filled by the Maikopian (Oligocene-Lower Miocene) deposits that make up numerous clay diapirs and fluid related features at the seafloor.

Detailed seismic investigations were carried out across faults, hydrocarbon fluid escapes, and fields of gas hydrates in the Sorokhin Trough during the UNESCO-TTR 6 (Training Through Research) cruise in 1996. High resolution seismic reflection profiling was carried out along five lines (PS256 to PS260) at water depths of 600 2100 m to define the faults, diapirs, mud volcanoes, hydrocarbon fluids and bright spots. The diapirs seem to have been produced by a lateral tectonic compression from the south (1).

A single channel seismic system was used during the survey with a recording length of 3 s. An airgun of 120 atm was used with a shot interval of 10 s (about 40 m). The receiving length of streamer was 75 meters with 6 active units.

Complex Trace Analysis

Complex trace attribute analysis is based on the computation of time-dependent envelope, phase and frequency variations of the seismic trace (2), which allows a better definition of the reflections from water-gas/oil or gas-oil interfaces. The applications of the complex trace analysis are generally restricted to the areas where large-scale bright spots occur (3, 4, 5). In these zones, the envelope of the seismic data shows strong acoustic anomalies because of the high velocity contrast between gas accumulated zone and the overlying sediments. Since the velocity of the gas saturated zone is lower than the sedimentary layers, polarity reversals are observed on the instantaneous phase and polarity sections, and the gas saturated zones are observed to have much lower frequencies on the instantaneous frequency sections because of the absorption of the seismic energy.

In complex trace analysis, the recorded seismic trace S(t) is supposed to be the real component of the complex (or analytical) signal and the imaginary component Q(t) is computed using Hilbert transform of S(t). Then the envelope R(t), instantaneous phase θ(t) and frequency φ(t) of the trace are given by (6, 2),

$$R(t) = \sqrt{[S(t)]^2 + [Q(t)]^2} \quad (1)$$

$$\theta(t) = \tan^{-1}[Q(t)/S(t)] \quad (2)$$

$$\varphi(t) = \frac{\partial \theta(t)}{\partial t} \quad (3)$$

Applications to the Sorokhin Through Data

The Sorokhin Through area shows many diapirs, most of which is crowned by mud volcanoes. The complex trace attribute analysis was applied whole seismic data to determine the acoustic anomalies (gas accumulations or bright spots). Bright spots are especially observed above the tops and slopes of the diapiric structures. This is especially evident on line PS256 in which a number of diapiric folds are observed. Fig. 1 shows the envelope section of the PS256 showing several diapiric structures and very high-amplitude reflections (bright spots) near the diapirs. Fig. 2 shows a small part of envelope, instantaneous frequency and polarity sections from slope of a diapiric uplift from PS256. Envelope section shows very strong reflection event between 3.1-3.2 s. Polarity section shows that this reflection has negative polarity and frequency section indicates very low frequency zone below this strongly reflective interface. These indications clearly state a localized gas accumulation located at the side of the diapir. On the other hand, some gas uplifting structures as low frequency transparent columns with strong reflections at both sides are also observed in PS258, whereas some localized and horizontal gas accumulation anomalies are observed on envelope section of line PS257.

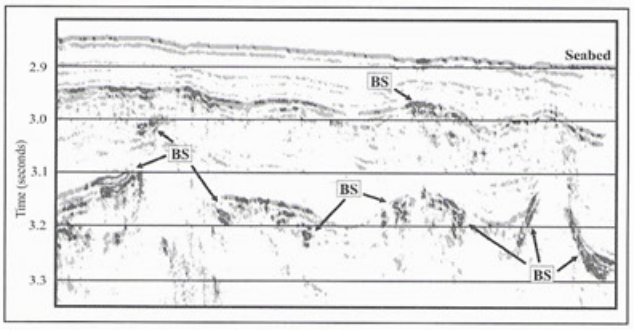


Fig. 1. Envelope of line PS256 showing several diapiric structures and a number of bright spot anomalies (BS) near the diapirs.

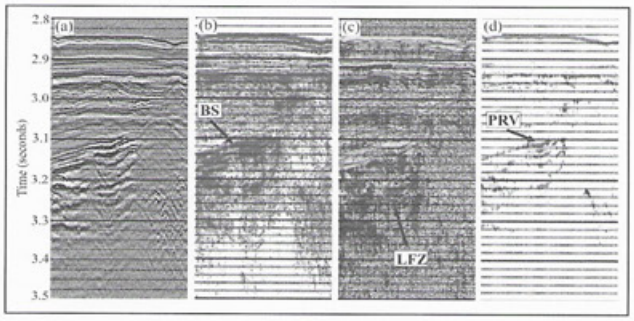


Fig. 2. Complex trace application to a part of line PS256. (a) Original data, (b) envelope, (c) instantaneous frequency and (d) instantaneous polarity sections. The bright spot anomaly (BS) in (b), the low frequency zone (LFZ) in (c) and the polarity reversal (PRV) in (d) indicate a localised gas accumulation.

The application of the complex trace analysis showed the presence of shallow accumulations of hydrocarbon gases. These negative polarity, high amplitude, and relatively short reflections are distributed 250-800 ms interval below the sea floor.

References

1 - Limonov A.F., Ivanov M.K., Kozlova E.V., VanWeering T.C.E., Meisner L.B., Woodside J.M., 1998. The structure of the sedimentary cover and active fluid venting in the Sorokhin Trough (Northern Black Sea), *Rapp. Comm. int. Mer Médit.*, 35: 80-81.

2 - Taner M.T., Koehler F., Sheriff R.E., 1979. Complex seismic trace analysis. *Geophysics*, 44: 1041-1063.

3 - Morozov I.B., Smithson S.B., 1996. Instantaneous polarization attributes and directional filtering. *Geophysics*, 61: 872-881.

4 - Yılmaz Ö., 1987. Seismic Data Processing. Society of Exploration Geophysicists, Tulsa.

5 - Ampilov I.P., and Arts R.J., 2000. Seismic multi-attribute analysis techniques for reservoir characterization. 62nd EAGE Meeting.

6 - Farnbach J.S., 1975. The complex envelope in seismic signal analysis. *Bull. Seism. Soc. Am.*, 65: 951-962.

SEDIMENTOLOGICAL AND PALAEOCEANOGRAPHICAL RECONSTRUCTIONS OF THE NILE DEEP-SEA FAN BASED ON SEDIMENTARY CORES : PRELIMINARY RESULTS

E. Ducassou [1] *, A. Murat [2], E. Gonthier [1], S. Migeon [3], T. Courp [4], P. Carbonel [1], S. Bernasconi [5], L. Capotondi [6], C. Müller [7], L. Loncke [8], T. Mulder [1], J. Mascle [3]

[1] Université Bordeaux 1, Département de Géologie et Océanographie, Talence, France - * e.ducassou@epoc.u-bordeaux1.fr
[2] Cnam-Intechmer, Cherbourg, France
[3] Géosciences-Azur, Villefranche sur mer, France
[4] Laboratoire d'Etude des GéoEnvironnements Marins, Université de Perpignan, France
[5] Geologisches Institut ETH-Zentrum, Zurich, Switzerland
[6] Istituto per la Geologia Marina Consiglio Nazionale delle Ricerche, Bologna, Italy
[7] 6bis rue Haute 92500 Rueil Malmaison, France
[8] Université de Picardie Jules Verne, Département de Géologie, Amiens, France

Abstract

Based on forty five piston cores, an interdisciplinary study is developed for sedimentological and palaeoceanographical processes reconstructions. Two pelagic sites have been selected as stratigraphic references. The Nile deep-sea fan shows a wide range of sedimentary dispersal and deposition mechanisms from west to east : typical turbidite channel-levee complexes characteristics of Rosetta area, giant upper slope destabilization in the central province, complex deformed corridor with a high variability of facies north of Damietta mouth and nearly israelian margin a shift in sedimentary processes with basal glacial stage 6 turbidites overlaped by pelagic sediments.

Keywords : Nile, deep-sea fan, sedimentary processes, palaeoceanography

The Nile deep-sea fan is the most important sedimentary accumulation within the eastern Mediterranean. It is built on mobile Messinian evaporites and this specific setting has induced, through times, the gravity spreading of the salt/sediment package. The initial distributions and thicknesses of Messinian evaporites (related to specific pre-messinian structural heritage) have strong impacts on the actual contrasted sea floor shaping and associated sedimentary dispersal processes. Fluid migration pathes to the seafloor are also largely influenced by the specific structural pattern of the Nile deep-sea fan, resulting from interactions between gravity spreading and structural heritage (1). The Nile is also a possible source of fresh water enhancing the density stratification of the water column and the organic matter preservation. For this, the Nile margin represent a key area for investigating sapropel formation processes and for reconstructing palaeoceanographic scenarious (2).

About forty five piston cores have been collected on the Nile continental margin mainly during Noe 1984, Fanil 2000 and Nautinil 2003 cruises. Based on these cores an interdisciplinary study is developed for sedimentological and palaeoceanographical processes reconstructions : lithological facies analysis, lithostratigraphy, tephrochronology, biostratigraphy (planktonic and benthic foraminifers, ostracods and nannoplankton), isotopic stratigraphy, ^{14}C datings, clay mineralogy and geochemistry (TOC, carbonates, sulfur, iron...). We have selected two pelagic sites as stratigraphic references : the first one on the southern Eratosthene seamount plateau (84 MD 637 and 638), the second one in the eastern province, north of Damietta (84 MD 648). These two sites allow a very high resolution for palaeoceanographic reconstructions.

The Nile deep-sea fan shows a wide range of sedimentary dispersal and deposition mechanisms : (A) typical turbidite channel-levee complexes (FKS05, 2823 m) and terminal lobes (FKS07, 2810 m) are characteristics of Rosetta area (western province) at the last glacial period (isotopic stage 2), (B) a giant upper slope destabilization occurs in the central province, debris flows are recorded on the continental margin between 1300 and 2300 water depth (84 MD 652, 653, 654 and 655), (C) the eastern province, north of Damietta corresponds to a complex deformed corridor and the recovered sediments exhibit a high variability of facies, debris flows (84 MD 644 and 647), turbidites interbedded in pelagic and hemipelagic sediments (FKS03, 84 MD 645, 646, 647, 650 and 651), (D) between Damietta area and the israelian margin, sedimentary deposits are mainly pelagic and hemipelagic since 125 Kyears (84 MD 640, 643, 627, 638, 637 and 635), however before, during the glacial isotopic stage 6 many turbiditic currents occur (84 MD 627, 635 and particularly 637 site where there is a shift in sedimentary processes).

References

1 - Loncke, L. 2003. Le delta profond du Nil : structure et évolution depuis le Messinien (Miocène terminal). Thèse de Doctorat, Université Paris 6, 404 p.

2 - Murat, A. 1991. Enregistrement sédimentaire des paléoenvironnements quaternaires en Méditerranée orientale. Thèse de Doctorat, Université de Perpignan, 280 p.

EVOLUTION SPATIO-TEMPORELLE DU TRANSIT LITTORAL DANS LA BAIE DE TANGER (MAROC)

Rachid El Bouzidi [1] *, Mustapha Labraimi [1], Bendahhou Zourarah [2] et Mohamed Maanan [2]

[1] Laboratoire de Sédimentologie et de Géologie Marine, Département des Sciences de la Terre, Faculté des Sciences, B.P. 1014, Rabat - Maroc

[2] Laboratoire de Géosciences Marines, Faculté des Sciences - El Jadida - Maroc

Résumé

Trente trois profils de plage ont été relevés durant les quatre saisons couvrant la période 1996-1997. Les résultats montrent une forte variabilité spatio-temporelle des évolutions morphologiques saisonnières indépendamment des saisons. L'étude de la dérive littorale a été réalisée à partir des tracés de 12 plans de vagues. Il en ressort l'existence de cellules sources, de cellules réceptrices et de cellules stables. Le changement de comportement de ces cellules est relié aux modifications des paramètres de la houle ; ce qui explique la variabilité spatio-temporelle de l'évolution morphologique de la plage.

Mots clés : Evolution morphologique / transit littoral / modèle de dérive littorale

Introduction

La baie de Tanger est située sur la rive méridionale du détroit de Gibraltar, entre le Cap des Juifs (35°48'28"N ; 5°51'W) et le Cap Malabata (35°41'21"N ; 5°45'2"W). Cette baie est bordée par une plage d'environ 5 km de longueur (Fig. 1). Actuellement un déséquilibre général commence à s'installer le long du littoral, se traduisant par un changement dans la morphologie des plages. L'objectif du présent travail est de répondre aux questions suivantes :

– L'évolution morphologique de la plage suit-elle un rythme saisonnier ?

– Comment expliquer la variation spatio-temporelle des profils de plage ?

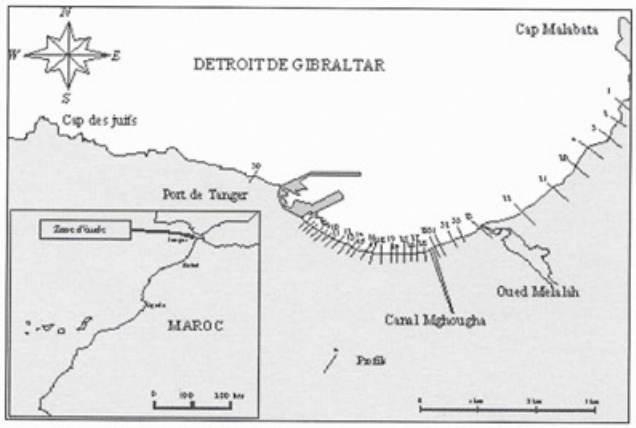


Fig. 1.

Matériels et méthodes

Trente trois profils de plage ont été relevés le long de la zone étudiée pendant les quatre saisons couvrant la période 1996-1997 (Fig. 1). Les paramètres de houles utilisés sont ceux établis par 1 et 2. Les plans de vagues ont été établis d'après la méthodologie préconisée par le "Shore Protection Manual" (3).

Résultats

La variation volumétrique saisonnière automne-hiver le long de la zone étudiée est indiquée sur la figure 2. Le bilan général est négatif et montre une érosion de 17,678 m^3 de sédiments. L'évolution saisonnière hiver-printemps montre un bilan sédimentaire général positif avec une sédimentation de 73,097 m^3 de sable. L'évolution saisonnière printemps-été indique un bilan général négatif avec une érosion de 19,232 m^3 de sédiments. Le bilan sédimentaire général annuel dans la baie de Tanger montre une accumulation de 36,186 m^3 de sédiments. Les plans de vagues établis montrent que la dérive littorale n'est pas à sens unique le long du littoral (4).

Discussion et conclusion

L'analyse morphologique des profils montre que la synthèse des mouvements verticaux saisonniers exprime parfaitement leur complexité, au niveau de leur amplitude mais aussi de leur répartition spatio-temporelle. Au sein d'une période de tendance donnée, on peut observer, ponctuellement mais tout le long de la baie, une tendance inverse. D'un autre côté, au cours d'une même saison, deux profils voisins peuvent présenter des mouvements verticaux opposés. Cette variabilité spatio-temporelle de l'évolution morphologique des plages a été observée ailleurs (5). Les résultats semblent *a priori* contradictoires dans la mesure où l'on observe une érosion des plages lors d'une période où les conditions hydrodynamiques semblent être peu énergétiques, alors qu' au moment où elles deviennent plus vigoureuses se produit une accrétion de la plage. Ce fait ne permet pas de conclure à un fonctionnement saisonnier de la plage mais plutôt à une forte variabilité spatio-temporelle des évolutions morphologiques saisonnières.

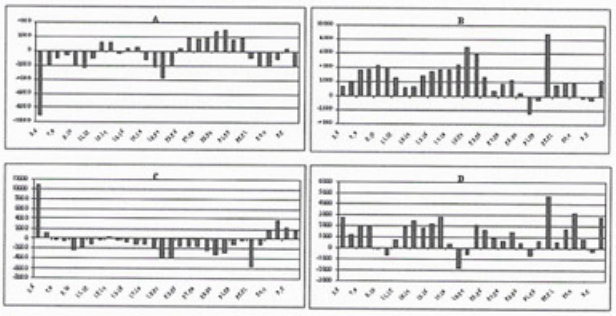


Fig. 2. Les variations saisonnières (automne-hiver : A; hiver-printemps : B; printemps-été : C) et annuelle (D) de la balance sédimentaire.

Le climat de houle dans la région n'a pas une signature saisonnière très marquée car l'analyse morphologique saisonnière a montré que le profil de plage ne suit pas un cycle saisonnier, mais présente plutôt une forte variabilité spatio-temporelle.

Ceci s'explique bien par les changements dans le sens et le volume du transit littoral le long de la baie, donnant ainsi naissance, à des cellules sources, des cellules réceptrices et des cellules stables. Ces dernières peuvent changer de comportement si les conditions de houle changent. La relation entre la morphologie de la plage et les conditions hydrodynamiques est certainement le résultat d'une combinaison de conditions de houles.

Références

1 - L.C.H.F. 1972. Baie de Tanger : Rapport de l'étude théorique sur document.

2 - Zakarya, E. 1994. La houle et son impact sur le littoral Atlantique Marocain, approche par modélisation. Thèse de Doctorat, Univ. Paris IV. 204 p.

3 - U.S. Army Corps of Engineers. 1984. Shore Protection Manual. Coastal Eng. Res. Cent., U.S. Gov. Printing Office, Washington, 2 Vol., 1226 p., 507 fig., 68 tab., 4 app.

4 - El Bouzidi R., Labraimi M., 2003. Morphological evolution and spatial and temporal variability of the long shore drift system in the Bay of Tanger (Morocco). *Journal of Africa Geosciences Review* (acceptée).

5 - Larson, M. et Kraus, N.C. 1994. Temporal and spatial scales of beach profile change, Duck, North Carolina. *Mar. Geol.*, 117: 75-94.

CONDITIONS DE LA RÉPARTITION DES SÉDIMENTS CÔTIERS ACTUELS ENTRE OUED OUM-ER-RBIA ET OUED SOUSS (CÔTE ATLANTIQUE MAROCAINE)

Ahmed El Foughali *, Kheir Eddine Azzaoui

Département de Géologie, Faculté des sciences Semlalia, BP 2390 Université Cadi Ayyad Marrakech - Maroc - * foughali@ucam.ac.ma

Résumé

La répartition des sédiments côtiers actuels, sur la côte atlantique marocaine entre Oued Oum-Er-Rbia et Oued Souss dépend essentiellement de trois facteurs. Une côte convexe s'exposant ainsi à un hydrodynamisme littoral très sévère. Des conditions hydrodynamiques caractérisées par une dérive littorale nord-sud. Enfin un climat aride avec des pluies rares ce qui donne des cours d'eau à débit faible à très faible. De ce fait, la nature des sédiments sera conditionnée par la nature des roches constituant la côte.

Mots clés : Sédiments actuels, Atlantique, Maroc.

Entre Oued Oum-Er-Rbia et Oued Souss, les sédiments côtiers actuels sont le résultat d'une interaction complexe entre les influences continentales et celles marines et dont le climat et la morphologie sont les facteurs prépondérants.

Les influences continentales découlent de plusieurs paramètres tels que la pauvreté en éléments fluviatiles importants avec des débits moyens à faibles ; une morphologie convexe du littoral accentuant l'hydrodynamique marine et des affleurements rocheux à dominante calcaire.

Les sédiments sont représentés donc par des sables bioclastiques avec plus de 65% de CaCo3 (1). Les silococlastes ne deviennent importants qu'au voisinage immédiat des embouchures, surtout sur les rives sud à cause d'une importante dérive littorale. Cette dernière favorise de grandes accumulations de galets qui, par diagenèse précoce, aboutissent à des formations de beach-rock importantes (2).

La morphologie de la côte, convexe vers l'océan, montre trois ensembles.

Le premier est représenté par les côtes basses avec des plages très étendues et à cordons dunaires très développés. On y trouve des sédiments généralement fins, bien classés avec des modes de transport dominants en saltation sous de faibles énergies.

Le deuxième ensemble correspond à la frange côtière du domaine des épandages dunaires quaternaires (domaine du Sahel). Les sédiments y sont très diversifiés, grossiers au niveau des baies (hydrodynamique marine forte), très grossiers et mal classés au niveau de la barrière, enfin très fins et mal classés vers l'intérieur de la lagune et dans les marais.

Le dernier ensemble est constitué de la bordure littorale des zones où affleurent les formations structurées du secondaire (régions d'El Jadida et de Safi) et de la continuité des reliefs du haut Atlas occidental vers l'océan. Ces affleurements donnent lieu au façonnement de falaises assez hautes dans l'ensemble avec installation de petites baies très réduites.

L'influence marine se matérialise, en premier lieu par une morphologie déterminée par celle du continent, ennoiement de reliefs anciens plissés ou celui de reliefs terrestres se continuant sous la mer.

La deuxième influence se manifeste au niveau de l'hydrodynamique marine assez rigoureuse avec un transport solide très important, du nord vers le sud, favorisant des engraissements spectaculaires de certaines plages.

L'importance du climat se matérialise au niveau des précipitations des vents et de la température. Les premières étant faibles, sur cette zone et sur les bassins versants des oueds, les débits des fleuves ainsi que les résurgences de la nappe phréatique restent faibles. Les vents interviennent, soit indirectement sur la dynamique marine (formation de vagues assez hautes), soit directement par un transport éolien assez important avec des énergies qui peuvent être moyennes à fortes. Les températures élevées en général instaurent un climat aride favorisant les fortes concentrations en CaCo3. Les températures moins fortes du domaine marin, en raison des remontées d'eau froides par le phénomène d'upwelling, favorisent le développement d'organisme à coquilles calcaires dont les débris alimentent les sédiments littoraux.

Références

1 - El Foughali A., 2002. Apport de l'analyse morphostructuraleet des sédiments côtiers dans la connaissance de la marge atlantique marocaine entre l'Oum-Er-Rbia et oued Souss. Thèse d'état, Université Université Cadi Ayyad-Marrakech (Maroc), 200 p., 150 fig., 5 Tab.

2 - Azzaoui K. A., 1988. Etude morphostructurale de la Méséta côtière marocaine entre l'oued Oum-Er-Rbia et l'oued Tensift et sédimentation actuelle sur le littoral atlantique correspondant. DES. Univ. Cadi Ayyad Marrakech.

PCBs AND PAHs IN MOROCCAN LAGOON AND RIVER SEDIMENTS

B. El Moumni [1] *, R. Piazza [2], L.G. Bellucci [3], M. Hamani [1], M. Frignani [3]
[1] Université Abdelmaleck Essaadi, Dept. of Earth Sciences and Oceanology, Tangier, Morocco
[2] Dipartimento di Scienze Ambientali, Università Cà Foscari, Venezia, Italy
[3] Istituto di Scienze Marine, Sezione di Geologia Marina, CNR, Bologna, Italy
* bmoumni@yahoo.fr

Abstract
Three surficial sediments from the Martil River and the lagoons of Nador and Moulay Bousselham were analysed for polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). The level of contamination was low in all samples, with higher values in the river sediments (4,8 and 124 μg kg^{-1} for PCBs and PAHs, respectively).

Keywords: PCBs, PAHs, sediments, Moroccan lagoons, Martil River

Introduction

Sediments, for their characteristics, can be considered as an archive of information on past and present environmental processes. In particular, the analysis of surficial sediments taken from rivers, lagoons and coastal areas can shed light on present contamination levels. Because of this we sampled sediments from several sites representing two areas of great environmental value, such as the lagoons of Nador and Moulay Bousselham, and the Martil River that flows through the industrial town of Tétouan.

Materials and Methods

A short sediment core was taken from a salt marsh in the Lagoon of Nador (north-eastern Morocco) in September 2000. Furthermore, in October 2001 other samples were collected along the terminal tract of the Martil River, whereas the Moulay Bousselham Lagoon was sampled in November 2002. The location of sampling sites is shown in Fig. 1. The concentrations of PCBs and PAHs were determined by GC-MS [1].

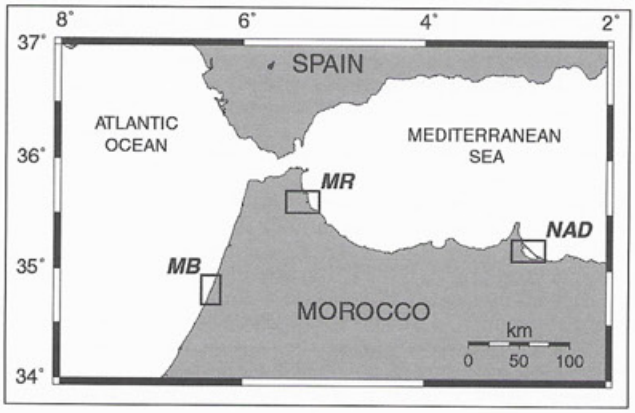


Fig. 1. Location of the study areas: NAD: Nador Lagoon; MR: Martil River; MB: Moulay Bousselham Lagoon.

Results and discussion

Total contents and relative abundances of PCB homologues and PAH congeners are shown in Figs. 2 and 3. All concentrations are low compared to polluted areas [2,3,4], even if the values in river sediments are significantly higher than in the lagoon environments, which can be considered uncontaminated. While the composition of PAHs shows only minor differences at the three sites, the relative abundances of PCBs in the Martil River is significantly different from those characteristic of the other two locations. In particular, in the Martil River the light PCB fraction (mainly the 3-CB and 4-CB) is rather important, whereas the high molecular weight PCBs are less represented. The clear differences among the three profiles account for the contribution of different sources. Among PAHs, the most abundant is naphthalene, followed by phenanthrene and acenaphthene. Unfortunately, the information is not yet sufficient to decide whether the prevailing source is oil or combustion.

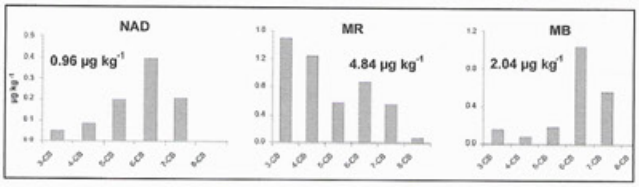


Fig. 2. Concentrations (μg kg^{-1}) of total PCBs and homologues in surficial sediments.

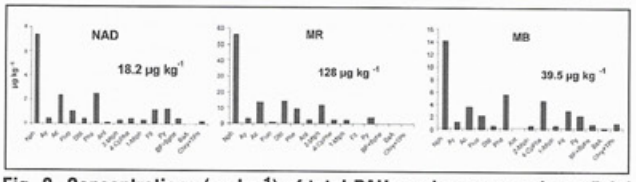


Fig. 3. Concentrations (μg kg^{-1}) of total PAHs and congeners in surficial sediments.

The inventories of ^{137}Cs calculated for lagoon cores suggest that Nador and Moulay Bousselham sediments are mostly subject to atmospheric contributions.

References

1 - Piazza R., Manodori L., Gambaro A., Moret I., Frignani M., Bellucci L.G., and Albertazzi S., 2003. Polychlorinated biphenyls in sediment cores from the northern Venice Lagoon. *Organohaogen. Compounds,* 62: 197-200.
2 - Frignani M., Bellucci L.G., Carraro C., Raccanelli S., 2001. Polychlorinated biphenyls in sediments of the Venice Lagoon. *Chemosphere*, 43: 567-575.
3 - Frignani M., Bellucci L.G., Favotto M., Albertazzi S., 2003. Polycyclic aromatic hydrocarbons in sediments of the Venice Lagoon. *Hydrobiologia*, 494: 283-290.
4 - Bertolotto R.M., Ghioni F., Frignani M., Alvarado-Aguilar D., Bellucci L.G., Cuneo C., Picca M.R. Gollo E., 2003. Polycyclic aromatic hydrocarbons in surficial coastal sediments of the Ligurian Sea. *Mar. Poll. Bull.*, 46: 903-917.

SPATIAL DISTRIBUTION AND STRATIGRAPHIC ARCHITECTURE OF THE ALMANZORA RIVER PRODELTA FROM SOUTHEASTERN SPAIN (PALOMARES, ALMERÍA)

Fernández-Salas L.M. [1, *], Díaz-del-Río V. [1], Sanz J.L. [2] and Tello O. [2]

[1] Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Puerto Pesquero, s/n, Apartado 285, Fuengirola 29640, Spain - * luismi.fernandez@ma.ieo.es

[2] Instituto Español de Oceanografía, Servicios Centrales, C/ Corazón de María, 8- 8º Pl. 28080. Madrid, Spain

Abstract

Konsberg Simrad EM3000 multibeam echosounder and very high resolution seismic profiles (TOPAS) data have been used to study the spatial distribution and the stratigraphic stacking of the Almanzora river prodelta (Almería, southeastern Spain).

Keywords: delta, Mediterranean Sea, sea-level changes, multibeam, high resolution seimic

The Almanzora River is characterised by a pronounced seasonal variability in the sediment supply regime and by its torrential character. This river is 90 km long and has a drainage basin that extends for about 2611 km^2 (1). The coastline configuration reflects the "Palomares Fault" direction (N10º-20ºE). Goy and Zazo (2) suggest that the tectonic trend for the 100 ky is uplifting in the south of the Almería littoral while this one is subsidence in the north. The dominant littoral drift has a SW direction. The width of the adjacent continental shelf is about 5.5 km and its average gradient ranges between 0.5º in the shallow water areas and 10º in the canyon faces.

The Almanzora river prodelta is 3500 m wide and 4000 m long with a predominant spatial distribution in E-NE direction (Fig. 1). The prodeltaic fan is divide in two lobes by, one in the south with 1500 m wide which axis is NW-SE, and the second one, which wide is 2000 m and extends in W-E direction. The creeping and the channels are a common feature in the whole prodelta.

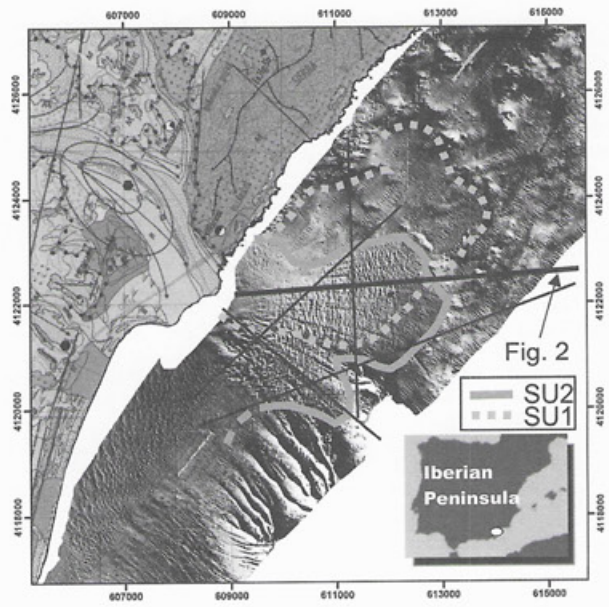


Fig. 1. Multibeam map of the study area shown the spatial distribution of the Almanzora river fan. SU1 distribution is represents in hard line and SU2 distribution in dotted line.

Other important characteristic is the presence of canyon heads near (<3000 m) of the coast. These channels play an important role in the transport of the sediment from the continental shelf to deep basin. Besides, these morphologic elements condition the spatial distribution of the prodelta. So, the prodelta has a greater development in the north part where do not exist the canyons.

The seismic stratigraphy analysis of the prodeltaic deposits evidence that surficial spatial distribution deduced of the multibeam data is not completely correct. So, this analysis shows that the Almanzora prodelta is wedge-shaped and extends about 5500 m along-shelf. The thickness exceeds 12 ms TWTT in the proximal and central areas and then gradually decreases in the northeastern and seaward direction.

Two distinct seismic units have been identified: SU1 and SU2. These units are located above a high amplitude seismic discontinuity (Fig. 2).

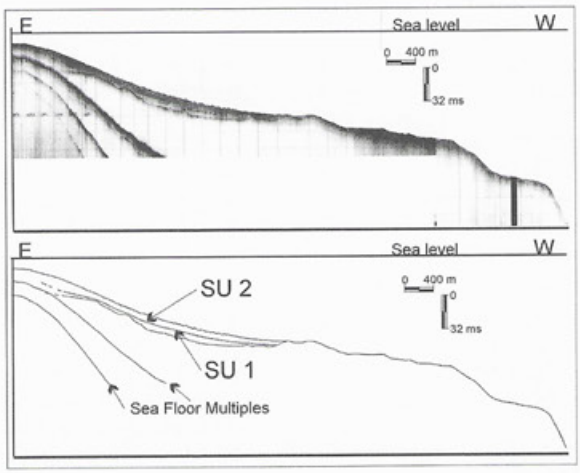


Fig. 2. Uninterpreted (above) and interpreted (below) seismic profile of the Almanzora prodelta. The prodelta is composed of two units: SU1 and SU2.

Seismic Unit 1 is a sheet shape, with average thickness values 4 ms TWTT. It displays a transparent acoustic response and extends from the mouth of Almanzora river to 5000 m in the northeastern direction. The upper boundary of this seismic unit is the present seafloor where it is not overlain by the shallowest seismic unit 2.

Seismic Unit 2 is a wedge-shaped unit, which displays a chaotic configuration and reflective pattern. This unit overlay the Seismic Unit 1. The reflection terminations are a downlap on the lower boundary. The upper limit is the present-day seafloor. Its average thickness value is 8 ms TWTT. This has smaller spatial distribution than SU1 and extends in NW-SE and W-E directions. The limits of the its spatial extension fit with the limits come to multibeam data.

The SU1 characteristics (transparent seismic facies, constant and moderate thickness through the entire distribution area and sheet shape) suggest that it is composed of fine sediments which escaped from the nearshore and also that it was deposited when sea level was transgressing and/or in a highstand position (3). In contrast, SU2 can be included in a reggresive and/or lowstand conditions. Somoza *et al.* (4) described that short cool/humid events should produce a sea-level fall and an increase in sediment supply by increasing precipitation within the Ebro drainage basin. So, SU2 would has been deposited under these conditions which explain its reflective and chaotic configuration.

Finally, the existence of delta lobe switching processes seems to be determined by the control of the sea-level cycles.

References

1 - Ferre Bueno E., 1979. El valle del Río Almanzora: estudio geográfico. Excma. Diputación Provincial de Almería y Caja Rural Provincial de Almería.

2 - Goy J.L. and Zazo, C., 1986. Synthesis of the Quaternary in the Almería littoral neotectonics activity and its morphologic features, eastern Betic, Spain. *Tectonophysics*, 10: 259-270.

3 - Fernández-Salas L.M., Lobo F.J., Hernández-Molina, F.J., Somoza L., Rodero J., Díaz del Río, V. and Maldonado, A., 2003. High-resolution architecture of late Holocene highstand prodeltaic deposits from southern Spain: the imprint of high-frequency climatic and relative sea-level changes. *Contin. Shelf Research*, 23: 1037-1054.

4 - Somoza L., Barnolas A., Arasa A., Maestro A. Rees J.G. and Hernández-Molina F.J., 1998. Architectural stacking patterns of the Ebro delta controlled by Holocene high-frequency eustatic fluctuations, delta-lobe switching and subsidence processes. *Sedim. Geol.*, 117: 11-32.

FLUID SEEPS OF THE NILE DEEP SEA FAN : FIRST RESULTS OF THE NAUTINIL (2003) DIVE EXPEDITION

J.P. Foucher [1] *, J. Mascle [2] , J. Woodside [3], A. Boetius [4] and the NAUTINIL Shipboard Scientific Party

[1] IFREMER, DRO/GM, B.P. 70, 29280 Plouzané cedex, France
[2] UMR 6526 Geosciences Azur, B.P. 48, 06235 Villefranche-sur-Mer, France
[3] Vrije Universiteit, De Boelelaan 1085, 108[1] HV Amsterdam, The Netherlands
[4] Max Planck Institute for Marine Microbiology, Celsiusstr. 1, 28359 Bremen, Germany

Abstract

Fluid seeps of the Nile deep sea fan were investigated with research submersible *Nautile* during the Nautinil expedition (2003). Dive observations revealed active manifestations of gas emanation and brine seepage through the summits of several mud volcanoe and pockmarks along the continental slope between depths of 500 and 3000 m. Densely distributed bacterial mats and filaments are associated with brine seeps. Authigenic carbonate crusts and chemosynthetic fauna are numerous in pockmarks.

Key-Words: Eastern Mediterranean, Nile fan, Fluid seeps, Mud volcanoes, Submersible dives

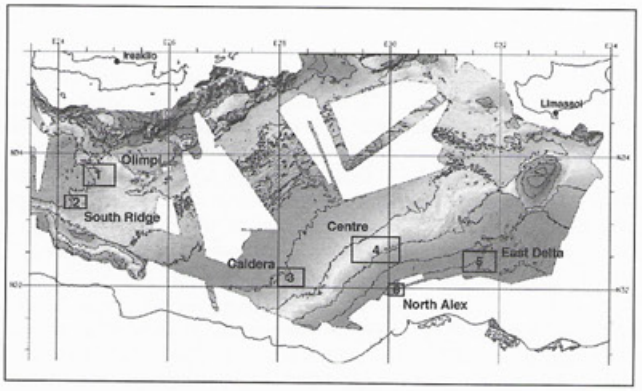
The Nile Fan is one of the largest deep sea fans in the world. It was built mainly in the past several million years since the Messinian salinity crisis and covers a segment of the ancient (late Jurassic to early Cretaceous) passive margin of Egypt. It is characterised, among other things, by the presence directly on the sea floor of numerous potential fluid-escape structures along the continental slope between depths of 500 and 3000 m. Several of these structures were investigated with research submersible *Nautile* during the Nautinil expedition that took place from 3 September to 3 October 2003 aboard the research vessel *L'Atalante*, starting and ending at Iraklion (Crete). Most of these structures were found to host active fluid seeps.

Fluid seepage target areas on the Nile deep sea fan exhibit diverse geophysical signatures and morphologies which facilitate their identification using surface geophysical data. These can be classified most simply as (a) sedimentary build-ups and flattened cones, often inferred to be mud volcanoes, varying from several hundreds to more than a kilometre in diameter and several tens of metres high, some situated either at the centre or periphery of large circular depressions with the appearance of volcanic calderas, and (b) high reflectivity patches inferred to be pock-marks, without apparent morphologic signature at the scale of the multibeam bathymetry.

Seven dives focused on four mud volcanoes situated directly over gas chimneys high on the continental slope of the Egyptian margin (Zones 5 and 6). Previous sampling had indicated unstructured sediment supersaturated in gas, thus confirming the interpretations based on seismic reflection data and implying strong degassing activity. Nautinil submersible observations demonstrated active seepage on the summits of the four visited volcanoes, where a rough topography suggests explosive gas eruption. Several seafloor spots of dark, reduced sediment, often covered with whitish bacterial mats, were interpreted as areas with high seepage rates. Large geothermal gradients, with mud temperatures as high as 45°C at 9 meters below the sea floor in the Isis mud volcano, attest to an overall vigorous seepage activity through the four visited mud volcanoes.

Nine dives with their numerous *in situ* samples were aimed at a detailed analysis of three mud volcanoes situated near or within a large caldera of nearly 8 km diameter and located at 3000 m depth in a region of the deep sea fan where underlying Messinian salt deposits, previously forming a veritable cap rock, were ruptured by gravity tectonics and thereby facilitated the rise of underlying fluids to the sea floor (Zone 3). Active brine flow, forming brine ponds, with extensive microbiological manifestations, was observed to be a main characteristics of the Cheops and Chefren mud volcanoes.

Three dives carried out on the pock-marks of the central Nile fan lead to a better understanding of the significance of these features (Zone 4). Authigenic carbonates occur on the seafloor as isolated chimneys or massive pavements. They are made of Mg-rich calcite and aragonite and are often found to be associated with chemosynthetic fauna (tube worms). Observations suggest a long-lasting seepage activity.



As part of Nautinil, three dives were also completed on the Mediterranean ridge (Zones 1 and 2), allowing for a comparison of seepage properties in two distinct tectonic provinces of the eastern Mediterranean sea to be made.

Nautinil is the first phase of a series of three marine expeditions planned for Mediflux, a project within the framework of the cooperative European programme Euromargins, itself part of *Eurocores*, a vehicle for financing research launched in 2001 by the European Science Foundation (ESF). *Mediflux*, a 4-year project begun in 2003, is based on cooperation among diverse institutes and university laboratories in France (Ifremer, IFP, and several CNRS associated universities including Géosciences-Azur and Lodyc), the Netherlands (NIOZ, University of Utrecht, and the Vrije Universiteit of Amsterdam), and Germany (the Max Planck Institute in Bremen). *Mediflux* is dedicated to multidisciplinary analysis of seafloor fluid seeps (cold seeps) and their associated deep environments.

CLIMATE CONTROL OVER THE TERRIGENOUS INPUT TO THE ALGERO-BALEARIC BASIN DURING THE LAST 50 KA

J. Frigola [1] *, A. Moreno [2], M. Canals [1], I. Cacho [1], E. Colmenero [3], F. Sierro [3], J-A. Flores [3], D. A. Hodell [4], J.H. Curtis [4]

(1) GRC Geociències Marines, Departament d'Estratigrafia, P. i Geociències Marines, Facultat de Geologia, Universitat de Barcelona, Barcelona, Spain - miquel@geo.ub.es

(2) Instituto Pirenaico de Ecología, CSIC, Zaragoza, Spain

(3) Departamento de Geología, Universidad de Salamanca, Spain

(4) Department of Geological Sciencies, University of Florida, Gainesville, USA

Abstract

We present the first geochemical results of a very high-resolution study carried out in the MD99-2343 IMAGES core recovered in the Algero-Balearic Basin to characterize the temporal evolution of the terrigenous input to this area. The high-resolution profiles obtained from this core and its close similarity with a core from the Alboran Sea previously studied bring new inputs to the understanding of the rapid climatic variability during the last glacial cycle in the Western Mediterranean Basin. Our multi-proxy approach helps improving the knowledge of the consequences of abrupt climatic changes on the terrestrial and marine environments of the Mediterranean region.

Keywords: Western Mediterranean Sea, aridity-humidity conditions, terrigenous inputs, geochemical records, teleconections.

Recent studies from the Alboran Sea (core MD 95-2043) have revealed high-frequency climatic oscillations in the Sea Surface Temperature (SST) record [1], in the aridity/humidity conditions in adjacent continental landmasses [2] and in the terrigenous (fluvial and eolian) inputs to the basin [3] that have been correlated with Heinrich Events (HE) and Dansgaard-Oeschger (D-O) cycles recorded in the North Atlantic region [4]. However, a high-resolution study to unravel how this climatic variability is represented in other Western Mediterranean sub-basins without a direct influence of Atlantic waters is still lacking.

Core MD 99-2343 was recovered north of Menorca Island (40°29,84'N 04°01,69'E; 2,391 m water depth; 32.44 m long) within the frame of the IMAGES international program. This core was collected to investigate the sources that supply terrigenous material to the Algero-Balearic Basin and to discriminate the climatic mechanisms that may affect the sedimentation processes in the area. Our study has been focussed in the top 18 m of the core, which has been sampled every 5 cm. The high sedimentation rate, a mean of 34 cm/ka during the last 50 ka, allows the study of past rapid climatic variability at centennial to millennial scales. MD 99-2343 core was selected because of its location along the path of present-day dust plumes originating from North Africa. The core location is far offshore from continental landmasses in order to minimize the effects of fluvial inputs on the sediment record. The core is thus intended to monitor changes in dust supply to the Western Mediterranean. In addition, since the core was recovered from a contourite drift [5], it was expected it would also contain a record of the variability of deep-water currents associated to the Gulf of Lions deep-water formation.

High-resolution analyses were carried out by means of X-ray fluorescence (XRF) to get the contents of major elements (Si, Ti, K, Al, Ca, Mg, Mn, Fe, P, Na) in the core sediments. The elementary profiles show high frequency oscillations through the last 50 ka. This is in particular the case of elements associated to terrigenous inputs like Si, Ti, K and Al. These profiles follow a clear D-O periodicity during Marine Isotopic Stage (MIS) 3. Although the Holocene sequence is characterised by lower contents of terrigenous elements and an overall smoother pattern, the variations recorded could be easily related to noticeable climatic oscillations, such as the African Humid Period. During Termination 1 a significant decrease in the supply of terrigenous elements is recorded synchronously to an increase of the Ca percentage, which probably denotes the accumulation of shelf carbonate during the postglacial sea level rise. The preliminary age model for MD 99-2343 was performed after tuning its *G. bulloides* oxygen isotopic record with that from the Alboran MD 95-2043 core [1]. This exercise allows a direct comparison between the elemental ratios normalized to Al in both cores. The strong parallelism between the Si/Al, Si/(Si+K) and Ti/Al records suggests a similar origin and, consequently, the action of similar transport and deposition processes in the Alboran Sea and in the Algero-Balearic Basin. Therefore, the results obtained point to an increase of Saharan dust transport during D-O stadials and cold events, thus supporting the hypothesis of stronger African winds during these episodes [3]. This suggestion correlates with arid conditions [2] and colder sea surface temperatures (SST) [1] that have been described previously during the D-O stadials in the Alboran Sea MD 95-2043 core. In addition, increased contents of the colder-water indicator *E. huxleyi* (>4μm) [6] in our core MD 99-2343 from the Algero-Balearic Basin during HE and D-O stadials confirm the important drop of SST during these periods, as formerly proposed from the Alboran Sea record.

The high parallelism between both Mediterranean cores and the GISP2 ice core oxygen isotopic record [7] shown after our study, strengthens the rapid response of the Mediterranean oceanographic-atmospheric system to climate oscillations thus pointing to an efficient climate teleconnection between the Mediterranean Sea and the North Atlantic region. Finally, although the intensification of atmospheric circulation has been suggested as the main force driving the variability of terrigenous inputs to the open Western Mediterranean Basin during cold events for at least the last 50 ka, complementary grain-size and isotopic analyses are in progress to distinguish the effects of deep-water currents intensity shifts on the sedimentation pattern.

References

[1] - Cacho, I., J.O. Grimalt, C. Pelejero, M. Canals, F.J. Sierro, J.A. Flores, and N.J. Shackleton, 1999. Dansgaard-Oeschger and Heinrich event imprints in Alboran Sea temperatures. *Paleoceanography*, 14 (6): 698-705.

[2] - Sánchez-Goñi, M.F., I. Cacho, J.-L. Turon, J. Guiot, F.J. Sierro, J.-P. Peypouquet, J.O. Grimalt, and N.J. Shackleton, 2002. Synchroneity between marine and terrestrial responses to millennial scale climatic variability during the last glacial period in the Mediterranean region. *Climate Dynamics*, 19: 95-105.

[3] - Moreno, A., I. Cacho, M. Canals, M.A. Prins, M.F. Sánchez-Goñi, J.O. Grimalt, and G.J. Weltje, 2002. Saharan Dust Transport and High-Latitude Glacial Climatic Variability: The Alboran Sea Record. *Quaternary Research*, 58 (3): 318-328.

[4] - Dansgaard, W., S.J. Johnsen, H.B. Clausen, D. Dahl-Jensen, N.S. Gundestrup, C.U. Hammer, C.S. Hvidberg, J.P. Steffensen, A.E. Sveinbjörnsdóttir, J. Jouzel, and G. Bond, 1993. Evidence for general instability of past climate from a 250-kyr ice-core record. *Nature*, 364: 218-220.

[5] - Velasco, J.P.B., J. Baraza and M. Canals, 1996. La depresión periférica y el lomo contourítico de Menorca: evidencias de la actividad de corrientes de fondo al N del Talud Balear. *Geogaceta*, 20 (2): 359-362.

[6] - Colmenero-Hidalgo, E., J.A. Flores, and F.J. Sierro, 2002. Biometry of *Emiliania huxleyi* and its biostratigraphic significance in the Eastern North Atlantic Ocean and Western Mediterranean Sea in the last 20000 years. *Marine Micropaleontology*, 46 (3-4): 247-263.

[7] - Grootes, P., M. Stuiver, J.W.C. White, S.J. Johnsen, and J. Jouzel, 1993. Comparison of oxygen isotope records from the GISP2 and GRIP Greenland ice cores. *Nature*, 366: 552-554.

RECENT EVOLUTION OF GULLIES AND CHANNELS IN THE NE ALBORAN SLOPE

García M. [1] *, Alonso B. [1], Ercilla G. [1], Estrada F. [1] and Gràcia E. [2]

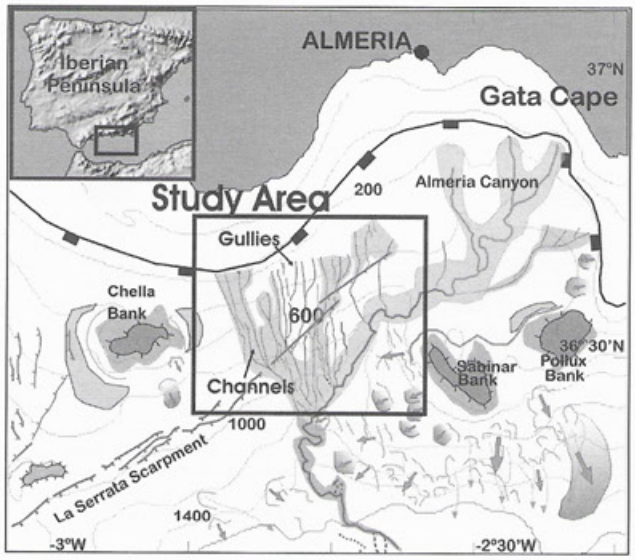
[1] Instituto de Ciencias del Mar. CSIC. Paseo Marítimo de la Barceloneta, 37-49 08003 Barcelona, Spain - * mgarcia@icm.csic.es
[2] Unidad de Tecnología Marina. CSIC. Paseo Marítimo de la Barceloneta, 37- 49 08003 Barcelona, Spain

Abstract

A complex system of valleys covers more than 300 km^2 at the Almeria Canyon western margin (300-1250 m deep). At least sixteen leveed channels and six gullies form a dendritic pattern convergent to the canyon. High-resolution seismic profiles show the alternance of seismic facies related to high- and low-energy sedimentary regimes, indicating a cyclic pattern in the recent evolution. Valleys develop during high-energy regimes, when the downslope gravity-flows produce overbank deposits in channel levees and erosion in gullies. Structural features, sea-level changes and variations in the slope gradient seem to have conditioned the spatial and temporal changes in valleys characteristics.

Keywords: Alboran Sea; Gullies; Channels; Turbidite Systems.

The Almeria Margin (NE Alboran Sea) is a complex geologic area where the morphology is controlled by tectonism, volcanism and depositional-erosive processes (Fig. 1). The main morphosedimentary feature in this area is the Almeria Turbidite System, formed by the Almeria Canyon and Channel, overbank deposits and lobe deposits (1). High resolution seismic profiles (TOPAS) and multi-beam bathymetric information off the NE Alboran Sea (Almeria Margin) obtained during the HITS cruise (2) reveal the existence of a complex pattern of valleys that cover more than 300 km^2 at the west margin of the Almeria Canyon (water depths between 300 and 1250 m).



The studied valleys can be grouped in two types -channels and gullies- according to their size, morphology and seismic imprint. Sixteen **channels** have been identified. They are leveed channels with channel infilling and typical U-shaped cross-sections. Channels have lengths of 2.5-22 km, widths of 0.3-1 km and relieves smaller than 15 m. In contrast, the six **gullies** lack present-day depositional features and are shorter and deeper than channels, with lengths minor than 12 km, and relief up to 40 m. Their widths range between 0.5 and 1 km, and the cross-sections are V-shaped. Channels and gullies have general N-S to NNW-SSE directions, perpendicular to the regional slope gradient. They have low sinuosity, except in the areas affected by La Serrata Fault (NE-SW direction) where axes display sharp changes in direction and gradient.

Channels and gullies spatial distribution is complex. Channels display a convergent hierarchical pattern, where shorter channels merge with larger ones that flow into the Almeria Canyon at depths between 1100 and 1250 m. Three gullies locate in the middle of the area occupied by channels and form part of the same hierarchical pattern, as they converge into one of the main channels at 600 m deep. Another three gullies locate at the eastern area, and flow directly into the canyon, at 765, 910 and 960 m deep. Valleys also present downslope variations in their characteristics. Three valleys can be classified as channels along their itinerary, except in an area located at the SE side of La Serrata Fault, between 650 and 950 m deep, where they display the morphologic and seismic characteristics of gullies.

The seismic stratigraphy of the area where channels and gullies develop comprises at least four seismic units defined by distinct seismic facies. The lateral continuity of the facies is interrupted by the incision of gullies and channel-fill and overbank deposits. These facies are, from older to younger: (1) parallel stratified unit formed by reflections of medium to high reflectivity in gullies and inter-valleys areas that laterally becomes chaotic near the channels; (2) A transparent facies unit that displays a layered sheet geometry; (3) High reflectivity facies unit, parallel-stratified in intervalley areas and chaotic near channels; and (4) Transparent to semi-transparent facies draping the whole area, including gullies and leveed channels.

The recent evolution of the system can be inferred from the sedimentary record. Seismic units 1 and 3, with high-acoustic amplitude and development of levees in the margins of the channels would be related to high-energy regimes, when the gravity-flows produce overbank deposits. In contrast, homogeneous seismic units 2 and 4 may be deposited by a low-energy sedimentary regime, when pelagic or hemi-pelagic deposition dominates the whole area. The alternance of high and low-energy periods indicates a cyclic pattern of valleys growth.

Channels and gullies characteristics and spatial distribution should be related to changes in the local sediment transport from gravity flows. The properties of the gravity flows vary downslope, across-slope and with time, conditioning the presence or absence of the overbank flows, and so the development of channels or gullies respectively. Structural features, sealevel changes and variations in the regional slope gradient seem to have conditioned the downslope changes of channels and gullies characteristics. The presence of a thin semitransparent layer over the whole system suggests that channels and gullies may have been inactive during recent times.

References

(1) - Estrada, F., Ercilla, G. and Alonso, B. 1997. Pliocene-Quaternary tectonic-sedimentary evoluciton of the NE Alboran Sea (SW Mediterranean Sea). *Tectonophysics,* 282: 423-442.

(2) - Gràcia, E. and HITS cruise party, 2001. HITSCruise Report on board *BIO Hesperides*. High resolution Imaging of Tsunamigenic Structures of the Southern Iberian Margins (HITS- REN 2000-2150E and EASSIII HPR1-CT99-0047). 187 p.

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DEPOSITIONAL PATTERNS OFF ALGERIA FROM ECHO-CHARACTER MAPPING (MARADJA 2003 CRUISE) : POSSIBLE LINKS WITH THE RECENT AND HISTORICAL EARTHQUAKES

V. Gaullier [1] *, B. Savoye [2], A. Domzig [3], J. Deverchere [3], and the MARADJA Team #

[1] LEGEM, E.A. 3678, Université de Perpignan, 52, avenue Paul Alduy, 66860 Perpignan, France - *gaullier@univ-perp.fr

[2] IFREMER, Brest, France

[3] UBO/CNRS Domaines Océaniques, Brest, France

Abstract:

We present new results deduced from the Chirp high-frequency echograms collected during the recent MARADJA cruise off Algeria. They reveal the importance of gravity-dominated depositional processes (turbidity currents and mass wasting) in this active area.

Key words: debris flows, turbidites, slumps, mud penetrator

The Algerian margin is one of the less documented margins of the Mediterranean Sea. The May 21, 2003 earthquake has shown that submarine deformation is indeed active there: a significant part of the Africa-Europe convergence is probably accounted for below the sea. As for the 2003 event, large coastal earthquakes (1954, 1980) have also triggered turbidity currents, but no data were available until now to describe them. The Algerian margin was recently surveyed during the MARADJA cruise (21 August- 18 September 2003, French R/V *Le Suroit*) using swath multibeam bathymetry, backscatter imagery, and 3-5 kHz (Chirp) and seismic profiling (1, 2, 3; Fig. 1). The purposes of this study are (i) to use this new data set to describe, illustrate and identify the recent Algerian margin depositional system, and (ii) to tentatively evaluate the relationships between the sedimentary processes and the historical seismicity that affects this area.

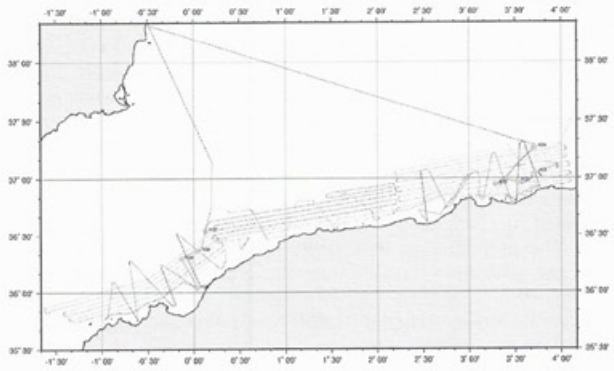


Fig. 1. Location of the CHIRP data collected during the MARADJA cruise (2003).

Recent depositional patterns, as deduced from echo-character mapping, show that gravity-induced sedimentary deposits are predominant on the steep continental slope and in the deep basin and are expressed through either slides, debris flows, or turbidites, as previously observed in various places around the Mediterranean (4, 5).

Turbiditic processes, corresponding to bedded echo characters, have been mainly identified at the foot of the steep slopes and in the deep part of the basin, where the turbidity currents seem to have been drained either by canyon and channel systems or by bathymetric lows created by deep-seated or salt tectonics, i.e., grabens or minibasins. Conversely, salt diapirs and steep fault scarps act as barriers for turbidites.

Mass-movement processes are mainly represented by transparent echo characters. They appear all along the margin, generated by slope destabilizations enhanced by thick-skinned and salt-related thin-skinned tectonics. Moreover, in the area of the May 21, 2003, earthquake, ~10-15 km off Algiers, and upslope to the area of the resulting numerous submarine cable ruptures, several mass-movement deposits are observed along the ~60 km long active fault zone, roughly parallel to the coast and that could be linked to the Boumerdes-Zemmouri earthquake (Fig. 2). One of these destabilized deposits has been cored during the MARADJA cruise and corresponds to a debris flow. Further analyses will focus on the relationships between these gravity-driven processes and the historical seismicity.

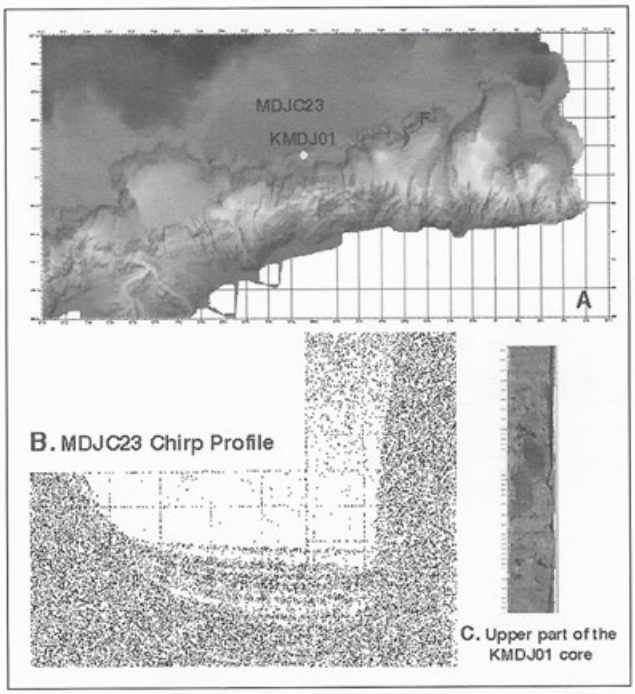


Fig. 2. A. Multibeam bathymetric zoom of the Algiers area (Z3). B. CHIRP profile located at the foot of one of the large active faults evidenced in this area. The representative echo character corresponds here to an alternance of bedded and transparent acoustic facies. The second one shows a thickening along the scarp, testifying for a syn-tectonic deposit. C. Upper part of the KMDJ01 core showing a recent debris flow.

MARADJA Team : K. Yelles, E. Calais, J-P. Bouillin, R Bracene, A. Kherroubi, B. Mercier de Lepinay, P. Le Roy, H. Pauc

References

1 - Deverchère J., Yelles K., Calais E., and the MARADJA Scientific Party 2003. Active deformation along the Algerian margin (MARADJA cruise): framework of the May 21, 2003, Mw-6.8 Boumerdes earthquake. AGU Fall Meeting, San Francisco, USA, 8-12 December.

2 - Deverchère J., *et al.*, 2004. Premier examen détaillé de la morphologie et de la structure superficielle sous-marine de la marge Ouest-Africaine: Campagne Maradja. 37th CIESM Congress, 7-11 June, Barcelona, Spain.

3 - Domzig A., Yelles K., Deverchere J., and the MARADJA Team, 2004. New, active faults revealed off Algiers area (Boumerdes and Khair-Al-Din) from seismic and swath bathymetric data (MARADJA 2003 cruise). EGU First General Assembly, Nice, France, 25 - 30 April.

4 - Gaullier V. and G. Bellaiche, 1998. Near-bottom sedimentation processes revealed by echo-character mapping studies, Northwestern Mediterranean Basin. *AAPG Bulletin*, 82 (6): 1140-1155.

5 - Loncke L., Gaullier V., Bellaiche G., and Mascle J., 2002. Recent depositional pattern of the Nile deep-sea fan from echo-character mapping: Interactions between turbidity currents, mass-wasting processes and tectonics. *AAPG Bulletin*, 86 (7):1165-1186.

STRUCTURE OF THE ANAXIMANDER MOUNTAINS WITH THE SYSTEM OF THE EASTERN MEDITERRANEAN

Tolga Gönenç [1], Mustafa Ergün [2 *] and Ersel Zafer Oral [1]
[1] Dokuz Eylül University, Buca-Izmir, Turkey
[2] Yasar University, Alsancak, Izmir, Turkey - * mustafa.ergun@yasar.edu.tr

Abstract
Anaximander Montains are a foundered part of the southern Turkish microplate (except the eastern mountains). The hypothesized foundering must be related to transpressive wrench tectonics from the Strabo Transform zone, compression across the Florence Rise, and the extension between the Turkish and Aegean microplates. The Anaximander Mountains form a group of topographically promeninent features rising more than 2 km above the surrounding seafloor.

Key Words: Foundering, Anaximander Mountains, Mud volcanoes.

Introduction

Neotectonics of the eastern Mediterranean is controlled by the reciprocal affects of the Eurasia, Africa and Arab plates and the other small plates and blocks. The tectonic situation in the northern eastern Mediterranean region is dominated by the interaction between the African plate and Eurasian plate (here it is represented by the Aegean and Anatolian plates). The African plate currently moves north-north-eastwards and north-eastwards relative to the Aegean and Anatolian microplates, respectively. The boundary between these microplates and Africa is delineated by the Hellenic Arc and the Pliny/Strabo Trench in the west and the Cyprus Arc and diffuse fault system in the east. Only the Hellenic appears to be an active subduction zone. Both the Pliny/Strabo Trench system and the East Anatolian Fault Zone are sub-parallel to the relative plate motion vector and hence are dominated by transform motion. The region between the west of Cyprus and the East Anatolian Fault Zone is less seismic than both the Hellenic Arc in the west and the East Anatolian Fault system in the northeast. The seismicity is particularly low between Pliny/Strabo Trench and Cyprus.

General Morphology and the Structure of the Anaximander Mountains and the Surroundings

The Anaximander Mountains are under compressional regime of the junction of the Hellenic and Cyprus Arcs. These mountains are made of three principal highs (1) which are separated from each other with faults and undergoing independent deformations. There are variations and unconformities on the strikes and dips of the faults and folds in the region which mean that those structures have been formed by the forces from different directions, and accordingly it could be said that the area has been affected by several deformations at different times. To the north, the mountains are bordered by a chain of relatively small but deep basins which are, from west to east, the Rhodes Basin (more than 4 km deep), the Finike Basin (3 km deep), and the Antalya Basin (about 2.5 km). The eastern continuation of the Strabo Trench, which is poorly expressed in the form of several shallow and gentle seafloor depressions, separates the Anaximander Mountains from the eastern termination of the Mediterranean Ridge and from the Florence Rise (Fig. 1).

The western and southern mountains, and probably the Beydaglar are, although they are spatially widely separated, they seem to be the same morphologically and geologically. The Rhodes and Finike basins indicate rifting in the region. The Finike Basin which was formed by rifting due to the tensional tectonics of the Beydaglar block in the north (Fig. 2) is filled by thick sedimentary sequence over which the sediments, derived from the area between the southern and western mountains, have pushed basinwise over the southern side.

However, the eastern mountain which is separated from the southern mountain with gentle relief of fold belt is quite from the other two mountains tectonically and morphologically and it has been affected from the other two mountains tectonically and morphologically and it has been affected by different tectonism and geological evolution. Mud volcanoes which are probably formed under compressional tectonics are distributed randomly over the eastern mountains. Also the cobblestone structures which were observed at the boundary of the eastern mountains and the Antalya Basin are the result of compressional tectonics. There is no evidence for any typical subduction along the Florence Rise which is a submarine feature extending from Cyprus in the southeast to the Anaximander Mountains. This arcuate structure is considered to act as the present boundary between the African and Anatolian-Aegean plates (2).

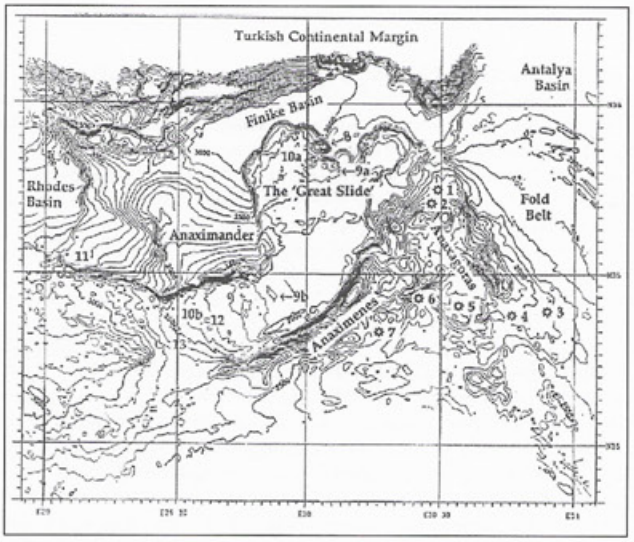


Fig. 1. Bathymetry map of Anaximander Mountains at 100 m contour interval showing locations of principal features. Numbers 1 to 7 are the mud volcanoes. The rest are the other features.

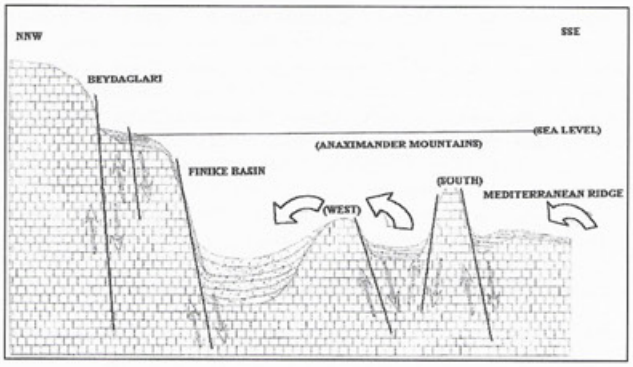


Fig. 2. The schematic NNW-SSE cross section indicating structural tectonic elements between the Beydaglar (SW Turkey), the Finike Basin, the Western and Southern Mountains.

References

1 - Woodside, J.M., 1995. ANAXIPROBE-95 Report of the l'Atalante Expedition, 4-11 August 1995, Heraklion, Crete to Port Said, Egypt, Amsterdam, Vrije Universiteit (unpublished cruise report).
2 - Woodside, J.M., Mascle, J., Zitter, T.A.C., Limonov, A.F., Ergün, M., and Volkonskaia, A., 2002. The Florence Rise, the Western Bend of Cyprus Arc. *Marine Geology*, 185: 177-194.

MINERALOGY AND GEOCHEMISTRY OF THE DIAGENETIC CARBONATE CRUSTS FROM THE MUD VOLCANOES OF THE NILE DEEP-SEA FAN

S. Gontharet [1], C. Pierre [1] *, M.M. Blanc-Valleron [2], J.M. Rouchy [2], Y. Fouquet [3], G. Bayon [3] and the NAUTINIL scientific party

[1] UPMC, LODYC, 4 Place Jussieu, 75252 Paris Cedex 05, France
[2] MNHN, Laboratoire de Géologie, 43 rue Buffon, 75005 Paris, France
[3] IFREMER, Centre de Brest, Géosciences Marines, Plouzané, 29280, France

Abstract

Carbonate crusts and concretions associated with mud volcanoes from the Nile deep-sea fan were recovered during the NAUTINIL cruise. These authigenic carbonates consist mainly of aragonite and Mg-calcite and of minor dolomite. The wide range of the oxygen and carbon isotopic compositions of these carbonates indicate variable sources of deep fluids providing methane which is oxidized by microbial processes either through bacterial sulfate-reduction within the sediment or via bacterial aerobic oxidation at the sea floor.

Keywords: Nile deep sea fan, mud volcano, diagenetic carbonate, oxygen and carbon isotopes

During the NAUTINIL cruise (September -October 2003), 22 submersible dives have been realized in the Nile deep-sea fan area. The main objective of this cruise was to investigate by a multidisciplinary approach, selected mud volcanoes which are very abundant and of various morphologies in the whole area (1). The deepest site (3019 m) located in the western part of the deep-sea fan, corresponds to a large caldera (about 8 km of diameter) where brines are seeping along the flanks of the structure and are sometimes collected in pools and lakes. The other sites in the central and eastern parts of the deep-sea fan correspond respectively to pock-marks located at 2120 m and to a mud volcano located at 1130 m where active ventings of fluids were identified by the presence of living benthic organisms (mainly vestimentiferan worms; rarely bivalves). At these three sites, hard carbonate crusts cover irregularly the sea floor and are sometimes present as dispersed fragments within the topmost sediments. The sediments from the venting areas are organic-rich and have a strong H_2S smell which is indicative of active sulfato-reduction. The petrographic observations and XRD analyses of the carbonate crusts indicate that aragonite, calcite, Mg-calcite are the dominant authigenic carbonate phases with a minor contribution of dolomite. The oxygen and carbon isotopic compositions of the bulk carbonate exibit very large variations ($-2.67 < \delta^{18}O$ ‰ PDB < 3.87 ; $-37.97 < \delta^{13}C$ ‰ PDB < 2.96). The distribution of the isotopic values is explained by the mixing of the authigenic carbonate with the sedimentary matrix which corresponds itself to a mixture of pelagic sediment and mud breccia issued from the mud volcano activity. The rather large range of $\delta^{18}O$ values might reflect variable sources of fluids, a ^{18}O-rich deep source and a ^{18}O-poor continental source. Typically, the very low $\delta^{13}C$ values of the diagenetic carbonates indicate that methane was the major source carbon which was oxidized as CO_2 either through bacterial sulfate-reduction within the sediment or via bacterial aerobic oxidation at the sea floor. Similar isotopic values were previously measured in the diagenetic carbonate crusts from the mud volcanoes of the Mediterranean Ridge area (2) as well as in other areas of cold seeps outside the Mediterranean sea (for instance Gulf of Mexico, Cascadia margin, Barbados prism).

References

1 - Loncke L., Gaullier V., Bellaiche G., and Mascle J., in press. Recent depositional pattern of the Nile deep-sea fan from echo-character mapping: interactions between turbiduty currents, mass-wasting processes and tectonics. *A.A.P.G. Bull.*

2 - Aloisi G., Pierre C., Rouchy J.M., Foucher J.P., Woodside J. and the Medinaut Scientific Party, 2000. Methane-related authigenic carbonates of eastern Mediterranean Sea mud volcanoes and their possible relation to gas hydrate destabilisation. *E.P.S.L.*, 184: 321-338.

HIGH-RESOLUTION IMAGING OF THE CARBONERAS FAULT ZONE ON THE ALMERIA MARGIN (NE ALBORAN SEA): PALEOSEISMIC IMPLICATIONS

Eulàlia Gràcia [1] *, Juan Ignacio Soto [2], Miquel Angel Marín [1], Alexis Vizcaíno [1] and HITS cruise party

[1] UTM-CSIC, Centre Mediterrani d'Investigacions Marines i Ambientals (CMIMA), Barcelona, Spain - * egracia@utm.csic.es, miki@utm.csic.es, alexis@utm.csic.es

[2] Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Campus Fuentenueva, Granada, Spain (jisoto@ugr.es)

HITS cruise party: P. Blondel, P. Terrinha, M. Farrán, R. Bartolomé, L. Bullock, M. Gómez, O. Gómez-Sichi, J. Gonçalves, C. Jacobs, G. Lastras, H. Perea, M.J. Román, C. Roque, V. Wilmott

Abstract

The South Iberian Margin is located at the convergence of the European and African plates, where large magnitude earthquakes in Western Europe take place. Based on data from Spanish and European programs, we identified several active structures which are potential sources of large magnitude earthquakes and tsunamis (Mw > 6) (1). We plan to undertake a paleoseismological onshore-offshore integrated study of the Carboneras Fault (Almería Margin). This is the best approach to accurately determine the past activity and seismic parameters of active faults (geometry, slip rate, maximum event magnitude, recurrence interval and time elapsed since the last earthquake). These parameters are of paramount importance to assess seismic hazard models in the Iberian Peninsula, especially when considering large magnitude earthquakes and long recurrence intervals (10^3-10^4 years).

Keywords: TOBI sidescan sonar, active faulting, turbidite system, Western Mediterranean

The continental margin south of Almeria, located at the NE part of the Alboran Sea (Western Mediterranean), is a complex and active area characterized by recent swarms of superficial earthquakes with magnitudes ranging from M_w 5.1 and 4.7 (2). With the main objective of identifying active structures potentially generators of earthquakes, we recently surveyed this area in the frame of the HITS project (3). During the HITS cruise carried out onboard the *BIO Hesperides* in September 2001, a multidisciplinary dataset comprising high-resolution (6 m) TOBI sidescan sonar from the Southampton Oceanography Centre (UK), Simrad EM12S swath bathymetry and backscatter, TOPAS sub-bottom profiler, and gravity data were acquired. This high-resolution dataset, exhibiting a range of acoustic facies, fully covers an area of approximately 33.3 x 100 km in water depths ranging from 80 m to 1700 m, and provides new insights into the control of neotectonic structure on the Plio-Quaternary sedimentary architecture of the Almeria turbidite system.

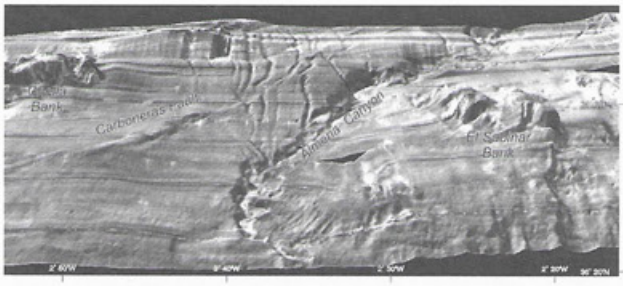


Fig. 1. Bathymetry superimposed on the high resolution TOBI sidescan sonar mosaic of the SE Spanish Margin, where we can easily identify the submarine prolongation of the left-lateral Carboneras Fault, tributary channels and Almeria Canyon and turbidite system.

The Almeria Canyon is a meandering channel system (4) showing steep slopes over most of its course (up to 17%), and confined between the Cabo de Gata Spur, Chella and El Sabinar Banks carbonate platforms, imaged as high-reflectivity areas in the TOBI mosaics. North of 36°26'N, the upper to middle part of the canyon parallels the submarine continuation of the Carboneras Fault Zone, following a N47 trend, whereas south of it, the canyon meanders downslope with a net N-S trend. At latitude 36°26'N, the 60 km long left-lateral Carboneras Fault shows a positive topography on the seafloor which suggesting a transpressional flower-structure, and offsets (about 2.5 km) into two segments: a northern N47-trending segment and a southern N60 trending segment. The fault also modifies locally the trend of tens of sub-rectilinear highly incised gullies and channels which converge feeding into the Almeria Canyon. Slope instability features and mass wasting deposits (headscarps, detached blocks and debris flows) are commonly observed on the flanks of the banks and especially south of the El Sabinar Bank. They might be associated with the seismic activity taking place along this margin.

The assessment of seismic risk in the region is largely based on the relatively short period of instrumentally recorded earthquakes (e.g., 5). Forthcoming work, in the frame of the National project IMPULS and ESF-Eurocores EuroMargins WESTMED project, will be based on onshore-offshore paleoseismic analysis and sedimentary record preserved in deep-sea cores, devoted to determining the past activity of the faults along the south Iberian Margin and to calculating their slip and recurrence rate.

Acknowledgement : The authors are grateful for funding from MCYT Acción Especial HITS (REN2000-2150-E), European Commission EASSS-III programme (HPRI-CT99-0047), and Spanish national project IMPULS (REN2003-05996MAR). We thank the captain and crew on board the R/V Hesperides, and particularly the UTM-CSIC technical staff and TOBI Team from the Southampton Oceanography Centre (UK) for their assistance throughout the data collection.

References

1 - Gràcia, E., Dañobeitia, J.J., Vergés, J., and PARSIFAL Team, 2003. Mapping active faults offshore Portugal (36°N-38°N): Implications for seismic hazard assessment in the southwest Iberian Margin. *Geology*, 31 (1): 83-86.

2 - Stich, D., Ammon, C.J., Morales, J., 2003. Moment tensor solutions for small and moderate earthquakes in the Ibero-Maghreb region. *J. Geophys. Res.*, 108, B3: 2148-2168.

3 - Gràcia, E., Dañobeitia, J.J., and HITS cruise party, 2001. High resolution mapping of Tsunamigenic Structures in the SW Iberian Margin: Implications for earthquake hazard assessment. *EOS (Trans., AGU)*, v. 120: 1024.

4 - Cronin, B.T:, Kenyon, N.H., Woodside, J., den Bezemer, T., van der Wal, A., Millington, J., Ivanov, M.K., Limonov, A., 1995. The Almeria Canyon: a meandering channel system on an active margin, Alboran Sea, western Mediterranean. Pp. 84-88. *In:* K.T. Pickering, R.N. Hiscott, N.H. Kenyon, F. Ricci Lucci, and R.D.A. Smith (eds.), Atlas of deep water environments: Architectural style in turbidite systems. Chapman & Hall., London.

5 - IGN, 1999. Boletín de sismos próximos 1999: Publicaciones del Instituto Geográfico Nacional, Madrid, Spain.

SUBDUCTION SYTEMS IN THE WESTERN MEDITERRANEAN : ASSESSING THE ACTIVITY AND SEISMIC RISK

M.-A. Gutscher, E. Thiebot *, J.-P. Rehault
IUEM, UMR 6538, Domaines Océaniques, Plouzané, France - gutscher@univ-brest.fr

Abstract
Geophysical and geochemical data indicate the presence of slabs of oceanic lithosphere, with recent subduction beneath the Gibraltar and Calabrian arc systems. Great historical earthquakes and tsunamis have been recorded in these regions, whose source remain unkown. We propose that subduction beneath Gibraltar and Calabria is active and that a large, locked seismogenic zone exists. Acqusition of additional data is required to test this hypothesis.

Key words : subduction, earthquake, tsunami, Gibraltar, Calabria

The Western Mediterranean (from S Iberia to S Italy) is the site of slow convergence between Africa and the southwest flank of Europe. Here, several Neogene basins situated on the interior of Alpine fold-and-thrust belts appear to have undergone extension and subsidence during active orogenic convergence [1,2]. The Western Mediterranean region is bounded at its extremities by two small subduction systems, with accompanying back-arc basins: the Gibraltar arc – Alboran Sea to the west and the Calabrian arc – SE Tyrrhenian Sea, to the east (Fig. 1). Arc volcanism occurs presently behind the Calabrian slab (the Aeolian Islands), but ceased in the W Alboran Sea around 5 Ma [3].

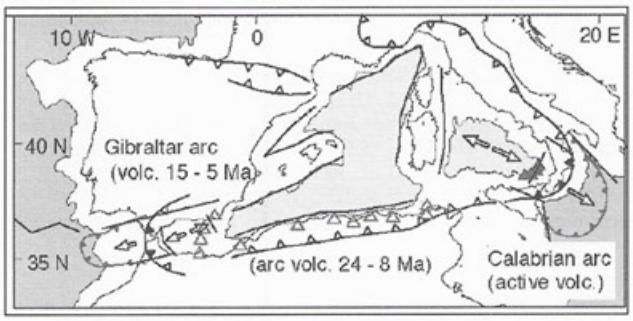


Fig.1. Geodynamic setting of the Western Mediterranean with the Gibraltar and Calabria subduction – arc systems indicated. Note the current volcanic arc in the SE Tyrrhenian Sea and the paleo-arc in the W. Alboran Sea.

Tomographic image reveal high p-wave velocity anomalies (cold, dense slabs of oceanic lithosphere) extending continuously from oceanic domains at the surface down to the 660 km discontinuity, and passing through regions of intermediate and deep focus seismicity [4,5] (Fig. 2). The regional kinematics and back-arc basin formation are best explained by models of slab-roll back during subduction [1,5,6] The question which remains is; are these subduction systems still active today ?

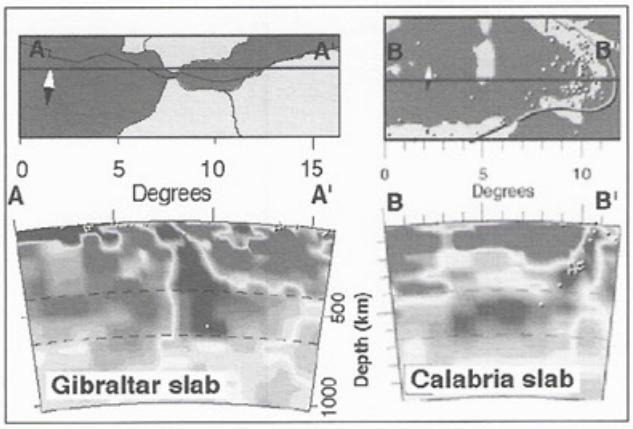


Fig. 2. Seismic tomographic images A: cross-section at 36°N across the Gibraltar Arc, B: cross-section through Calabria and Sardinia.

The Gibraltar and Calabria regions are marked by a moderately high degree of seismicity, but have been the site of devastating historical earthquakes. In particular, the sources of the great "Lisbon" earthquake of 1755 and the Catania earthquake of 1693 (which each caused upwards of 60,000 casualties), remain unknown to this day [7,8]. However, the generation of strong tsunamis (>5 m wave heights) implies a source region at least partly at sea. No instrumentally recorded subduction interface earthquakes (with a shallow-dipping, thrust-type focal mechanism) are known for either of these two sytems. Therefore, either subduction has ceased (no seismogenic zone), subduction is active and aseismic, or subduction is active and the seismogenic zone is currently locked. We favor the latter interpretation, in which case the two arcs would exhibit a similar behavior as the Nankai or Cascadia subduction zones, characterized by a large locked zone, and a recurrence time of 100 – 1000 years for great earthquakes.

The active subduction hypothesis requires testing and we propose the following criteria to determine the activity of the Gibraltar and Calabria subduction systems:

- active thrusting at the deformation front of the accretionary wedge
- active extension in the back-arc domain (subsidence or sea-floor spreading)
- great earthquakes with long recurrence interval
- independant kinematics of the upper plate block (Gibraltar / Calabria)
- active lateral bounding faults (likely with transcurrent motion)

A series of marine geophysical cruises are planned for 2003 – 2005 to constrain deformation in the Gulf of Cadiz accretionary wedge and the turbidite record in the adjacent abyssal plains.

References

1 - Rehault, J.-P., Boillot, G., Mauffret, A., 1985, The western Mediterranean Basin. Pp. 101-129. In: D.J. Stanley, and F.C. Wezel (eds.), Geological Evolution of the Mediterranean Basin. Springer, Berlin,
2 - Malinverno, A., Ryan, W.B., 1986. Extension in the Tyrrhenian Sea and shortening in the Appenines as a result of arc migration driven by sinking of the lithosphere. *Tectonics*, v. 5: 227-245.
3 - Duggen, S., Hoernle, K., van den Bogaard, P., Ruepke, L., Phipps-Morgan, J., 2003, Deep roots of the Messinian Salinity Crisis. *Nature*, 402: 602-606.
4. Wortel, M.J.R., Spakman, W., 2000, Subduction and slab detachment in the Mediterranean-Carpathian region. *Science*, 290: 1910-1917.
5 - Gutscher, M.-A., Malod, J., Rehault, J.-P., Contrucci, I., Klingelhoefer, F., Mendes-Victor, L., Spakman, W., 2002. Evidence for active subduction beneath Gibraltar. *Geology*, 30: 1071-1074.
6 - Gvirtzman, Z., and Nur, A., 1999. The formation of Mount Etna as the consequence of slab rollback. *Nature*, 401: 782-785.
7 - Baptista, M.A., Miranda P.M.A., Miranda, J.M., Mendes Victor, L., 1998. Constraints on the source of the 1755 Lisbon tsunami inferred from numerical modelling of historical data on the source of the 1755 Lisbon tsunami. *J. Geodynamics*, 25: 159-174.
8 - Piatenesi, A., and Tinti, S., 1998. A revision of the 1693 Sicily earthquake and tsunami. *J. Geophys. Res.*, 103: 2749-2758.

NATURE AND ORIGIN OF SMALL MUD DOMES FROM THE CENTRAL SOUTHERN MEDITERRANEAN RIDGE (EASTERM MEDITERRANEAN SEA)

C. Huguen *, J. Mascle and the NAUTINIL Scientific Party
UMR 6526 Geosciences Azur, B.P. 48, 06235 Villefranche sur mer, France

Abstract
Swath mapping, (PRISMED 2 survey) over the Mediterranean Ridge, have revealed, north of the libyan promontory, the presence of numerous small dome-shaped features delineating a NW-SE, 80 km long, belt. The morphology and backscatter characteristics of some of these features have been precised by near bottom side scan sonar. These structures were interpreted as mud volcanoes or mud diapirs [1]. During the recent NAUTINIL survey (Sept. 2003), one dive has been made, on one of theses domes ("Lorient" dome), to determine the nature of these enigmatic reliefs and provide constraints on their geology and type of emplacement.

Key-Words: Mud Diapirs, Deep dives, Central Mediterranean Ridge, Eastern Mediterranean.

Regional swath bathymetric and backscatter data from PRISMED II survey have shown the presence, within the inner Central Mediterranean Ridge, north of the Libyan promontory, of tens of small sub-circular domes delineating a NW-SE arcuate belt at about 50-60 km south of Olimpi Mud volcano field [1, 2]. Side scan sonar and sub bottom profiles from MEDINETH survey over one of theses features (Lorient dome) have provided details on their morphological and acoustic characteristics (Fig. 1). "Lorient" mud dome is a relatively steep, elevated (up to 200 m), and irregular relief characterized by an acoustic signature which does not support significant recent mud flows. Only restricted areas, with weak to intermediate backscatter strengths (Fig. 1) and chiefly seen at the base of the feature are suggestive of mud outflows; high backscatter patches (Fig. 1), could be interpreted as evidences of probable debris flows. One characteristic, well evidenced on the side scan sonar data (Fig. 1), is the presence of sets of lineaments which explain that the domes do not appear on near bottom plan views as sub-circular features but rather as angular reliefs. The main, N70 and N145, oriented lineaments, also expressed as vertical offsets on sub bottom profiles, are interpreted as R (N70), R' (N145) Riedel secondary faults generated along regional strike slip faults as determined from surface geophysical data.

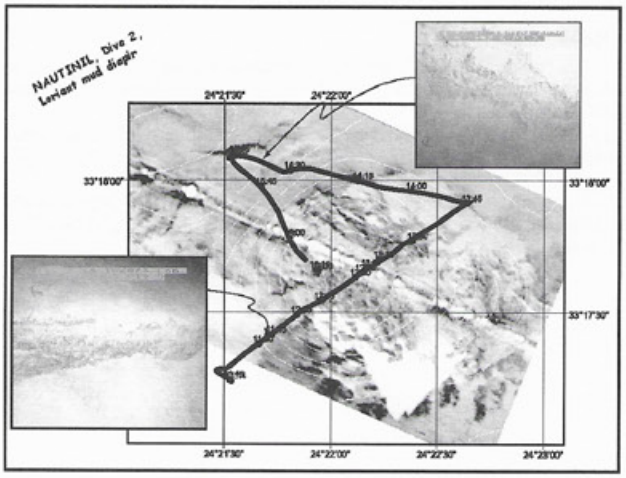


Fig. 1. Side scan sonar data over the "Lorient" mud diapir. The dive track is located as well as two seafloor pictures over the southern slope and the northern surroundings of the structure.

The objective of the Nautile dive, made on "Lorient dome" during the recent NAUTINIL cruise was, through direct seafloor observations, to collect informations on the nature and origin of this feature, in order to compare it to the well known Olimpi field mud volcanoes which lies at about 50 km north of this belt [1].

No mud flows nor specific fluid venting, authigenic carbonate pavements , or biologic communities, all characters typical of active mud volcanoes [3] were observed. "Lorient" dome is characterized by strong slope sedimentary unstabilities, especially along its southern border (Fig. 1). Several observations, such as the existence of numerous N60 trending metric/decametric scarps, a recent fault plane (showing sliken slides) support a tectonic control for the emplacement of the structure whose, moreover, displays near its top numerous anastomosed open fractures similar to fractures commonly seen on salt diapir caprock covers

All available data (geophysical and in situ observations), support that the feature results from diapiric emplacement mechanisms rather than from mud extrusion processes. This suggests that the Southern Belt is made of a series of mud diapirs emplaced through recent to active regional fractures cutting across the cover of the Mediterranean Ridge and therefore proceeds from different mud levels and different expulsion mechanisms than the active mud volcanoes from the Olimpi field.

References

(1) - Huguen, C. 2001. Déformation récente à actuelle et argilo-cinèse associèe au sein de la Ride Méditerranéenne (Méditerranée Orientale). Thèse de Doctorat, Université Paris VI.
(2) - Mascle J., Huguen C., Benkhelil J., Chamot-Rooke N., Chaumillon E., Foucher J.P., Griboulard R., Kopf A., Lamarche G., Volkonskia A., Woodside J. and T. Zitter, 1999. Images may show start of European-African plate collision. *E.O.S.* 80: 421, 425, 428.
(3) - MEDINAUT/MEDINETH Shipboard Scientific Parties, 2000. Linking Mediterranean brine pools and mud volcanism. *EOS, Transactions, American Geophysical Union*, 81(51): 625, 631-633.

SEEPAGE ACTIVITY OF THE NAPOLI MUD VOLCANO: EVIDENCE FROM OBSERVATIONS MADE DURING THE MEDINAUT (1998) AND NAUTINIL (2003) DIVE EXPEDITIONS

C. Huguen [1, 2 *], H. Ondréas [2], M. Sibuet [3], J.P. Foucher [2], J. Woodside [4], J. Mascle [1]
and the NAUTINIL Shipboard Scientific Party.

[1] UMR 6526 Geosciences Azur, B.P. 48, 06235 Villefranche sur mer, France
[2] IFREMER, DRO/GM, B.P. 70, 29280 Plouzané, France
[3] IFREMER, DRO/EP, B.P. 70, 29280 Plouzané, France
[4] Vrije Universiteit, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands

Abstract

Dive observations made during the MEDINAUT (1998) and NAUTINIL (2003) expeditions demonstrate long-lasting seepage activity at the surface of the Napoli mud volcano in the eastern Mediterranean basin. Numerous spots of dark reduced sediment were identified as active seeps. Brine lakes, authigenic carbonate crusts, chemosynthetic fauna, bacterial mats and filaments are associated with seeps. Seepage activity varies with time over the summit.

Keywords: Napoli mud volcano, Fluid seeps, Mud volcanoes, Submersible dives, Central Mediterranean Ridge.

Unlike many other mud volcanoes that have been mapped on the summit of the Mediterranean ridge, the Napoli mud volcano, one of several large mud volcanoes that form the Olimpi mud volcano field to the south of Crete, is characterized by an overall weak backscatter (Fig. 1). One explanation for the low backscatter is a different type of extruded mud, as attested by ODP Leg 160 cores, which recovered mud containing only millimetric clasts (1). Over most of the summit of the mud volcano, a relatively chaotic acoustic pattern is observed on the side scan sonar records, which probably results from the relatively unstructured mud flows. The fluid nature of the sediment was also anticipated as one reason for the low backscatter.

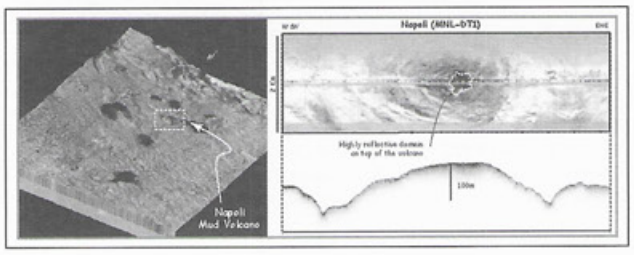


Fig. 1. (a) 3D-view of the Olimpi mud volcanoes field South of Crete. (b) Ore-Tech deep-tow side scan sonar profil recorded across Napoli Mud Volcano during the *MEDINETH* cruise

The MEDINAUT dive expedition carried out in 1998 revealed a peculiar characteristic of the Napoli mud volcano surface which was the occurrence of several brine lakes (2). Based on the observations of four dives, a first detailed geological map of the volcano summit was completed (Fig. 2). Shallow brine lakes, up to a few tens of meters long and only a few tens of centimeters deep were found.

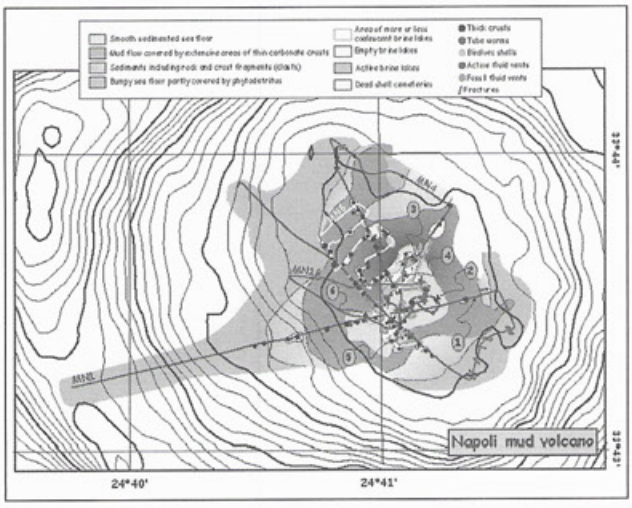


Fig. 2. Geological interpretation of the Napoli mud volcano, deduced from seafloor observations and sampling from 4 dives performed during the *MEDINAUT* cruise (3).

The NAUTINIL dive expedition in 2003 yielded additional seafloor observations on the summit of the Napoli mud volcano. Three new dives were carried out. Observations covered areas that had not been explored at all during MEDINAUT, but also covered areas that had been visited for a first time during MEDINAUT allowing for a comparison of seepage activity to be made after a 5 year interval.

The new observations showed that fluid seepage through the seafloor of the Napoli mud volcano was still active and that the seepage activity had remained focussed in the central part of the volcano. Numerous spots of dark reduced sediment were identified as active seeps. Whitish bacterial mats and filaments were commonly observed in association with the numerous seeps, as well as thin carbonate crusts. Chemosynthetic fauna indicators of past or recent seeps include tube worms (vestimentiferans) mainly at the edge of crust, small living bivalves (mytilidae) fixed on crust and large fields of bivalve shells (Lucinidae, Thyasiridae). Occasionally, isolated tubeworms and sponges were observed.

Our preliminary results suggest that the overall area of brine accumulation moved significantly to the northeast over the five years elapsed since MEDINAUT.

References

(1) - Robertson, A.H.F., Emeis, K.-C., Richter, C., and Camerlenghi, A. (eds.), 1998. *Proc. ODP, Sci. Results*, 160: College Station, TX (Ocean Drilling Program).

(2) - MEDINAUT/MEDINETH Scientific Shipboard Parties, 2000. Linking Mediterranean Brine Pools and Mud Volcanism. *Eos Trans. Am. Geophys. Union*, 625-632.

(3) - Huguen, C. 2001. Déformation récente à actuelle et argilo-cinèse associée au sein de la Ride Méditerranéenne (Méditerranée Orientale). *Thèse de Doctorat, Université Paris VI*, 260 p.

RECENT SEDIMENTATION RATES IN THE AEGEAN SEA

H. Kaberi * and V. Lykousis
Hellenic Centre for Marine Research, Anavyssos, Greece

Abstract
Sedimentation rates were determined in three deep basins of the Aegean Sea, using the ^{210}Pb method. In the North Aegean basin the sedimentation rate was the highest (0,21 cm y^{-1}); in the Central Aegean Sea, the Skyros basin, the sedimentation rate was found lower than the previous one (0,105 cm y^{-1}); the lowest sedimentation rate was calculated in the South Aegean basin (0,02 cm y^{-1}), where the main sources of particles are the biological processes in the water column and the atmospheric fall-out.

Keywords: sedimentation rates, ^{210}Pb, Aegean Sea.

Sediment accumulation rates were determined in three basins of the Aegean Sea in the framework of the MTP-II-MATER project. The cores that were analyzed for ^{210}Pb were collected from the North Aegean basin (MNB-1), the Skyros basin in the Central Aegean Sea (MNB-3) and the South Aegean basin (MSB-2) (Fig.1). According to Lykousis *et al.* (2002) there appears to be a N-S gradient in the biogeochemical processes in the Aegean Sea. Moreover, in the North Aegean mass fluxes in the water column are characterized strongly by the lithogenic constituent, due to the river discharge from the northern mainland of Greece. In contrast, the South Aegean fluxes appear to depend more upon the biogenic component and less on the lithogenic fall-out [1].



Sediment cores (∅ 6cm and about 50cm long) were sub sampled from a box corer, during the August 1997 cruise of the R/V *Aegaeo*. For the total dissolution of the dry sediments the analytical method described by Sanchez-Cabeza *et al.* [2] was followed. ^{210}Po isotopes were deposited on silver discs and counted in both sides on a total alpha-counter (Ortec EG&C) [3]. Sedimentation rates were calculated assuming secular equilibrium between ^{210}Po and ^{210}Pb.

For the determination of the biomixing zone and the calculation of the sedimentation rates the Biodiffusive Model was used [3, 4, 5] according to which the biological process is given by the advection - diffusion equation. The accumulation rate (S) is calculated in the zone below the mixed layer whereas the mixing coefficient (D_B) is calculated within the mixing layer of the sediment core. It must be noted that the rates calculated this way are the apparent one. Supported ^{210}Pb concentrations were determined from the deeper parts of the cores where the total ^{210}Pb concentrations were constant with depth.

Core MNB-1 was collected from a depth of 1287 m in the deep basin of the North Aegean Sea. The vertical profile of the unsupported ^{210}Pb activity showed a significant decrease below the 10-11 cm layer of the sediment core. Surface ^{210}Pb activity was 34.5 dpm g^{-1}. The upper 4-4,5 cm of the core seemed to be mixed. The apparent accumulation rate calculated according to the Biodiffusive model was found to be 0,21 cm y^{-1} and the mixing coefficient about 4.2 cm^2 y^{-1}.

Core MNB-3 was taken from the Skyros basin (820 m) in the Central Aegean Sea. The vertical profile of the unsupported ^{210}Pb showed an almost theoretical exponential decrease until the 18 cm depth, with a surface concentration of 40 dpm g^{-1}. The sedimentation rate was found 0.105 cm y^{-1}, whereas, no mixing was observed in the surface layer of the sediment core.

MSB-2 core was collected from a depth of about 1600 m, in the South Aegean deep basin. Surface ^{210}Pb total activity was 13,9 dpm g^{-1}, lower enough than in surface sediments of the North Aegean Sea. Below the first 0,5cm of the sediment core, ^{210}Pb activities decreased very sharply. According to the Biodiffusive model, the apparent sedimentation rate was found to be 0,02 cm y^{-1} and the mixing coefficient 0,022 cm^2 y^{-1}.

Concluding, the most important finding of this work is the quantification in a way of the previously demonstrated difference between the three basins of the Aegean Sea as far as the sediment supply is concerned.

References

1 - Lykousis V., G. Chronis, A. Tselepides, N.B. Price, A. Theocharis, I. Siokou-Frangou, F. Van Wambeke, R. Danovaro, S. Stavrakakis, G. Duineveld, D. Georgopoulos, L. Ignatiades, A. Souvermezoglou, F. Voutsinou-Taliadouri, 2002. Major outputs of the recent multidisciplinary biogeochemical researches undertaken in the Aegean Sea. *Journal of Marine Systems*, 33-34: 313-334.

2 - Sanchez-Cabeza, J.A., Masque, P. and Ani-Ragolta, I., 1998. ^{210}Pb and ^{210}Po analysis in sediments and soils by microwave acid digestion. *Journal of Radioactivity and Nuclear Chemistry*, 227(1-2): 19-22.

3 - Radakovitch O., 1995. Etude du transfert et du dépôt du matériel particulaire par le ^{210}Po et le ^{210}Pb. Application aux marges continentales du Golfe de Gascogne (NE Atlantique) et du Golfe du Lion (NW Méditerranée). PhD. Thesis Univ. of Perpignan.

4 - Nittrouer C.A., DeMaster D.J., McKee B.A., Cutshall N.H. and I.L. Larsen, 1983/1984. The effect of sediment mixing on Pb-210 accumulation rates for the Washington continental shelf. *Mar. Geol.*, 54: 201-221.

5 - Guinasso N.L. and Schink D.R., 1975. Quantitative estimates of biological mixing rate in abyssal sediments. *Jour. Geophys. Res.*, 80: 3032-3043.

EVOLUTION OF NILE DEPOSITS INPUT DURING THE QUATERNARY AND ITS EFFECT ON EGYPTIAN COASTLINE

Ahmed M. Khadr

AUDO, Alexandria University, Department of Oceanography, Alexandria, Egypt - amedkhadr@dataxprs.com.eg

Abstract

The study of prehistoric geology is an important tool to interpret the ancient civilizations and their environment. Evolution of the Nile Delta and the coastline of the Mediterranean are discussed. The dryness of North Africa was dominant, 3000 B.C., and man was stimulated to move near the valleys where he settled. Man-made actions, e.g. high dam (Egypt), impacted the stability of the southeast coast of the Mediterranean in the present time. Many authors claim that there is a global warming intensified by human activity; however, it is difficult to separate the anthropogenic impact from the natural cycles shown by paleo-studies.

Key words: Nile deposits, Quaternary, coastal changes

Introduction

The topography of the basin and the relief of the adjacent land are quite spatially variable. The coastline is very irregular and the continental shelves are narrow except near the river deltas. Geologically, it can be divided into three provinces: Western, Central and Eastern. They are subdivided into distinct basins by submarine ridges, tectonic blocks and Iberian Apennine and Hellenic peninsulas. The shape of this basin with its surrounding lands make the Mediterranean sea sensitive to paleo-climatic changes, which left their finger prints on the nature of the accumulated sediments since ancient times. The study of the Holocene, which started at about 10000 B.C., is of utmost importance to understand the past, manage and control the present coastal zone and to forecast the future global climatic and environmental changes.

Paleoclimate in the Mediterranean Sea

Sea Surface Temperature (SST) is a relevant factor affecting the climatic conditions. Ariztigui *et al.* (1) applied two techniques; $\delta^{18}O$ compositions of plankton foraminifers and alkenone index, to investigate paleoceanographic conditions in the Meso-Adriatic Depression (MAD) and their relationship with climatic changes in the Mediterranean region. Different cores were studied. The temperature estimation obtained by the mentioned two methods indicated SST of about 20° C at 5290± 40 BP and at 10940± 60 BP, and about 15° C at 13384± 100 BP. The Adriatic exists at high latitudes in the Mediterranean, therefore, it is expected that SST in the southern Mediterranean to be higher by about 3 to 4 degrees. Due to the nature of the Mediterranean Sea, its water does not mix much vertically with seawater and sediment composition is especially sensitive to climate change. Therefore, environmental signals are preserved within sediments in great details. The Mediterranean latitudes (30-45°N) lie in a sensitive transition zone between the belt of prevailing Westerly and subtropical hi-pressure belt, with variety of land, sea, islands, mountains and gulfs. In the glacial periods, the Westerly are dominant, and the climate is characterized by cold, and dry high pressure cell of Euro Asiatic continent. During interglacial maximum, there were northward shifts of the subtropical hi-pressure cell leading to climatic conditions similar to the hot-humid subtropical regime of the present day in the Gulf of Mexico. These climatic changes were reflected on supplying weathered rock detritus (2). At least 12 climatic oscillations can be recognized in this epoch (3, 4), but the critical climatic events in the Holocene record in the Mediterranean latitudes could be simplified to three main phases: The early Holocene (10000-8000 BP) is marked by a general warming trend, with increased precipitation and a wide spread return of forests, even along the north African littoral.

History of Nile Delta

According to De Heinzelin (5), the course of the present Nile as a continuous river was not established until geologically very recent times. The dating of Holocene sediments indicates that moist periods lasted 2000-3000 years and the hyper-aridity about 1000 years each. The Nile delta is presently subjected to significant coastal changes because of reduction in the Nile discharge and sediment load to the Nile promontory mouths following the construction of dams along the Nile. Since building of the High Dam, sediment discharge at the Nile promontories has reduced to near zero. The sedimentary sequences consist of wide varieties of deltaic and marine Quaternary sediments. The vertical motion of land, subsidence refers to the lowering of the land surface relative to a geodetic datum. Vertical motion varies locally depending upon rates of isostasy, tectonism, and compaction. Subsidence is generally independent on world (euostatic) sea-level changes. The valley and delta troughs of the Nile offered the only environment in Egypt that favoured the accumulation and preservation of sediment during the Quaternary, which was an epoch of intensive erosion. The field mapping of the fluviatile and associated sediments of the Nile valley and the examination of a large number of boreholes both deep and shallow show that it is possible to conceive of the Nile as having passed through five main episodes since the valley was cut down in late Miocene time. Each of these episodes was characterized by a master river system. Toward the end of each of the first four episodes (the last is still extant) the river seems to have declined or ceased entirely to flow into Egypt These five rivers are termed by Said (6). The Eonile was a late Miocene feature, which was responsible for the cutting of the modern valley to great depths. The depth of the Eonile canyon in northern Egypt reaches about 2500m No deposits of the Eonile system are known in outcrop since the river was dredging its bed to the new lowered base level of the desiccated Mediterranean. The sediments belonging to the Paleonile consist of a long series of interbedded, red brown fluviatile to fluviomarine clays and thin, fine-grained sand silt lamina, which crop out along the banks of the valley and many of the wadies which drain into it. The Protonile, was a highly competent river that carried cobble and gravel-sized sediments made up mainly of quartz and quartzite. The deposits of the Prenile are mainly of massive cross-bedded sands. The deposits of the Neonile, which is still extant, are indistinguishable from those of the present day river.

References

1 - Ariztegui D., Chondrogianni C., Wolff G., Asioli A., Teranes J., Bernasconis M., McKenzie J.A., 1996. Paleotemperature and paleosalinity history of Meso-Adriatic Depression (MAD) during the late Quaternary: a stable isotopes and alkenones study. Paleoenvironmental analysis of Italian Crater Lake and Adriatic Sediments. *Mem. 1st ital. Idrobiol*, 55: 219- 230.

2 - Fairbridge R.W., 1972. Quaternary sedimentation in the Mediterranean region controlled by techtonics, paleoclimates and sea level. Pp. 43- 46. In: Daniel J. Stanley (ed.), Mediterranean sea a natural sedimentation laboratory. Dowden, Hutchinson &Ross, Inc.

3 - Fairbridge R.W., 1976. Effects of Holocene climatic change on some tropical geomorphic processes. *Quaternary Research*, 6: 529- 556.

4 - Fairbridge R.W., 1982. Holocene. Pp 463- 464. In: Maurice L. Schwartz (ed.), Encyclopedia of beaches and coastal environments. Huchinson Ross Publishing Company.

5 - De Henzelin, J., 1968. Geological history of the Nile valley in Nubia. Pp. 19- 55. In: Wondorf F. (ed.), The prehistory of Nubia Dallas. Thouthern Methodist University press.

6 - Said, R., 1981. The geological evolution of the River Nile. New York. Springer Verlag, 151 p.

GEOCHEMISTRY AND MINERAL ASSEMBLAGES OF THE MEDITER-RANEAN EVAPORITE DEPOSITS 4. EUXINIC DEPOSITION OF HEAVY METAL MINERALS IN THE TUZLA SALT DEPOSIT, BOSNIA AND HERCEGOVINA

Goran Kniewald [1] *, Vladimir Bermanec [2], Joan Carles Melgarejo [3] and Ladislav A. Palinkaš [2]

[1] Center for Marine and Environmental Research, Rudjer Boskovic Institute, Zagreb, Croatia - * kniewald@rudjer.irb.hr
[2] Department of Mineralogy and Petrology, Faculty of Sciences, University of Zagreb, Croatia
vberman@public.srce.hr, lpalinka@public.srce.hr
[3] Departament de Cristal·lografia, Mineralogia i Dipòsits Minerals, Facultat de Geologia, Universitat de Barcelona, Spain - joanc@natura.geo.ub.es

Abstract

The evaporite deposit of Tuzla in Bosnia-Hercegovina is the largest rock salt deposit in the Balkan peninsula. In spite of extensive investigations, there is still no final evidence regarding the depositional environment in which it formed. The evaporite series contains a suite of accessory and secondary boron containig minerals, while the lateral equivalents of the rock salt series, in the form of layered marls, contain a suite of heavy metal minerals. Electron microscopic investigations revealed the presence of pyrite and minerals of Hg, Ag, Sb, Sn and U. These findings are dicussed in terms of the diagenetic and dynamic processes of sulfide precipitation at or near redox fronts of euxinic depositional environments of the Tuzla deposit.

Keywords: evaporites, heavy metal minerals, euxinic environments

Introduction

The Tuzla salt deposit is located in the north-eastern part of Bosnia and Hercegovina and is the largest rock salt reservoir on the Balkan peninsula. The essentially stratified salt type deposit is of middle Miocene age, hosted in a sedimentary series of gray marls. In spite of the rather well known geological setting of the occurrence and extensive research of the geochemistry of the host rocks (2,3), there is no unambiguous evidence indicating the depositional environment in which the evaporites formed. The geochemistry of coexisting brines and their saturation states imply that the formation environment may be interpreted in terms of the mixing-zone model, as opposed to the end-member marine or salt-lake type deposits. However, the close relationship of the evaporite series and associated dolomitic limestones, and evidence of progressive dolomitization may account for their formation under evaporative, non-evaporative or seepage reflux conditions (4).

Materials and Methods

The petrographic characteristics of the samples were studied in thin and polished sections, under the optical microscope, both in transmitted and reflected light. Scanning electron microscope images (backscattered electrons mode) were obtained working at 25 keV in a Cambridge Stereoscan S-120 instrument. Qualitative chemical analyses were obtained using a coupled EDS LINK analyser.

Petrographic description of the sulphide-rich marls

The investigated samples of marls contain a suite of sulphides. Pyrite (FeS_2) is very common and forms small crystals (less than 50 microns in diameter). These crystals appear in the following positions: a) rimming euhedral crystals of diagenetic minerals (i.e. northupite), b) as single crystals or clusters disseminated in the marls, c) as thin beds (less than 1 mm in thickness) and d) filling thin veins in the marls, in association with halite and tuzlaite.

All mineral grains are extremely fine, usually lesser than 10 microns, precluding X-ray diffraction identification. They can appear as disseminations (i.e. Fe-poor sphalerite, which occurs as fine disseminations among the searlesite aggregates), the most common occurrence being vein fill-ins. The mineral associations comprise cinnabar, acanthite, silver sulphosalts (possibly, members of the proustite-pyrargyrite series), and tin sulphosalts. These minerals are found included in salt veins, or in cracks into other minerals. They are usually euhedral. Coffinite is also found in veinlets. Finally, barite has also been found as fine disseminations in the marls.

It is interesting to note that no other iron sulfide phases could be identifed. The occurrence of pyrite and barite suggest moderate Eh values in the environment of deposition, and the absence of marcasite suggests moderate pH. The presence of heavy metals in lateral equivalents of the principal rock salt series at Tuzla is an indication of associated syngenetic and postsedimentary volcanic activity in the area of the Tuzla salt deposit. The reduction of sulfate and the formation of an euxinic environment imply the preservation of organic carbon in the marls, which is consistent with a shallow basin sedimentation type of these rocks (5,6).

In the Tuzla deposit, sulfate minerals in the evaporites are not directly responsible for the precipitation of metal sulfides. Euxinic environment in the brine pools above the water-sediment interface is not ultimate prerequisite to ensure favorable condition for sulfate reduction. Sulfate entraining solutions percolating through the marl sediments are reduced in the presence of organic matter to form H_2S by activity of desulfurizing bacteria. High concentration of organics in the sediment, availabe as food for bacterial digestions, ensures low redox potential, mobilisation of divalent iron and precipitation of early diagenetic iron sulfides. Pyrite is the first sulfide phase formed in the sediment. Presence of As, Sb, Hg sulfides suggests prolonged circulation of terrestrial, oxidizing water from the surrounding uphills, probably of lower salinity, leaching base metals and uranium from pyroclastics and siliciclastic rocks. The underground flow is supported by evaporitic pumping and lowering of water tabel in the evaporitic pools. Precipitation occurred directly from the aqueous H_2S species or metasomatic replacement of the early diagenetic iron sulfides.

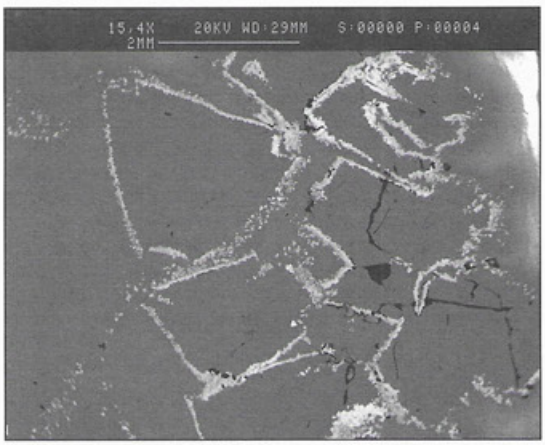


Fig.1. Sulphide grains arround big northupite crystals.

References

1 - Warren, J., 1999, Evaporites - their evolution and economics. Blackwell Science Ltd., Oxford, 438 p.

2 - Kniewald, G., Bermanec, V., Tibljas, D., 1986. On the origin and type of the Tuzla salt deposit in Yugoslavia. *Rapp. Comm. int. Mer Médit.*, 30/2: 72.

3 - Kniewald, G., Bermanec, V., 2001. Geochemistry and mineral assemblages of the Mediterranean evaporite deposits. 2. Boron hydrogeochemistry in the Tuzla deposit in Bosnia-Hercegovina. *Rapp. Comm. int. Mer Médit.*, 36: 9.

4 - Hardie, L.A., Eugster, H.P., 1971. The depositional environment of marine evaporites: a case for shallow, clastic accumulation. *Sedimentology*, 16: 187-220.

5 - Canfield, D.E., 1989. Sulfate reduction and oxic respiration in marine sediments: implications for organic carbon preservation in euxinic environments. *Deep-Sea Res. Part A*, 36: 121-138.

6 - Canfield, D.E., 1994. Factors influencing organic carbon preservation in marine sediments. *Chemical Geology*, 114: 315-329.

THE TETHYAN TRIASSIC VOLCANISM : REMNANTS OF INTRA-OCEANIC ISLANDS RELATED TO THE OPENING OF THE TETHYAN OCEAN

Lapierre H. [1] *, Chauvet F. [1], Muceku, B. [2], Mascle G. H.1, Bosch, D. [3], Demant A. [4], Maury, R.C. [5], Tashko A. [2], Tardy M. [6], and Marcoux J. [7]

[1] LGCA UMR-CNRS 5025, Université J. Fourier, Grenoble, France - * lapierre@ujf-grenoble.fr
[2] Geology Faculty, Polytechnic University of Tirana, Albania
[3] Laboratoire de Tectonophysique, UMR-CNRS 5568, ISTEEM, Université Montpellier II, France
[4] Laboratoire de Pétrologie magmatique, Faculté des Sciences de St Jérôme, Marseille, France
[5] Laboratoire des Domaines océaniques, UMR-CNRS 6538, Université de Bretagne Occidentale, Plouzané, France
[6] LGCA, UMR-CNRS 5025, Université de Savoie, Le Bourget du Lac, France
[7] UMR-CNRS 7578, Institut Physique du Globe, Université Paris VII, Paris, France

Abstract

Triassic volcanism is largely exposed in the Tethyan ranges and its tectonic setting is a matter of debate. Trace element and Nd, Sr and Pb isotopic chemistry of Triassic volcanic rocks from the Himalayas, Oman, SE Mediterranean and Albania will help to constrain the geodynamic setting of the widespread Triassic egneous event.

Keywords : Triassic Tethyan volcanics, tholeiite, alkali basalt, trace element geochemistry, Nd and Pb isotopes, OIB-type mantle source

Tectonic setting

Triassic volcanic rocks are closely asociated with Mesozoic ophiolites from the Central and Eastern Mediterranean (Serbian, Mirdita, Pindos, Antalya, Troodos, Baër Bassit) up to the Persian Gulf (Samail nappes in Oman) and Himalaya (Lamayuru nappe). Triassic volcanites constitute tectonic nappes generally sandwiched between the ophiolites and the Apulo-African, Arabian or Indian margin. They are stratigraphically associated with pelagic and/or reef limestones, which are spatially associated with Triassic, Jurassic, and Cretaceous sedimentary sequences recording the contemporaneous shallow to deep water evolution of the basin. The Triassic volcanic suite has been interpreted as remnants of a rifted volcanic passive margin or within-plate oceanic volcanoes.

Petrology and geochemistry of the Triassic volcanic suites.

In Himalaya ,the Drakkar Po Melange, exposed within the Indus-Tsan Po suture consists of exotic blocks of Upper Permian, Triassic and Cretaceous volcanic and sedimentary rocks, caught within a turbidite matrix. The Jurassic Spotang ophiolite is thrust upon the Drakkar Po Melange. The Triassic pillow basalts are associated with pelagic limestones. They display alkaline affinities: *i.e.,* $2.17 < TiO_2 < 3.38$, LREE- enriched $(2.75 < La/Yb)_N < 5.73$) patterns and low La/Nb ratios ($0.36 < La/Nb < 0.77$). Preliminary isotopic investigations suggest that the Triassic volcanics derive from an enriched OIB-mantle source devoided of crustal contamination.

In Oman, the Sumeini and the Hawasina nappes consist of imbricated sedimentary and volcanic units squeezed between the platform and the Samail ophiolite. They are respectively interpreted as continental slope and ocean basin deposits of the southern Tethyan Arabian margin at the end of the Paleozoic and the Mesozoic. Volcanism is dated as mid-Permian and Late Triassic. The Upper Triassic volcanics consist predominantly of pillow basalts associated either with Halobia- and Ammonites-bearing micritic limestones and shallow marine carbonates (reefs) or radiolarites and shales. Preliminary geochemical studies show that the volcanic rocks display intra-plate tholeiitic and alkaline affinities and a large range of εNd values.

In SW Cyprus, the Upper Triassic Mamonia volcanic suite consists of four types. Type 1 is composed of depleted olivine tholeiites, characterized by LREE-depleted patterns and multi-element plots with Th and Pb negative anomalies and no Nb and Ta enrichment or depletion relative to La. Type 1 basalts have εNd values (+7.5 to 5.4) that fall in the range of OIB while according to the Pb initial ratios, they plot in the N-MORB field. Type 2 exhibits typical features of oceanic tholeiite: slightly LREE-enriched, flat multi-element plots. Type 2 differs from Type 1 by significantly higher Pb isotope ratios. Both Types 1 and 2 are interbedded with deep-basin siliceous and/or calcareous sediments. Type 3 is composed of olivine-plagioclase-clinopyroxene phyric basalts and hawaiiites, which are strongly enriched in LREE, Nb, Ta and Th. The enriched nature of the mantle source of the alkaline rocks is confirmed by the εNd values (+6.4 to 3.4) and Pb isotope ratios which are the highest of all the Mamonia rocks. Type 3 is associated with Halobia-pelagic and reef limestones. Type 4 consists of trachytes, which are the most fractionated rocks of the Mamonia suite and shares with Type 3 similar εNd values and Pb isotope ratios. Trachytes occur as dykes intruding the alkali pillow basalts or restricted columnar-jointed flows resting on pillowed mafic flows.

In SW Turkey, the thick (1000 m) Upper Triassic volcanic pile is very well exposed in the Antalya Nappes. The predominantly pillowed flows are interbedded with Halobia and Ammonites-bearing limestones. The alkaline affinity of this mafic volcanism was demonstrated by various authors. New trace element and isotopic investigations show that most of the Upper Triassic volcanic rocks are mafic in composition and exhibit geochemical features of alkaline suites: high TiO_2, Nb, Ta and Th abundances, important LREE-enrichment and εNd values ranging between +5.1 and +4.4).

In NW Syria (Baër Bassit), the Upper Triassic volcanic rocks, interbedded with marls and Halobia-bearing limestones, are exposed within imbricate sheets of ophiolites and pelagic sedimentary rocks. Rare weathered mafic lava sequences are associated with Carnian-Norian calcilutite with red ribbon radiolarite intercalations, either in small lenses or surrounding horsts formed by reef limestones. The volcanism exhibits tholeiitic ($TiO_2 = 1.2$) to alkaline trends ($TiO_2 = 3.2$ to 5.2. The La/Nb ratios (0.6 to 0.9) of the basalts range in the field of intra-plate volcanism.

In Albania, the volcanic rocks are exposed on both eastern and western sides and in some tectonic windows below the Mirdita ophiolitic nappe and belong to the "peripheral complex" or Guerret-Miliska zone. Micropaleontologic datation of sedimentary intercalations (Conodonts and Radiolaria) range from uppermost Permian to Upper Triassic with mainly Aniso-ladinian age. The rocks display ophitic, porphyritic or aphyric textures and include abundant calcite-filled vesicules. The dolerites consist of plagioclase phenocrysts set in a groundmass formed of plagioclase laths surrounded by clinopyroxene and Fe-Ti oxide. The porphyritic basalts consist of olivine and plagioclase phenocrysts set in an intersertal groundmass formed of quenched plagioclase microliths and oxides. The aphyric basalts include quenched needdle-shaped plagioclase in an abundant glassy groundmass. According to the sequence of crystallisation observed in the basalts (*i.e.*, olivine → plagioclase → clinopyroxene → oxides) the Triassic volcanism of Albania is tholeitic.

Conclusion

The Tethyan domain is characterized by an important and widespread Triassic volcanism which displays features of tholeiitic and alkaline suites. The Nd and Pb isotope compositions suggest that the Triassic volcanics derive from the partial melting of an OIB-type mantle. There is no evidence of the involvement of continental crust in the genesis of the rocks exposed in Cyprus and Turkey. According to paleogeographic reconstructions, the Triassic volcanism emplaced in narrow basins floored or not by oceanic crust, divided by continental blocks, interpreted as fragments rifted from the Gondwanian margin at the same time.

SLIDES AND RELATED FLUID ESCAPE FEATURES IN THE EIVISSA CHANNEL, WESTERN MEDITERRANEAN

G. Lastras *, M. Canals

GRC Geociències Marines, Universitat de Barcelona, Barcelona, Spain - * galderic@natura.geo.ub.es

Abstract

Four slides have been identified in the Balearic margin of the Eivissa Channel. They are easily recognizable in detailed swath bathymetry maps and very-high resolution seismic reflection profiles. The slides share the same slip plane, which corresponds to a continuous, high amplitude reflector. Headwall scars are related to pockmarks, which are also present further upslope on the Balearic margin of the Eivissa Channel. Therefore, it can be stated that there is a link between fluid escape features and destabilisation of the upper sediment layers.

Keywords: Submarine slides, pockmarks, fluid escape, Eivissa Channel

The Eivissa Channel opens between Alacant, in the Iberian Peninsula, to the west, and the island of Eivissa, to the east (Fig. 1A). It has a slightly asymmetric saddle morphology, with the Iberian margin steeper than the Balearic margin. The Eivissa Channel is interrupted by a ca. 200 m high east-west trending seamount named the "Xàbia Seamount". Most of the fine sediment reaching the Eivissa Channel is thought to come from the Iberian Peninsula, transported by the southwards regional circulation along the Iberian margin.

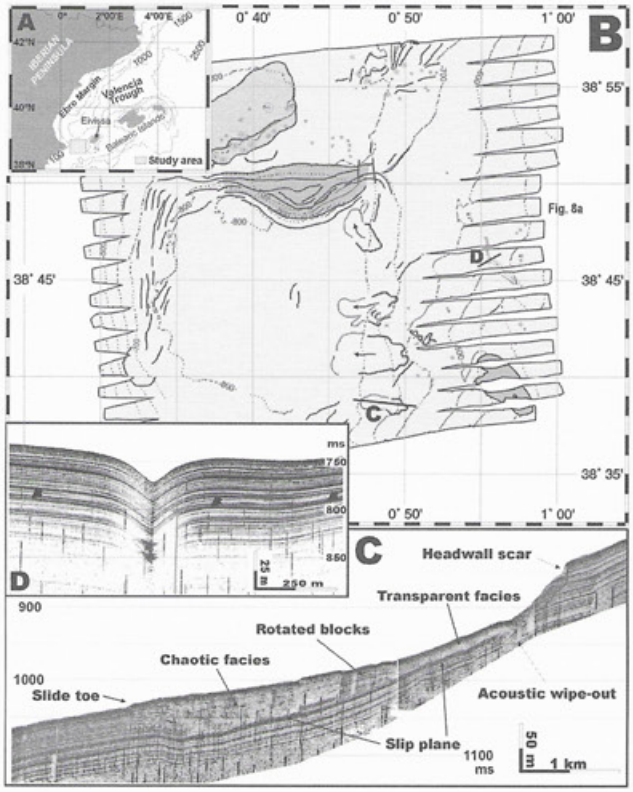


Fig. 1. A. Location map of the study area. B. Interpretation of the swath bathymetry data, showing the four slides in the Balearic margin, the pockmarks (stars), and the Xàbia Seamount (dark grey). C. Seismic profile across the Ana Slide, showing its characteristics and seismic facies. D. Seismic profile across a pockmark. Black arrows show location of the reflector related to the slip plane of the slides.

Swath bathymetry data allowed to identify four headwall scars and associated slide deposits, namely from south to north Ana, Joan, Nuna and Jersi slides, which are roughly aligned along the 0°48'E meridian on the Balearic margin flanking the southern sector of the Eivissa Channel (Fig. 1B). The Ana Slide, located at ~38°38'30"N at water depths ranging from 635 m at the rim of the headwall scar to 815 m at its toe, with a horseshoe shaped headwall scar up to 30 m high, disturbs an area of 6 km^2 and involves 0.11 km^3 of sediment (Fig. 1C). The Joan Slide, located approx. at 38°41'N from 600 to 870 m of water depth and a headwall scar up to 10 m high, affects 16 km^2 of the seafloor. The Nuna Slide, located at ~38°43'30"N between 675 and 860 m of water depth, is the result of two events disturbing 10.3 km^2 of the seafloor. It has a headwall scar of up to 20 m high. Finally, the Jersi Slide displays a 15 m high headwall scar and covers 7.9 km^2 of the seafloor at ~38°47'30"N.

Very-high-resolution seismic reflection profiles image these slides as sediment bodies mostly made of transparent seismic facies (Fig. 1C). Chaotic facies are observed at the toe of some of the slides, and blocks of coherent stratified facies embedded in the slide deposit have been identified too. These profiles demonstrate that the four slides share the same slip plane, which corresponds to a continuous, high amplitude reflector.

At a short distance from the Ana Slide headwall there is an acoustic wipe-out (Fig. 1C). In plan view, the headwall is complicated by a semi-circular embayment that could mark the location of a former large pockmark. Acosta *et al.* (1) identified the pockmark field north of Xàbia Seamount, in the northern Eivissa Channel region, but additional pockmark fields and isolated pockmarks can be identified south of the Xàbia Seamount, upslope the slides (Fig. 1B). These are often aligned, ~100 m in diameter and ~15 m in depth. They are either currently active or have been active in recent times. This is supported by the lack of buried pockmarks in the profiles and by the fact that all of them disturb not only the uppermost sediment layers but also the seafloor (Fig. 1D).

Since pockmarks are related to the headwall scars of some of the slides, it can be stated that there is a link between fluid escape features and destabilisation of the upper sediment layers. The role of pockmarks in favouring the triggering of the slides may be double. Escaping fluids forming the pockmarks may have been injected into the common slip plane, thus increasing the pore pressure; and pockmarks represent a discontinuity reducing the shear resistance along the potential failure plane. The fact that all the slides in the Eivissa Channel occupy the same stratigraphic position and share the same slip plane could indicate that they occurred simultaneously following a common triggering mechanism.

References

1 - Acosta, J., Muñoz, A., Herranz, P., Palomo, C., Ballesteros, M., Vaquero, M., Uchupi, E., 2001. Pockmarks in the Ibiza Channel and western end of the Balearic Promontory (western Mediterranean) revealed by multibeam mapping. *Geo-Mar. Lett.*, 21: 123-130.

THE BLACK SEA AS A RECORD OF THE YOUNGER DRYAS CLIMATE CHANGE

Gilles Lericolais [1] *, Nicolae Panin [2], François Guichard [3], Irina Popescu [2]
and the Blason scientific crew

[1] IFREMER, Centre de BREST, BP 70, F29200 Plouzané cedex, France
[2] GeoEcoMar, 23-25 Dimitrie Onciul Str , BP 34-51, Bucuresti, Romania
[3] LSCE, CNRS-CEA, Avenue de la Terrasse, BP 1, 91198- Gif-sur-Yvette cedex, France

Abstract

The north-western Black-Sea continental shelf was revisited from April 23rd to May 23rd 1998 within the French-Romanian BlaSON (Black-Sea Over Neoeuxinian) survey on Board the French RV *Le Suroît*. More than 4500 km of multichannel (24) High Resolution (HR) seismic reflection data were acquired in parallel with multibeam echo-sounding (EM1000), monochannel Very High Resolution seismic and Chirp Xstar data. Several hundred of kilometres of seismic have been shot also over the Danube deep sea fan, in strike and dip direction in order to have a general understanding of the sediment supplies from the delta over the Quaternary periods.

Keywords : Black Sea; Rapid transgression; Younger Dryas; Climate variability

The transition of the Black Sea system from a fresh-water lake to a marine environment was perhaps one of the most dramatic Late Quaternary environmental events in the World. It has been proposed (1) that 20,000 years ago the Black Sea was a giant freshwater lake. Till recent studies, the generally accepted picture was that the postglacial warming and melting of ice caps which started 15,000 yr ago, generated a general rise of the sea level. As the Black Sea was in a very close vicinity to the Scandinavian-Russian ice cap, the supply of the melting water from the glaciers into the Black Sea was supposed to be sufficiently important that at approximately 12,000 yr B.P., the level rose up to the Bosphorus sill and even higher (much quickly than in Mediterranean basin). Thus, a large flux of fresh water flowed through the Bosphorus-Dardanelles towards the Aegean Sea and the two-way water exchange was established, starting so the process of transformation of the Black Sea in anoxic brackish sea. Based on results collected on the Ukrainian shelf in 1997, American scientists (2) proposed another theory to comment the re-connection between the Mediterranean Sea and the Black Sea. For these authors, the sill of the Bosphorus was breached by about 7,150 yr B.P. and a catastrophic flooding of the continental shelf of the Black Sea was inferred in the course of global sea-level rise. Saltwater poured through this spillway to refill the lake and submerged more than 100,000 km^2 of its previously subaerially exposed continental shelf.

In August 2002, the French research vessel *Le Suroît* equipped with a EM 300 multibeam echosounder and a TritonElics Chirp Sonar mapped the Bosphorus outlet at the shelf edge.

The results show the existence of an important retrogressive canyon incised on the platform and two more recent canyon heads, the incision of which can be followed landward on the shelf in front of the Bosphorus outlet. The direction of these canyon heads being West-East is puzzling. One suggestion is that they may follow a tectonical direction. Coring realized on the platform and then in the canyon itself revealed some meggaripples made of shell debris and witnessing a very recent activity.

The results presented here confirm that the Holocene climate modifications in the intercontinental setting of Eastern Europe had a significant implications on the behaviour of the Black Sea sea-level fluctuation. Rare preservation of an intact regressional surface, two-way exchange of water through the Bosphorus and Dardanelles Straits, and impact on the Neolithic population are the major consequences related to reconnection between the Marmara Sea and the Black Sea.

References

1 - Degens, E.T. and Ross, D.A., 1974. The Black Sea - Geology, Chemistry and Biology, 20. Amer. Assoc. Petroleum Geol., Tulsa, 633 p.
2 - Ryan, W.B.F. *et al.*, 1997. An abrupt drowning of the Black Sea shelf. *Marine Geology*, 138(1-2): 119-126.

MORPHOLOGIC FEATURES OF THE MARESME CONTINENTAL SHELF (NE BARCELONA) AND THEIR CAUSAL SEDIMENTARY PROCESSES

C. Liquete [1] *, R. Urgeles [1], M. Canals [1], J.H. Clarke [2]

[1] GRC Geociències Marines, Dept. Estratigrafia, Paleontologia i Geociències Marines, Fac. Geologia, Univ. de Barcelona, Spain - * cliquete@geo.ub.es

[2] Ocean Mapping Group, Univ. of New Brunswick, Fredericton, New Brunswick, Canada

Abstract

The seafloor bathymetry, backscatter and upper sediment cover of the Maresme continental shelf (NE Barcelona) were analized by means of multibeam mapping and very high resolution seismic reflection profiling. Two large morphological steps identified as part of relict coastal sand bodies as well as some longitudinal beachrock bars have been linked to successive sea level rise pulses. Numerous bedforms with NNE-SSW orientation are related to present long-term and/or stormy currents. In conclusion, the overall morphology and sediment distribution in the study area results from fluvial sediment input and relative sea level variations during the Late Quaternary.

Keywords: Maresme continental shelf, high-resolution morphology.

Full coverage Simrad EM1002 data and very high-resolution Simrad TOPAS parametric profiles were collected from the Maresme continental middle and outer shelf (NE Barcelona), between the Blanes, Arenys and Mataró canyons, covering an area of around 28×16 km (2°20'-2°50'E, 41°15'-41°40'N). The EM1002 data were used to construct detailed bathymetric and shaded relief maps, backscatter mosaics and combined products of the Maresme continental shelf that, together with the TOPAS profiles, depict the major morphosedimentary elements occurring in the area.

The Maresme coast is mostly wave-dominated and the seafloor is primarily sandy. Prevailing oceanographic currents (mainly the Liguro-Provençal current) and littoral drift flow southwestwards. Typical mesoscale anticyclonic structures migrating from the Gulf of Lions are often present in the study area (1), as well as other ones related to the local submarine physiography (2). Winter storms caused by strong eastern winds create downwelling bottom currents that can transport large volumes of sediment downshelf and offshore (3).

Inspection of the TOPAS profiles shows that the upper sediment cover (most probably Late Quaternary) ranges from 3 to 10 m thick on the westernmost part of the study area to more than 40 m on the easternmost part. The dominant sedimentation pattern is aggradational. Seawards, the sediment cover is more scarce and the terrain more rugged, as can also be observed in the EM1002 data.

The most conspicuous morphological features of the study area are two large steps around 20 m high subparallel to the coastline (Fig. 1). The shallowest one deepens eastward from 40 to 70 m depth evolving to a more subdued relief, while the deepest one ranges from 100 to 120 m depth and shows a gentler slope. These two steps were interpreted as relict sand bodies built up during the Versilian transgression in a shoreface environment (3). Indeed, they seem to be related to different sea level stages showing, at least the deepest one, a progradational internal structure. The relative coarse nature of their sediments appears to be confirmed by a relatively high backscatter compared to surrounding areas (Fig. 1). The upper truncation of these bodies indicates that they have been later reworked.

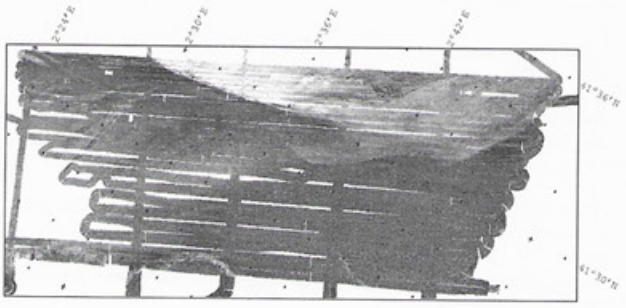


Fig. 1. Backscatter mosaics show a clear difference in reflectivity values above and below the two morphological steps. The largest beachrock bars, showing relative high backscatter (light tones), can be noticed in the upper left part of the picture. Mataró and Arenys canyon heads start at the bottom left corner of the map.

Different groups of longitudinal bedforms (probably dune fields) appear over most of the study area. The structures show different size and textural properties but all them maintain a NNE-SSW orientation. Their origin is probably related to long-term and/or stormy currents which undergo refraction processes and propagate from deeper to shallower areas.

Below the steps, two large crescent shaped bars appear. They become asymptotically parallel to the coast and are probably made up by partially cemented deposits. Their orientation turns from N-S to NE-SW being finally buried by the sediments forming the steps. Their morphology appears similar to that of other minor bodies parallel and closer to the shoreline that have been identified as beachrocks (4). Therefore, these structures can be also linked to successive sea-level rise pulses.

At the northwestern end of the steps, near the Blanes Canyon, the sea-floor becomes very steep, whilst sediment thickness increases suddenly. This appears to be related (a) to a deceleration and consequent lost of competence of the coastal southwestward current previously constrained by the Blanes Canyon head, (b) to the influence of the Tordera River input and/or (c) to a continuous sediment capture towards the aforementioned depressed area and, ultimately, to the Blanes Canyon (2,3).

In conclusion, the Maresme shelf shows a morphological signature that is largely the result of sediment input from the continent and reworking of these sediments during emersion and transgression periods and, more recently, by bottom currents. The shelf morphology and sediment cover show the result of the interplay between these processes during the Late Quaternary.

References

1 - Arnau P.A., 2000. Aspectos de la variabilidad de mesoescala de la circulación marina en la plataforma continental catalana. Universidad Politécnica de Cataluña, PhD Thesis, 426 p.

2 - Granata T.C., Vidondo B., Duarte C.M., Satta M.P. and Garcia M., 1999. Hydrodynamics and particle transport associated with a submarine canyon off Blanes (Spain), NW Mediterranean Sea. *Cont. Shelf Res.*, 19: 1249-1263.

3 - Diaz J.I. and Maldonado A., 1990. Transgressive sand bodies on the Maresme continental shelf, Western Mediterranean Sea. *Mar. Geol.*, 91: 53-72.

4 - Serra J., 2002. Els condicionants geomorfològics de les praderies de *Posidònia* del Maresme. *L'Atzavara*, 10: 7-10.

BEDFORMS ACROSS A SANDY-GRAVEL CONTINENTAL INNER SHELF, MARETTIMO ISLAND (EGADI ISLANDS; SOUTHERN-WESTERN TYRRHENIAN SEA)

Claudio Lo Iacono [1] *, Jorge Guillén [2]

[1] Dipartimento di Geologia e Geodesia, Università di Palermo, Via Archirafi 26, 90126 Palermo, Italy - * clageo@katamail.com
[2] Istituto de Ciencias del Mar, C.S.I.C., Pg. Maritim de la Barceloneta 37-49, E-08039 Barcelona, Spain - jorge@cmima.csic.es

Abstract

Side scan sonar data were recorded across Marettimo island inner shelf (Egadi Islands; southern-western Tyrrhenian sea). The distribution and morphological characteristics of bedforms were analyzed across this sandy gravel inner shelf to examine possible forcing mechanisms. It is discussed that these morphological features could be produced by waves of period higher than 8 s and/or medium-high velocity bottom currents.

Keywords: gravel and sandy bedforms; inner shelf; waves and currents

Introduction

Inner shelf gravel bedforms have been observed in a number of shelves around the world (1, 2, 3). In the Mediterranean, few studies deal with bedforms on sandy gravel shelves: Kenyon and Belderson (4) described coarse sand sandwave across Spanish and Moroccan shelves and Lykousis (5) observed coarse megaripple in the Aegean Sea. The sedimentary processes able to generate gravel bedforms in moderate-energy environments like the Mediterranean are unclear from previous studies. However, it is relevant to know if these bedforms are relict features that correspond to episodic/catastrophic events occurred in the past or, in contrast, they can be generated by present day processes.

In this study, bed features have been recognized, measured, described and digitally mapped. The aim of this work is to reconstruct which are the forcing processes that could generate them.

Methods

Side scan sonar records range in water depths of 10-60 m and have been obtained during a cruise around the Egadi Island offshore. The instrument was a chirp technology side scan sonar, model SIS 1500 (Benthos-Datasonics), operating at 100 kHz.

Sea bed samples were recovered by mean a Van-Veen grab sampler. Calibration by dives was effectuated for collecting further sedimentological data and observing sedimentary structures dimensions.

Bedforms and their distribution

Data analysis revealed the presence across the inner shelf of symmetrical coarse grained subaqueous dunes and elongated small sand patches. Bed forms can be defined as small subaqueous dunes *sensu* Ashley (6). They are observed all over the inner shelf, from 15 to 50 m depth, and range from 1 to 2.2 m in wavelength and from 0.15 to 0.30 m in height. These bedforms are formed in sandy-gravel areas with modal grain sizes ranging from 2 to 11 mm. The biggest dunes appear at 25-35 m water depth, their orientation is almost parallel to the coast (35° E) and the sediment displays a medium grain size of 8-11 mm.

Sand patches have been observed in a small area of the north eastern sector of the inner shelf. They develop from 40 m to the maximum depth of the survey coverage (60 m approx.), in a main direction perpendicular to the coast. Their width varies from 50 to 150 m and the sediment corresponds to sinuous bands of medium sand over a gravel and sandy gravel area.

Discussion about forcing mechanisms for the formation of the subaqueous dunes

Theoretical estimation using different hydrodynamic conditions (waves and currents) have been effectuated to investigate over the forcing mechanisms that generated the observed small subaqueous dunes.

Starting from hypothetical waves conditions (height ranging from 3 to 6 m; period raging from 7 to 11 s), applied to different grain sizes sediments (2, 5, 10 mm), theoretical dune dimensions (7, 8) have been obtained (Fig. 1). For a depth interval of 10 - 70 m, bedform wavelength (λ) values range from a minimum of 0.5 m to a maximum of 4 m. No relevant differences were observed in the resulting dimensions of sedimentary structures using grain sizes from 2 to 10 mm.

Threshold conditions for sediment movement based on the critical Shields parameter (θcr) values (9) have been obtained for different grain sizes (1-10 mm),. The corresponding critical velocities values (uz cr) at 1 m above the bottom (10), reveal how the critical values for sediment moving ranges from 0.56 to 1.85 m/s for grain sizes of 1 to 10 mm respectively.

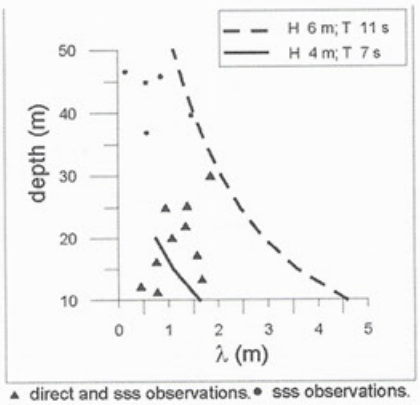


Fig. 1. Bedform spacing (λ) (8) for different waves conditions compared to Marettimo sub. dunes. Theoretical equations have been applied to 2 mm grain size sediments.

The wavelength of the Marettimo subaqueous dunes are comprised within interval obtained by theoretical formulas. Most of the observed dunes could have been formed with the presence of waves ranging from 4 to 6 m in height and 7 to 11 s in period. These conditions can be reached during strong NW storms that episodically occur on the north-western Sicilian continental shelf (11). Sand patches can develop with the presence of moderate velocity bottom currents (< 50 cm/s).

Conclusions

Comparison between observed dunes with theoretical estimations of bedform characteristics generated under different hydrodynamic conditions, suggests that most of bedforms observed on the Marettimo inner shelf can be caused by waves of 4-6 m in height and 7-11 s in period. Therefore, dunes are active morphological features only during major storms and are relict bedforms for most of the time.

References

1 - Langhorne D.N., Heathershaw A.D., Read A.A.,1986. Gravel bedforms in the West Solent, Southern England. *Geo Mar. Lett.,* 5: 225-230.

2 - Forbes D.L., Boyd R., 1987.Gravel Ripples on the inner Scotian Shelf. *Jour. Sed. Petrology*, Vol. 57, 1: 46-54.

3 - Anthony D., Leth J.O., 2002.Large-scale bedforms, sediment distribution and sand mobility in the eastern North Sea off the danish west coast. *Mar. Geol.*, 182: 247-263.

4 - Kenyon N.H., Belderson R.H., 1973. Bed-forms of the Mediterranean undercurrent observed with side-scan sonar. *Sedim. Geo.,* 9: 77-99. -172.

5 - Lykousis V., 2001. Subaqueous bedforms on the Cyclades Plateau (NE Mediterranean) – evidence of Cretan Deep Water Formation? *Cont. Shelf. Res.*, 21: 495-507.

6 - Ashley G.M., 1990. Classification of large scale subaqueous bedforms: a new look at an old problem. 1997 SEPM Bedforms and bedding structures research symposium, Austin, TX. *Jour. Sed. Petrology,* Vol. 60: 160-172.

7 - Grant W.D., Madsen, O.S., 1982. Moveable bed roughness in unsteady oscillatory flow. *J. Geophys. Res.,* 87: 469-481.

8 - Nielsen P., 1992. Coastal Bottom Boundary Layer and Sediment Transport. World Scientific Publishing, Singapore, Advanced Series on Ocean Engineering, vol. 4.

9 - Soulsby R. L. & Whitehouse R. J. S. W., 1997. Threshold of sediment motion in coastal environment. Proc Pacific Coasts and Ports '97 Conf. Christchurch, 1, pp 149-154. University of Canterbury, New Zealand.

10 - Soulsby R.L., 1997. Dynamics of marine sands. Thomas Telford editions. London.

11 - Istituto Idrografico della Marina, Genova, 1979. Il vento e lo stato del mare lungo le coste italiane e dell'Adriatico. Vol III, IIM editions.

CHARACTERISTICS OF SLOPE INSTABILITIES OF THE NILE DEEP-SEA FAN

Lies Loncke [1] *, Virginie Gaullier [2], Sébastien Migeon [3], Laurence Droz [4] and Jean Mascle [3]

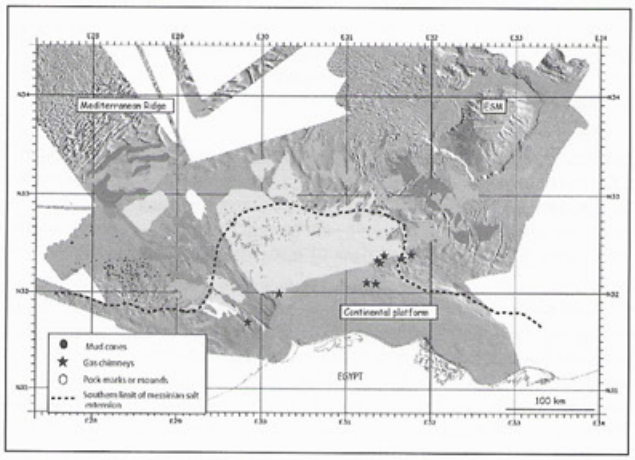
[1] Université de Picardie Jules Verne, Dept. de Géologie, Amiens, France - *lies.loncke@u-picradie.fr
[2] Univ. de Perpignan, France - gaullier@univ-perp.fr
[3] Géosciences Azur, Villefranche-sur-Mer, France - migeon@obs-vlfr.fr, mascle@obs-vlfr.fr
[4] IUM, Univ. de Bretagne Occidentale, Plouzané, France - ldroz@univ-brest.fr

Abstract

The Nile deep-sea fan, turbiditic system reaching a size of about 90 000 km^2 is the locus of multi-scale slope instabilities. Three main types of instabilities have been defined: (1) first order instabilities, related to the generalized gravity spreading of the Plio-Quaternary deep-sea fan on Messinian salt layers. This global spreading is accomodated by numerous localized slides, (2). Second order instabilities. These are corresponding to giant mass movements related either to earthquakes, fluids, eustatism or sedimentary overloading. Finally, (3) third order instabilities, corresponding either to localized levee liquefactions or to thin-skinned slides on the steep slopes of the Eratosthenes seamount.

Key words : Slope instabilities, salt-tectonics, eustatism, fluids, Nile deep-sea fan

The Nile deep turbiditic system, reaching a size of about 90 000 km^2, is the most important terrigenous system of the Mediterreanen sea. It is the place of important slope instabilities, giving rise to mass wasting deposits differing in size and location. These deposits are interfingered between turbiditic units and participate for an important part of the edifice's building. We defined three main type of instabilities, that correspond to three main scales of events (Fig. 1):



(1). **First order instabilities** related to the regional gravity spreading and gliding of the Plio-Quaternary sedimentary cover above thick Messinian mobile evaporites. These regional movements are accomodated by frequent readjustements of proximal extensional faults and distal contractional folds, leading to localized slides. The resulting mass deposits are settled at the foot of growth faults or the flank of folds. They are generally thin, not exceeding a few meters in thickness, but extremely frequent. They appear as acoustically transparent or chaotic bodies on 3-5 kHz profiles. These are frequently interfingered between bedded deposits. These instabilities are reccurent and their location can be roughly predicted: they appear in all areas where salt is thick enough to allow gravity movements.

(2). **Second order instabilities** corresponding to giant mass movements not related to salt-tectonics. One recent instability of this type, more than 12100 km^2 in surface, is particularly well imaged in the central province of the Nile deep-sea fan (1). This slope area exhibits rough and chaotic small-scale reliefs, together with linear furrows (e.g., channels), disconnecting individual sedimentary flows. On 3-5 kHz profiling, this area displays a creeping sedimentary cover whose maximum thickness is of about 30 meters, slowly gliding on the top of a a debris flow. This debris flow has been cored and shows numerous mud clasts. On top of this creeping area, numerous high reflectivity patches, corresponding to pockmarks, have been observed on backscatter imagery. Pockmarks and gas chimneys have also been observed in the vicinity of the failure area. The association between those destabilized deposits and pockmarks suggests that both phenomena are probably related.

Giant mass movements have also been active in the past, in the western province of the Nile deep-sea fan. This area corresponds to the main active turbiditic pathway and numerous slope failures are observed in its upper slope domain near the head of the feeding canyon (between 800 and 1000 meters depth). A detailed analysis based on the interpretation of high resolution seismic data allowed to define at least eight imbricated slumps that evolved downslope to large debris flows. The four main basal slumps that we defined exhibit a volume of 1900 km^3 and are covered by recent stacked channel-levees units. Smaller scale debris-flows are inter-fingered within these constructional units and led to numerous channel migrations and avulsions characterised by typical HARP's seismic facies. The slope failures corresponding to these giant destabilizations are localized very nearby gas chimneys, suggesting the importance of fluids in these phenomenons. Also, important sediment overloads, eustatic varaiation and the tectonic activity of the Cairo-Alexnadria trend may be important additional factors trigerring these destabilisations. A tentative stratigraphic correlation suggest that these imbricated slope failures, are active at least since 250 000 years. This area clearly not reached its equilibrium and seem to be potentially reactivated: numerous extensional faults upslope the last incisions suggest further retrogressive evolution of these slumps.

(3) finally, less impressive **third order slope instabilities** have been defined. Some of them are associated with ponctual liquefactions of channel levees in the mid-slope domain. These events sometimes led to channel avulsion. Small slides have also been observed in another context, on the sides of the Eratosthenes seamount, piece of continental crust involved in the subduction near Cyprus, bounding the northeastern part of the Nile deep-sea fan. The sides of this seamount are very steep and "thin-skinned" slides are numerous. Slope failures are concave and deformation toes convex. These slides seem to be related both to the steepness of the sides of the seamount and to extensional tectonics.

To conclude, different types of instabilities, corresponding to different stimulations have now been defined on the Nile deep-sea fan area. Their relative importance in terms of volume has now to be defined more quantitatively and the potential relationship between giant slope instabilities and fluids has to be investigated. Also geotechnical measures on cores will be performed. This will be the basis of proper risk assessment studies.

References

1 - Loncke, L., Gaullier, V., Bellaiche, G. and Mascle, J., 2002. Recent depositional patterns of the Nile deep-sea fan from echo-character mapping. *AAPG bulletin*, 86/7: 1165-1186.

IN-SITU OBSERVATION OF POCK-MARKS FROM THE NILE DEEP-SEA FAN DURING THE NAUTINIL CRUISE: PRELIMINARY RESULTS

Lies Loncke [1] *, Germain Bayon [2], Sébastien Duperron [3], Jean Mascle [4] et l'équipe scientifique Nautinil

[1] Université de Picardie Jules Verne, Dept de Géologie, Amiens, France- * lies.loncke@u-picardie.fr
[2] IFREMER, Département Géosciences Marines, Plouzané, France - Germain.Bayon@ifremer.fr
[3] IFREMER, Département Environnement Profond, Plouzané, France - Sebastien.Duperron@ifremer.fr
[4] Géosciences Azur, Villefranche-sur-Mer, France - mascle@obs-vlfr.fr

Abstract

Recent geophysical surveys on the Nile deep sea fan have revealed numerous patches of high reflectivity, mainly in the Central province, locus of recent sediment slumps. It has been suggested that those features may correspond to pockmarks linked to gas-rich fluids escaping the seafloor. Here we present preliminary results from the Nautinil cruise, which has taken place on the Nile deep-sea Fan from September 3rd to October 5th 2003. Direct observation of the seafloor with the Nautile submersible has confirmed that these high reflective patches correspond to carbonate concretions associated with cold seeps. Two distinct types of structures have been identified: (1) circular pockmarks with central carbonate chimneys or debris, and (2) massive carbonate pavements of Mg-rich calcite and aragonite. A specific fauna has been observed in association with these seeps.

Key words : pockmarks, cold seeps, carbonate crusts, Nile deep-sea fan

Since 1998, several geophysical surveys (multibeam bathymetry, backscatter imagery, 3-5 kHz profiling, MCS data) have shown that the Nile deep sea fan (NDSF) exhibits various structures characteristic of an active fluid circulation within continental margin sediments. Those structures include mud volcanoes ressembling small cones (100 to 900m in diameter), mud-pies (5 km in diameter), and pockmarks or mounds [1; 2]. Pockmarks and mounds, represent the most widely observed evidence of potential cold seeps on the NDSF. They are particularly abundant in its Central province, between 1700 and 2500 water depth, where they are characterized by distinctive high backscatter patches. In this province, a widespread field of pockmarks coincides with an area of major sediment destabilization, which covers an area of more than 10 000 km^2 [3]. Multibeam bathymetry reveals that this slope area exhibits rough and chaotic small-scale reliefs, together with linear furrows (e.g., channels), disconnecting individual sedimentary flows. The association between those destabilized deposits and pockmarks suggests that both phenomena are probably closely related. Although no clear BSR has yet been observed in this area, the potential presence of gas hydrates remains a possibility which may explain this association between slump deposits and pockmarks.

In september 2003, the NAUTINIL cruise, as part of the Mediflux European program, has allowed the in-situ observation of these highly reflective patches with the Nautile. Three dives on different parts of the central province, between 1700 and 2000 meters depth, have confirmed that high backscattered patches in this part of the Nile cone correspond both to active and extinct cold seeps. More specifically, high-reflectivity signals are induced by massive carbonate concretions, which precipitate from fluids escaping the seafloor. Two distinct sedimentary structures have been observed during these dives:

1) circular pockmarks of variable diameter (~3-15m), where carbonate chimneys (up to ~1m height) and/or infilled burrows have sometimes built up in the central part. Observed pockmarks are coalescent one to each other, covering areas varying from ~30m^2 to 100m^2. Debris of authigenic carbonates and dead shells (pogomorpha tubes, clams, urchins...) accumulate in the central part of all pockmarks. In some pockmarks, carbonate chimneys (composed mainly of magnesian calcite and aragonite) have been identified together with unfilled burrows, covered by manganese oxides. Carbonate chimneys are ~1m height and are composed of several distinct layers of aragonite (up to 10). Unfilled burrows almost certainly formed within the first few cm below the sediment/water interface initially. Therefore, the presence of these burrows on top of one carbonate chimney suggests that these chimneys may have formed within the sediment similarly. From this above consideration, it would be expected that freshly precipitated carbonates form from the base of the chimney. Then, winnoying of the soft sediment around the freshly emplaced carbonates would bring this aragonitic layer 'out of' the sediment and allow the chimney to "grow". Living fauna (pogomorpha worms, urchins) can be observed at the base of the carbonate chimney.

2) massive carbonate pavements of aragonite, covering larger areas (> ~100m^2) of the seafloor. As a matter of fact, high-reflectivity signals can also be associated to massive carbonate pavements, sometimes covered by pelagic sediments. No fauna has been observed on their surface. Those carbonate slabs are intensively fractured in ~m^2 size pieces. This has allowed us to examine some fresh cuts across the pavements. It consists mainly of "*gruyere-like*" magnesian calcite (i.e., calcite scattered with mm- to cm-size holes). Whereas the surface of the pavements has been intensively oxidised (i.e., brownish ochre color), fresh cuts of aragonite are greyish. Underneath the pavements, living fauna (pogomorpha worms, urchins, clams, galatheas, mussels) are extremely important.

The discovery of these cold seeps associated with authigenic carbonate precipitates demonstrate that sub-circular patches of high-reflectivity almost certainly correspond to areas where gas-rich fluids escape the seafloor. While circular pockmarks must be linked to localised fluid vents, massive carbonate pavements most likely correspond to more diffused flow of gas from the seafloor.

Several push-cores have been taken and carbonate samples have been grabbed. In the near future, a better characterization of those authigenic carbonates (mineralogy, geochemistry, dating) will bring additional constraints on how pockmarks may form in such cold seep environments. In addition, geochemical analyses on sediments sampled by the push-cores will help determining the gas source (biogenic or thermogenic?) and the eventual presence at depth of gas hydrates.

References

1 - Loncke, L., 2002. Le delta profond du Nil: structure et évolution depuis le Messinien (Miocène terminal). Thèse de doctorat de l'Université Paris 6. 209 p.

2 - Loncke, L. Mascle, J. et l'équipe scientifique Fanil. Mud volcanoes, gas chimneys, pock-marks and mounds in the Nile deep-sea fan (Eastern Mediterranean): geophysical evidences. *Marine and Petroleum Geology* (submitted).

3 - Loncke, L., Gaullier, V., Bellaiche, G. and Mascle, J., 2002. Recent depositional patterns of the Nile deep-sea fan from echo-character mapping. *AAPG bulletin*, 86/7: 1165-1186.

SWATH MAPPING SYNTHESES OF DEEP MEDITERRANEAN SEA BASINS : A PARTNERSHIP BETWEEN SEVERAL NATIONAL OCEANOGRAPHIC INSTITUTIONS, COORDINATED BY CIESM AND IFREMER

Benoit Loubrieu [1] and Jean Mascle [2] *

[1] Ifremer, Centre de Bretagne, Plouzané, France
[2] Géosciences-Azur, Observatoire de Villefranche, Villefranche/Mer France

Abstract

Swath mapping of most of the deep Mediterranean Sea basins is currently progressively completed by several national Oceanographinc/Hydrographic Institutions from Southern Europe. The CIESM Marine Geosciences Committee and Ifremer DRO mapping office have jointly promoted and pilot compilations and publication of synthesis maps of the Eastern and Western Mediterranean basins, These maps reveal many geological characteristics (tectonic, volcanic, sedimentologic, geochemical) imprinted on the sea floor. The first map (Eastern Mediterranean), already published in 2001, is now progressively upgraded using new data sets; the second one (Western Mediterranean) is a new synthesis based on swath data originating from Italian, Spanish and French Institutes and laboratories.

Key words: Mediterranean basins, swath bathymetry synthesis

Introduction

Since about 10/12 years systematic swath mapping surveys (including bathymetry, and often acoustic bottom reflectivity) have been conducted in the deep Mediterranean sea, particularly in its Eastern basins, and more recently in the Western ones. These data have been collected for two main purposes : **(a)** for each country to obtain a better knowledge of their EEZ; **(b)** a better understanding of the complex and active sedimentary, geochemical, volcanic, and tectonic processes operating concurrently in the Mediterranean marine spaces.

These data have been systematically recorded by different national oceanographic and hydrographic Institutions or Laboratories from Europe (France, Greece, Italy, the Netherlands and Spain mainly) most of the time in the framework of national programs.

In 1999 the CIESM Marine Geosciences committee has promoted an unformal cooperation between several laboratories willing to cooperate in producing compilations of swath data to better image, at a basin scale, the various active processes shaping the seafloor of the Eastern Mediterranean Sea. Ifremer DRO mapping office has been volunter to act as the necessary technical advisor and practical support for these compilations. A first set of two maps (bathymetry and acoustic imagery), at a scale of 1/1.500.000, has been produced in 2001 (1). These maps illustrate the startling changes brougth to the knowledge and understanding of deep basins by mapping using swath systems. They particularly reveal a completely new view (and greatly help to a better understanding) of most of the major physiographic features (Mediterranean ridge, Nile cone, etc.) of the deep basin.

During the last CIESM congress (Monaco, September 2001) a round table on swath mapping of the Mediterranean sea has concluded on the great scientific interest and necessity to: **(1)** promote, if possible, a compilation, at the scale of 1/1.500.000, of available sawth data for the Western Mediterranean Sea.; **(2)** up-grade, as far as possible and using all new data made available by partners willing to participate, the Eastern Mediterranean sea compilation.

We present here the state of the art concerning these two attempts.

Eastern Mediterranean Sea compilation (see Fig. 1)

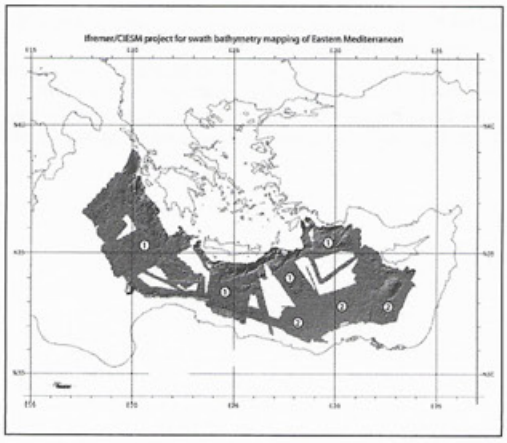


Fig. 1. Present stage of the Eastern Med Sea multi-beam bathy-metric compilation.

A detailled map of the Egyptian margin has been published in 2003 (2). Recent data recorded in 2001 and in 2003 (Fanil, Blac and Nautinil expeditions, respectively) by different French laboratories (Géoscience-Azur, Villefranche; Legem, Univ. Perpignan; Ifremer DRO-GM, Brest) will be incorporated to the compilation, as well as a few swath data, mainly from the Aegean sea, to be potentially provided by HCMR (Greece). Moreover it is hoped that complementary data will be obtained during a new french survey already scheduled in late 2004.

Western Mediterranean Sea compilation (see Fig. 2)

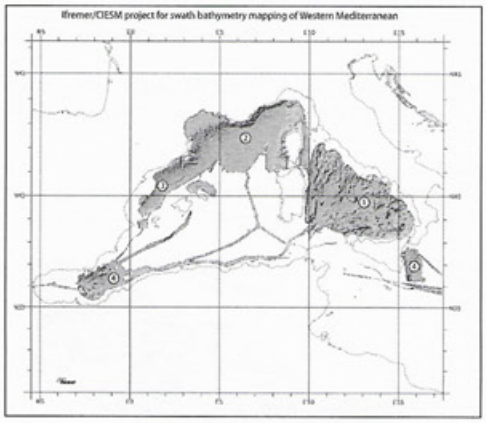


Fig. 2. Present stage of the Western Med Sea multibeam bathymetric compilation.

Different Institutions (ISMAR Bologna, Italy; Ifremer and IUEM, Brest, France; IEO, Madrid, GRC, Barcelona and IACT, Granada, Spain) have agreed to provide DTM, at a 500 m grid spacing, extracted from their own swath surveys (and processing) in Western Mediterranean sea, to Ifremer DRO-GM mapping office in charge to construct an homogenous synthesis which will be the first multibeam echo-sounding derived map for the Western Mediterranean Sea.

The two maps (upgraded Eastern and new Western Mediterranean), at a scale of 1/2.000.000, should be jointly published by CIESM and IFREMER in late 2004. It is also anticipated to publish a map of the whole Mediterranean sea at a scale of 1/4.000.000.

These documents, the first multibeam bathymetric maps of a complete oceanic space, will greatly improve our global knowledge of the Medietereanean sea floor and of its different geological processes.

Finally we anticipate that such an open, and productive, collaboration will progressively widen to others laboratories and Institutions, and lead to a mapping, as complete as possible, of the deep Mediterranean basins. We also hope that data from shallower areas (continental shelf and uppermost slope) will soon be made available to produce a complete picture of the Mediterranean sea and thus provide a necessary link with the still evolving adjacent onshore domains.

References

1 - Loubrieu B., Satra C., Cagna R., 2001. Cartography by multibeam echo-sounderof the Mediterranean Ridge and surrounding areas. 2 maps échelle 1/1500000ème (Acoustic image and Morpho-bathymetry of the Nile deep-sea Fan). éditions Ifremer/CIESM.

2 - Sardou O., J. Mascle, 2003. Cartography by multibeam echo-sounderof the Nile seep-sea Fan and surrounding areas. 2 maps échelle 1/600000ème (acoustic image and Morpho-bathymetry of the Nile deep-sea Fan). Géosciences Azur/ CIESM Special Publication.

NATURE ET ORIGINE DE LA PHASE ARGILEUSE DE LA LAGUNE DE SIDI MOUSSA (CÔTE ATLANTIQUE MAROCAINE)

Mohamed Maanan [1], Bendahhou Zourarah [1 *], Christian Carruesco [2], Ahmed Aajjane [1], Mustapha Labraimi [3] et Jean Naud [4]

[1] Département de Géologie, Laboratoire de Géosciences Marines, Faculté des Sciences, El Jadida, Maroc - * m_maanan@hotmail.com
[2] Département de Géologie et d'Océanographie, Université Bordeaux I, Talence, France
[4] Département de Géologie, Université Catholique de Louvain, Louvain-La-Neuve, Belgique

Résumé

L'étude des caractères de la phase argileuse de l'envasement récent de la lagune de Sidi Moussa contribue à évaluer l'origine et la nature des sédiments de remplissage. Les cortèges argileux sont comparables à ceux observés au niveau du bassin versant de la lagune de Sidi Moussa ce qui suppose une filiation continent-lagune.

Mots-cles: lagune, envasement, minéraux argileux, Maroc.

Introduction

La lagune de Sidi Moussa (32° 52' 0" N et 8° 51' 05" W) est située sur la façade atlantique marocaine. Elle est séparée de la mer par un cordon littoral et la communication est assurée par une passe permanente qui permet des échanges entre les eaux salées et saumâtres (1). Le climat qui y règne est de type méditerranéen sous influence océanique (2).

La lagune de Sidi Moussa et son bassin versant appartiennent à la grande unité structurale nommée Meseta Marocaine occidentale. Les formations géologiques qui affleurent dans la zone lagunaire et dans l'arrière pays sont d'age plio-quaternaire et sont constituées principalement de calcaires détritiques jaunes formés de débris coquilliers et de sables (3, 4).

L'objectif de la présente étude est de tenter de mettre en évidence la nature et l'origine de la phase argileuse des sédiments superficiels de la lagune.

Méthodes d'étude

Les sédiments superficiels ont été prélevés, au niveau de la zone intertidale et du chenal de la lagune par benne Van Veen (Fig. 1).



Fig. 1. Localisation des échantillons de surface et des carottes dans la lagune de Sidi Moussa.

Les minéraux argileux ont été déterminés par diffractométrie de rayon X, selon la méthode décrite par 5.

Résultats

Le cortège argileux des sédiments superficiels de la lagune de Sidi Moussa est formé par ordre de décroissance (Fig. 2), d'illite (59 % en moyenne), dont les fortes teneurs sont atteintes à l'extrémité Nord-Est (66 %) et les faibles teneurs sont enregistrées à l'extrémité Sud-Ouest de la lagune (43 %). La chlorite représente 30 % en moyenne ; les teneurs les plus élevées (38%) sont enregistrées au niveau du chenal ; la cristallinité de ce minéral est parfaite. La kaolinite représente 6 % en moyenne ; elle se trouve homogène sur toute la lagune, la kaolinite ne présente pas une bonne cristallinité. La smectite est moins représentée (5 % en moyenne), on rencontre le taux le plus élevé (13%) près des marais salants.

Discussion et conclusion

La répartition superficielle des paragenèses argileuses dans la lagune ne montre pas d'évolution différentielle notable (1). Il apparaît quelques différences entre le cordon littoral et les dunes continentales; l'illite est légèrement plus importante sur les dunes littorales que sur les formations continentales (4).

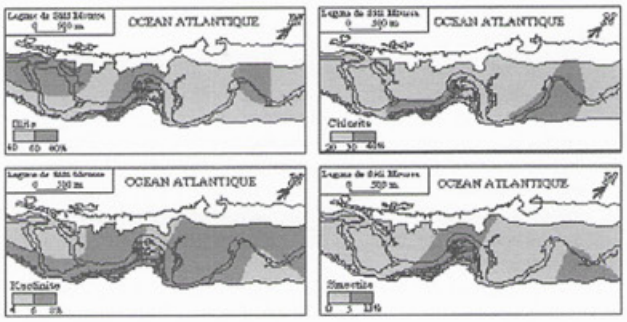


Fig. 2. Carte de répartition des teneurs en minéraux argileux au sein des sédiments superficiels de la lagune de Sidi Moussa.

Ces résultats confirment d'autres travaux qui, sur le même type de formations, un peu plus au sud de Oualidia, indiquent l'illite et la chlorite comme minéraux dominants (6). Shoen (7) note des pourcentages en illite élevés dans des sols recouvrant les formations dunaires, la chlorite est également présente. Cet auteur déduit de ses études que l'illite et la chlorite sont stables vis à vis des altérations à caractère physique, en particulier dans les zones à fortes déflations éoliennes. Ces minéraux ont pour origine les colluvions qui remanient les dépôts encaissants.

Références

1 - Maanan M., Zourarah B., Carruesco C., Aajjane A., Naud J., 2003. Etude sédimentologique et géochimique du de la lagune de Sidi Moussa (côte atlantique marocaine). *Africa Geosciences Review* (sous presse).
2 - Kabbaj A., Combe M. 1975. Ressources en eau du Maroc. Plaines et bassins du Maroc atlantique. Notes et Mem. Serv. Géolo., n° 231, t. 2, Rabat, Maroc, pp. 21-39.
3 - Bidet J.C., Carruesco C., 1982. Etude sédimentologique de la lagune de Oualidia (Maroc). *Oceanologica Acta*, 1982, N° SP: 29-37.
4 - Carruesco C., 1989. Genèse et évolution de trois lagunes du littoral atlantique depuis l'holocène : Oualidia, Moulay Bousselham (Maroc) et Arcachon (France). Thèse de Doctorat d'état, 2 tomes, 485 p., Université Bordeaux I (France).
5 - Holtzapffel T., 1985. Les minéraux argileux, préparations, analyses diffractométriques et détermination. *Soc. Géol. Nord*, 12: 136.
6 - Weisrock A., 1983. Sur la notion du pluvial au Maghreb et péninsule ibérique. *Bull. Inst. Géol.* Bassin d'Aquitaine, Bordeaux. 34: 137-149.
7 - Schoen U., 1969. Contribution à la connaissance des minéraux argileux dans le sol marocain. *Cahiers de la Recherche Agronomique*, Rabat, 26 :1-153.

GEOMORPHOLOGICAL OUTLINE FEATURES OF THE EASTERN IBERIAN PENINSULA MARGIN (WESTERN MEDITERRANEAN)

A. Maestro *, A. Martín-Serrano, E. Llave, T. Medialdea and L. Somoza
Instituto Geológico y Minero de España, Madrid, Spain - * a.maestro@igme.es

Abstract
This work is a summary of the study carried out for the preparation of the Spanish Continental Margin Geomorphological Map at 1/1.000.000 scale, that nowadays is being elaborated by the Geological Survey of Spain, Marine Geology Division. The main objective of this study is to map the main continental margin and abyssal plain morphological features, and the related active proceses, on the basis of several scientific publications and local studies from different authors and new data from recent oceanographic cruises.

Keywords: Western Mediterranean, geomorphological map, Catalonia-Iberian continental margin, Betic continental margin

In the elaboration of this map, three processes that influence the relief generation have been stablished: tectonic, erosive and depositional processes. In addition, two more groups have also been differentiated: poligenetic (unknown origin) and gravitational processes. The mapping of these elements has been carried out upon a simplified bathymetric base provided by the Marine Hydrographic Institute and upon a synthetic sea bottom lithological cartography.

Two main sectors have been differenciated in the eastern Iberian margin, specifically in the Mediterranean margin context, according to structural and sedimentary features:

1) Catalonia-Iberian continental margin. It extends from the Creus Cape (Girona) in the north, to the southern zone of the Valencia Gulf. This area is structurally controlled by two main directions: the NE-SW direction which controls the margin orientation, whereas the NW-SE direction constitutes the submarine canyons trend. The continental shelf has 55 km of average width. The principal morphologic features of this fisiographic unit are the presence of important prodeltaic bodies (where it can be remarkable the Ebro and Llobregat), and a relevant erosive surface that extends southwards the Ebro Delta, affected in its southern margin by the Columbretes Islands volcanic outcrops. The continental slope is come across by submarine canyons, some of them of huge lenght (La Fonera, Blanes and Francolí) and important turbiditic deposits (Ebro and Rodano). These canyons and turbiditic deposits converge in a broad NE-SW direction basin, named the Valencia Trough, where a turbiditic deposit named Valencia Fan is developed in its distal part, extending towards the abyssal plain.

2) Betic continental margin. It extends from the La Nao Cape, in the north, to the Gibraltar Strait, in the south, including the Balearic Islands. The morphological features of this area are controlled by a short fluvial system, giving place to scarce sedimentary supplies on the shelf, and by an intensive tectonic activity, which controlls the narrow dimensions of the shelf, and the slope compartmentalization caused by structural highs. The southern sector (Gibraltar Strait and Alboran Sea) is tectonically controlled by two main structural directions: NE-SW (e.i. Alboran Ridge) and NW-SE (e.i. Djibouti and Avempace Banks). It is remarkable the development of a significant marginal platform (Motril Platform) on the continental slope. The eastern sector is compartmentalized and controlled by the activity of N-S trending faults (Palomares and Adra faults) and E-W faults (Mazarron escarpment). In this sector it stands out the presence of sand ridges of kilometric length following a N-S orientation, which developed in front of Menor Sea. The Balearic Promontory constitutes the eastwards prolongation of the NE-SW Betic trend. The continental margin of these islands shows a narrow shelf and a smooth slope to the north and west, that becomes steeper to the south (NE-SW orientation Emile Badout escarpment) and east (N-S orientation Menorca escarpment). Both escarpments have a tectonic origin. In the Emile Badout escarpment numerous volcanic buldings have been observed. The main Betic continental margin morphosedimentary features are the Ceuta and Menorca contouritic drifts as well as the Calahonda, Almería and Menorca turbiditic fans.

USE OF MULTIBEAM ECHOSOUNDER TO DETECT TERRAIN CHANGES A ROUND TWO ARTIFICIAL REEFS (WESTERN ADRIATIC SEA, ITALY)

Sarine Manoukian *, Gianna Fabi and Alessandra Spagnolo
Istituto di Scienze Marine ISMAR-CNR, Sezione Pesca Marittima, Ancona, Italy - * s.manoukian@ismar.cnr.it

Abstract

Since the end of eighties, Senigallia and Portonovo, on the Western Adriatic Sea, host two artificial reefs at a depth of about 10 m. After about sixteen years from their construction, they were monitored through a multibeam echosounder to assess sea-bottom morphology and terrain changes around the structures. The bathymetric system was proved a very advanced geophysical instrument able to detect the distribution of artificial reefs and the location of every single unit. 3-D visualizations of the study areas showed clearly movements of the single units and subsidence of the reefs, above all the central zone.

Key-words: multibeam echosounder, artificial reefs, sea-bottom, Adriatic Sea

Introduction

During the last thirty years, fourteen artificial reefs were built-up along the Western Adriatic coast at a depth ranging from 11 to 15 meters. In the present work the artificial structures of Senigallia and Portonovo were considered after about sixteen years from their construction to observe how they altered in the time, as well as the effects on sea-bottom morphology due to the whole reef and on terrain changes around individual reef units. High-resolution seabed maps of artificial reefs created with data from a multibeam echosounder (MBES) were previously performed in Taiwan in 1998 (1;2).

Materials and Methods

Senigallia reef was built-up at 12 m depth, about 1.2 nm offshore, on a sandy-muddy seabed far from natural hard substrates. The reef was constructed in 1987 and consists of 29 pyramids, each made of five 2-m cubic concrete blocks, and twelve concrete cages (6x4x5 m) for shellfish culture placed in a rectangular arrangement. Portonovo reef was deployed in 1988 in Portonovo Bay (Conero Promontory), 0.5 nm offshore on sandy bottom at 12 m depth. It consists of 87 pyramids and 36 cages arranged in three oasis of the same type as Senigallia reef and 100 m far from each other. The main difference between the two reefs is their geographical position: Senigallia reef is an open area, exposed to winds between NW-SE and currents that run parallel to the shoreline in the same direction, while the Portonovo reef is more protected from winds and currents due to the indented coastline of the promontory.

In 2002 the two artificial reefs were investigated through the Kongsberg-Simrad MBES EM-3000 system to evaluate terrain changes around the structures. The system mounted on research vessel M/N *Tecnopesca II* belonging to ISMAR–CNR of Ancona, meets all standards suggested by International Hydrographic Organization (3).

EM-3000 operated at a frequency of 300 kHz, with an angle of 120° along six survey lines at a distance of 30 m from each other. To obtain detailed depth information the vessel speed was 3-6 knots.

Recorded data were processed using Simrad Neptune and Roxar C-Floor software. The first one allowed applying the post-processing steps: the "cleaning" of the navigation and the tidal corrections. Processed depth soundings from EM-3000 system were available as ASCII xyz files. Their processing using C-Floor was the next step to obtain 3D images of the reefs.

Results and Discussion

The geometric structure of both reefs and how the terrain around concrete blocks was changed were illustrated using sun-illuminated option (Fig. 1). Darker areas just around the single units evidenced a certain subsidence of the terrain, followed by lighter boundary that represented the bank of removed substrate. These terrain movements caused in some cases the instability of the pyramids inducing the upper block falling.

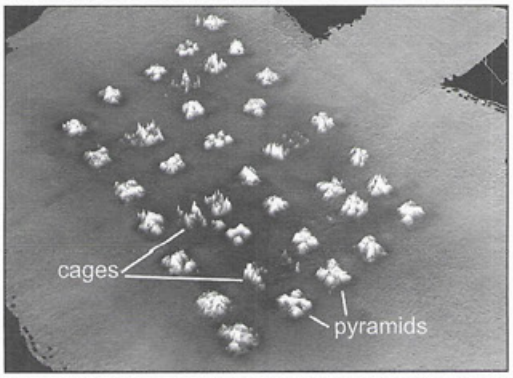


Fig. 1. Sun-illuminated 3D image of Portonovo artificial reef.

Regarding the complete bathymetric coverage of the two artificial reefs, it was possible to observe the sinking of the whole sea-bottom under the structures and particularly strong subsidence in the central zone of the areas. This vertical movement and the amount of it were also confirmed through cross sections along the longer side of the reefs. It was clearly evident from the profiles that the central areas were about 1 m deeper than the surrounding terrain (Fig. 2).

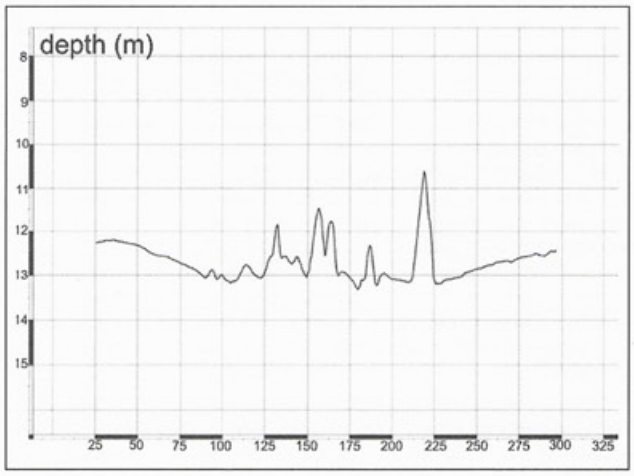


Fig. 2. Profile of a cross section along the whole length of Senigallia artificial reef.

Conclusions

The results showed that EM-3000 system was an efficient instrument not only to delimit the extension of artificial reefs but also to identify single units and to assess their spatial movements and subsidence. In fact, in both study areas, it allowed to point out a scouring of some concrete blocks that composed the pyramids and certain subsidence that occurred around the single pyramids or cages. In addition, EM-3000 enabled also to show a subsidence in the whole areas that hosted the artificial structures. It was likely that the close settlement of one pyramid or cage with the other made the reef as a single large structure that changed currents direction and wave motion, acting in this way on the bottom and inducing this significant alteration of the entire seabed morphology.

References

1 - Shyue S., 1998. Preliminary study on the distribution of artificial reefs by using multibeam echo sounder. Proceedings of OCEANS'98 – IEEE/OES: 1144-1148.

2 - Shyue S. and Yang K., 2002. Investigating terrain changes around artificial reefs by using the multibeam echo sounder. *ICES Journal of Marine Science,* 59: S338-S342.

3 - IHO Standards for Hydrographic Surveys, 1998. Special Publ., 44. 25 p.

SPATIAL-TEMPORAL VARIABILITY AND COMPOSITION OF DOWNWARD PARTICULATE MATTER FLUXES IN THE PALAMÓS SUBMARINE CANYON (NORTH-WESTERN MEDITERRANEAN)

J. Martín*, A. Palanques, P. Puig, J. Guillén

Instituto de Ciencias del Mar – CSIC, Barcelona. Spain - * jmartin@icm.csic.es

Abstract

Seven sediment traps were moored in the Palamós Submarine Canyon (NW Mediterranean) to study temporal and spatial variability of downward particle fluxes. Total mass fluxes and major constituents (organic carbon, opal, calcium carbonate and aluminosilicates) are presented here. The data obtained in the Palamós Canyon show some patterns similar to those observed in other studied submarine canyons along the north-western Mediterranean margin, although singular results were obtained in relation to the magnitude, location and timing of maximum fluxes, and to the occurrence of specific sediment transport events.

Keywords: Submarine canyons, sediment traps, particulate matter, sediment transport, downward fluxes

Introduction

The Northwest Mediterranean continental margin is indented by numerous submarine canyons, comprising about 60% of the total area in this region. Previous studies have highlighted the important role of submarine canyons in the biogeochemical cycles, particularly as channelling routes for off-shelf export of suspended organic matter.

The Palamós Submarine Canyon is one of the major canyons in this area, and its head is deeply incised in the shelf.

Material and methods

Six moorings equipped with seven sediment traps and eighteen current meters (some of them equipped with turbidimeters) were deployed inside and nearby the Palamós Canyon, three in the canyon axis at 470, 1200 and 1700 meter depth, two in the canyon walls at 1200 m depth, and two in the adjacent slope. Each mooring had a sediment trap 25 meters above the bottom.

The study lasted from March to November 2001, separated in two 4-month deployments. Subsampling and total mass flux were estimated according to the method described in (1). Organic carbon and calcium carbonate were measured using a LECO auto-analyser. Biogenic silica was analysed following the method described in (2). The lithogenic fraction was calculated as the difference between the total mass and the sum of the biogenic components.

Results and discussion

Total downward mass fluxes varied by more than three orders of magnitude inside the canyon. From 40 mg/m^2.d in the northern wall in summer to more than 100000 mg/m^2.d in the canyon axis at 1200m during the storm that took place in November 2001. The exact maximum amount is unknown, because that trap overfilled during the storm.

The trap at 470m, located at the head of the canyon, showed quite constant downward fluxes along the period of study, with a mean flux of 28758 mg/m^{2}d, but also a sharp increase in November. The canyon axis trap at 1200 m, presented a wide range of fluxes, from 8 to more than 100 g/m^{2}d, specially during summer. Deeper in the canyon axis, the trap at 1700m displays lower values (mean flux of 8484 mg/m^2.d), although there were two peaks of 40 and 60 g/m^2.d respectively, the latter corresponding to the November storm.

Regarding the downward fluxes in the canyon walls, these were higher in the southern wall, where the mean flux was 5157 mg/m^{2}d. In the northern wall, the mean flux was about three times lower than in the southern wall (1514 mg/m^{2}d). In both sites, there was a maximum of downward fluxes in November, coinciding with the occurrence of a major storm. Finally, in the open slope at 1200 m the maximum downward flux occurred in spring (230 mg/m^2.d), decreasing by an order of magnitude in summer. During the November storm, downward flux at this slope site was only 175 mg/m^{2}d. The mean downward fluxes at the open slope are from 4 to 70 times lower than inside the canyon.

Regarding particulate matter composition, the lithogenic fraction dominated the composition of the settling particles at all sites. At each location, the percentages of aluminosilicates and carbonates were relatively constant during the experiment. The maximum contents of opal and organic were coherent with the spring biological bloom in almost all traps. In general, the biogenic fraction was inversely correlated with the total mass fluxes. A seasonal pattern with higher fluxes in winter was more evident in the open slope. The sites at 470 m and 1200 m along the canyon axis showed relatively constant and low values of biogenic constituents throughout the year, whereas the rest of the sites displayed wider ranges of biogenic constituents and followed, to some extent, the slope seasonal pattern.

This spatial-temporal distribution of total mass fluxes and major constituents, allowed us to define two domains in the Palamós Canyon: an "inner" domain (<1200 m) constricted by the canyon topography and mainly influenced by lateral transport from the adjacent continental shelf in which the canyon is incised, and an external domain, where slope dynamics and seasonal trends are more important in determining the composition and amount of downward fluxes (3).

Table 1. Mean values of total mass fluxes and major constituents contents and fluxes in mg/m^{2}d, for each sediment trap.

	Canyon Axis 470 m		Canyon Axis 1200 m		Canyon Axis 1700 m	
	%	Flux	%	Flux	%	Flux
Total Mass Flux	100	28758	100	44284	100	8484
Lithogenics	72.6	20880	72.28	32007	70.35	5969
Carbonates	22.95	6600	24.35	10784	25.61	2173
Opal	2.07	595	1.82	808	1.95	166
Organic Matter	2.37	683	1.55	685	2.07	176

	Southern Wall 1200m		Northern Wall 1200m		Open Slope 1200m	
	%	Flux	%	Flux	%	Flux
Total Mass Flux	100	5157	100	1514	100	428
Lithogenics	70.21	3621	68.43	1036	58.17	249
Carbonates	24.14	1245	23.64	358	25.70	110
Opal	2.93	151	4.49	68	10.28	44
Organic Matter	2.73	141	3.50	53	16.12	25

References

1 - Heussner S., Ratti C., Carbonne J., 1990. The PPS 3 time-series sediment trap and the trap sample processing techniques used during the ECOMARGE experiment. *Cont. Shelf Res.*, 10: 943-958.

2 - Mortlock R.A, Froelich P.N., 1989. A simple method for the rapid determination of biogenic opal in pelagic marine sediments. *Deep-Sea Res.*, 36: 1415-1426.

3 - Palanques A., Garcia-Ladona E., Gomis D., Martín J., Marcos M., Pascual A., Emelianov M., Puig P., Guillén J., Gili J.M., Tintoré J., Jordi A., Basterretxea G., Font J., Segura M., Blasco D., Monserrat S., Ruiz S., Pages F., 2003. A Multidisciplinary Program to study the dynamics and the ecology of a Northwestern Mediterranean submarine canyon: The Palamós Canyon. *Prog. Oceanogr.* (in press).

MUD VOLCANOES, GAS CHIMNEYS, POCK-MARKS AND MOUNDS IN THE NILE DEEP-SEA FAN (EASTERN MEDITERRANEAN)

Jean Mascle *, Lies Loncke, Laurent Camera, and the Nautinil/Fanil/Medisis scientific parties

* Géosciences-Azur, Villefranche/mer, France - * mascle@obs-vlfr.fr

Abstract

The Nile continental margin is characterized by numerous fluid seepages which have been well imaged by different geophysical technics and particularly by swath and acoustic data. These features, expressed by mud volcanoes, gas chimneys and pockmarks, occur in diferent settings and reflects different processes of fluid emissions on the sea bed.

Keywords : Nile continental margins, deep sea fan, fluid seepages, deep environnements

The Nile turbidite system, or Nile deep sea fan (NDSF), represents an area of about 100 000 km^2 which results from deposition, chiefly since latest Miocene, of thick salt-bearing and terrigenous sediments covering a segment of the Mesozoic African passive margin of Mesogea (1). Several 360 channel MCS profiles, collected in summer 2002, have allowed us to investigate and image, locally down to the Moho, this African passive margin segment. The terrigenous cone, fed by erosional products transported by one of the world's most important rivers, the Nile river, has moreover been nearly entirely mapped by swath bathymetry and back-scatter imagery during two geophysical surveys run in 1998 and 2000. Simultaneously, continuous high resolution and 3-5 kHz seismic reflection profiling, as well as magnetic and gravity measurements, were recorded; and several Kullenberg piston-cores were collected (2).

In different areas of the NDSF, subdued sub-circular bathymetric features, suggesting active fluid releases and vents directly on the sea bed, have been discovered (3). Some of these, particularly at depths around 3000 meters within the north-western NDSF, are characterized as small cones, ranging from 100 to 900m in diameter and a few tens of meters in elevation; locally small cones are associated with large caldera-like depressions.

Along the NDSF upper continental slope (between 1000 and few hundred meters of water depth), a few large flat subcircular (5 km in diameter) mud "pies" delineate a belt of apparently very active gas chimneys. Most of the fluid-releasing features are clearly fault-controlled. In 2000, two cores, one on a mud cone and a second on a gas chimney, have yielded structure-less and gassy muds with high sulfide content, including rock clasts.

Finally, numerous pock-marks, or mounds, have also been identified on the seabed; depending on the areas, these are associated with strongly destabilized sedimentary masses or with gas chimneys. Most of these fluid-rich features are found in regions where underlying Messinian evaporites are extremely thinned and nearby growth faults act as conduits (3).

More recently (September 2003) the NAUTINIL expedition, the first phase of the European scientific project MEDIFLUX (2003-2006) within the Euromargins programme initiated by the European Science Foundation which involves research groups from France, the Netherlands and Germany, has allowed the observation and demonstrated the occurrence of active fluid seepage through the seafloor at several of these features.

On the Nile margin five main parameters influencing fluid release locations are distinguished: (1) the presence, at depth, of potential source rocks and reservoirs; (2) the regional distribution of Messinian evaporites whose presence may prevent upward fluid migration; (3) the distribution of sedimentary loading which may induce localized overpressures on under-compacted and fluid-rich sediments; (4) the presence of a network of syn-sedimentary faults acting as potential conduits for fluid migration; and finally, and chiefly for pockmarks and mounds, (5) areas submitted to large scale sedimentary instabilities.

References

(1) - Loncke, L., 2002. Le delta profond du Nil: structure et évolution depuis le Messinien (Miocène terminal). Thèse de doctorat de l'Université Paris 6. 209 p.

(2) - Loncke, L., Gaullier, V., Bellaiche, G. and Mascle, J. (2002). Recent depositional patterns of the Nile deep-sea fan from echo-character mapping. *AAPG bulletin*, 86(7): 1165-1186.

(3) - Loncke, L. Mascle, J. et l'équipe scientifique Fanil. Mud volcanoes, gas chimneys, pock-marks and mounds in the Nile deep-sea fan (Eastern Mediterranean): geophysical evidences. *Marine and Petroleum Geology* (submitted).

^{210}PB AS A TRACER OF SEDIMENTARY PROCESSES IN THE CONTINENTAL SLOPE: THE ROLE OF SUBMARINE CANYON SYSTEMS IN THE WESTERN MEDITERRANEAN SEA

P. Masqué [1] *, J.A. Sánchez-Cabeza [1], J. Garcia-Orellana [1], J.M. Bruach [1], A. Palanques [2], M. Elkathab [2], P. Puig [2], J. Fabres, A.M. Calafat, M. Canals [3]

[1] Institut de Ciència i Tecnologia Ambientals – Departament de Física, Universitat Autònoma de Barcelona. Bellaterra, Spain
* Pere.Masque@uab.es

[2] Institut de Ciències del Mar – CMIMA (CSIC), Departament de Geologia Marina i Oceanografia Física, Barcelona, Spain

[3] GRC Geociències Marines, Departament d'Estratigrafia, Paleontologia i Geociències Marines, Universitat de Barcelona, Spain

Abstract

The natural radionuclide ^{210}Pb is used here to assess the extent to which transfer of particles and sedimentation in continental margins is controlled by the presence of canyons. We studied three sites in the Western Mediterranean Sea, focusing on the evaluation of the global budgets of ^{210}Pb and the temporal variability of the activity distributions in the water column and fluxes derived from sediment traps and activity profiles in bottom sediments.

Keywords: sedimentation, submarine canyons, Pb-210, Western Mediterranean

Tracers with well constrained input functions can be used to study particle transport processes in continental margins (i.e. transfer of sediment from the continent to the ocean), a fundamental issue to better understand the organic carbon cycle in the oceans. Amongst them, ^{210}Pb is of particular interest, as its half-life (22.3 years) is suitable for the kind of processes to be characterised (1-4). This work has been carried out at three continental margin sites in the Western Mediterranean Sea: i) the Foix Canyon off Barcelona; ii) the Guadiaro Canyon, east of the Gibraltar Strait; and iii) a depression in the Balearic Islands margin. Sampling stations were located at different depths at the axis of the canyons/depression and at the adjacent open slopes. ^{210}Pb was determined in the water column, bottom sediments and sinking particles (collected with sediment traps). This strategy allowed us to: build a balance of the ^{210}Pb distributions using the water column and bottom sediment inventories; estimate sediment accumulation and mixing rates using excess ^{210}Pb (and ^{137}Cs) activity profiles in the sedimentary record; and compare these to mass and ^{210}Pb fluxes obtained from deployments of sediment traps during one year at each site.

The Barcelona site is characterised by sediment accumulation rates significantly higher along the axis of the canyon than in the open slope, and a sedimentary depocenter was identified at mid-slope (0.51 $\pm$ 0.02 g·cm^{-2}·y^{-1}), between 600 and 850 m depth. The expected fluxes of ^{210}Pb to the bottom sediments associated to sinking particles, calculated from the balance of the annual atmospheric flux, *in situ* production from disintegration of ^{226}Ra and ^{210}Pb decay, are only 7-36% of those actually measured with traps and derived from inventories in bottom sediments. This suggests the existence of lateral input of ^{210}Pb, which would be driven by particulate material that is transported as nepheloid layers from the continental shelf and the upper slope along the pathways of the prevailing currents after resuspension events. This material would be focused down the canyon axis, thus indicating that the canyon acts as a natural trap.

At the Guadiaro site, where the canyon incising the slope is also clearly defined, the highest sediment accumulation occurs at 600 m depth in the axis of the canyon (0.290 $\pm$ 0.015 g·cm^{-2}·y^{-1}). This sedimentation rate is between 3 and 4 times larger than those determined in the canyon head (260 m depth) and that those at about 700-770 m, deeper in the continental slope, regardless of the location in the Guadiaro submarine Fan or in the open slope. Similarly to the Foix Canyon, this also indicates the presence of a sedimentary depocenter at mid-slope depths. Moreover, from the relationships between the ^{210}Pb activities and fluxes and the total mass fluxes obtained with the sediment traps, it is suggested that the Guadiaro Canyon is also effectively acting as a conduit of resuspended particles originating in the shelf and/or the upper slope. In addition, the activity profiles and inventories of ^{210}Pb and ^{210}Po ($T_{1/2}$ = 138 days) in the water column indicate that the scavenging of particle-associated elements is only slightly enhanced in the axis of the canyon, thus confirming that the sediment transport would be mostly driven by near-bottom nepheloid layers. In fact, the distribution of both elements in the water column seems to be governed by regional-scale processes, as similar temporal variability was observed for stations located in the central region of the western Alboran Sea.

At the Balearic Islands site, sediment accumulation rates were similar in and out of the depression (about 0.07 g·cm^{-2}·y^{-1}), much smaller than those at the continental slope off Barcelona and only slightly lower than those in the deep slope at the Guadiaro site. The balance between the estimated ^{210}Pb fluxes from the water column and the actual ^{210}Pb flux reaching the sea floor as measured in bottom sediments is off by only a 20%. Although resuspension and subsequent transport of material offshore may also take place in the Balearic margin, the absence of major rivers precludes the magnitude of the fluxes of being large and vertical particle fluxes are dominant. On the other hand, there is no significant difference of fluxes between the depression and the open slope. Thus, the submarine depression does not act as an efficient conduit for the particulate material, nor as a preferential depositional area, and it can be considered as controlled by the open slope regime.

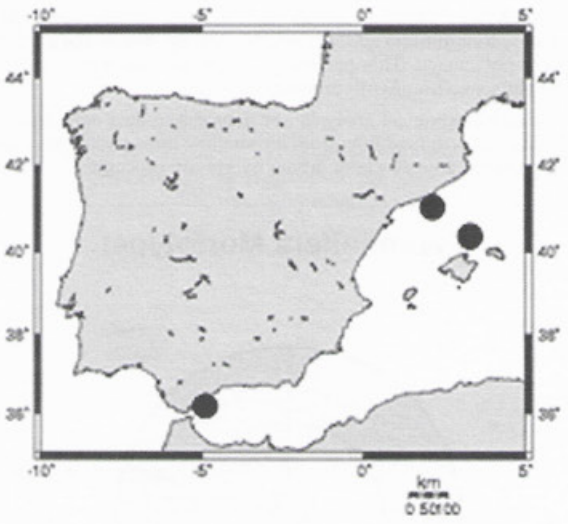


Fig. 1. Location of the three study sites in the Western Mediterranean Sea.

References

1 - Biscaye, P.E., Anderson, R.F., 1994. Fluxes of particulate matter on the slope of the southern Middle Atlantic Bigth: SEEP-II. *Deep-Sea Res. II*, 41: 459-509.

2 - Buscail, R., Ambatsian, P., Monaco, A., Bernat, M., 1997. ^{210}Pb, manganese and carbon: indicators of focussing processes on the northwestern Mediterranean continental margin. *Mar. Geol.*, 137: 271-286.

3 - Sanchez-Cabeza, J.A., Masqué, P., Ani-Ragolta, I., Merino, J., Frignani, M., Alvisi, F., Palanques, A., Puig, P., 1999. Sediment accumulation rates in the Southern Barcelona continental margin (NW Mediterranean Sea) derived from ^{210}Pb and ^{137}Cs chronology. *Prog. Oceanog.*, 441 (1-3): 313–332.

4 - Zuo, Z., Eisma, D., Gieles, R., Beks, J., 1997) Accumulation rates and sediment deposition in the Northwestern Mediterranean. *Deep-Sea Res. II*, 44: 597-609.

SEDIMENT-GRAVITY FLOWS RICH IN BIOGENIC COMPONENTS (FORAMINIFERA)

G. Mateu [1] *, J. Acosta [2], M.J. Viñals [3], M. Moreiro [1], G. Nadal [1] & G. Mateu-Vicens [1]

[1] Laboratori de Micropaleontologia. Universitat de les Illes Balears, Spain - * guillem.mateu@terra.es
[2] Instituto Español de Oceanografía. Dpt. De Geología Marina, Madrid, Spain
[3] Universitat Politècnica de València. Dpt. Enginyeria Cartogràfica, Geodèsia i Fotogrametria, Spain

Abstract

Micropaleontological and geoseismic techniques are used to ascertain the sediment fluxes through the balearic platform and talus. The importance of mud flows in the major productivity zones is evidenced by using benthic and planktonic forams (production areas and *post mortem* offshore transportation).

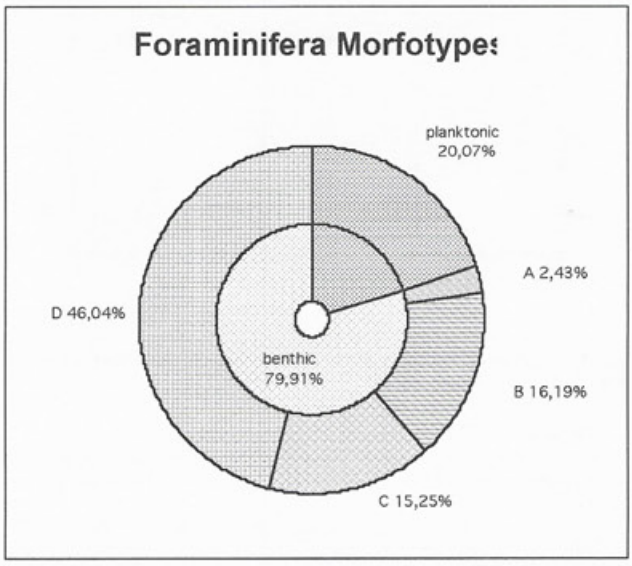
In the IEO "Carpabal 85" cruise, between 2° 15'-2° 55' E and 38° 30'-39° 10' N, in the South of Mallorca, a series of seismic profiles (sparker 4500 J and "mud penetrator" 3,5 KHz) evidences the presence of resedimented quaternary materials (mud flows).

These sediments, acousticly transparents, form large tongues, 6 Km wide and 30 m thick.The sediment instability has been reported in other papers (1, 2).

The benthic forams, in the NE of Emile Baudot Escarpment, are distributed in 119 species clustered by Langer Morfotypes (3), sessile/crusting (A), temporaly motile (B), trophic motile (C) and permanently motile (D). Figure 1 shows the dominance of the permanently motile forms (46,04%) and the scarce presence (2,43%) of non motile, photophile forms from the infralittoral (*Planorbulinidae, Soritidae, Cibicididae, Rotaliidae, Elphidiidae* and *Homotrematidae*) indicate biotops of production areas less than 50 m depth. The taphocoenosis that they produce reach the 2000 m depth down to the Balearic Abyssal Plain (4).

Globorotalia inflata (levogyre form) and *Globorotalia truncatulinoides* (levogyre form) are the most conspicuous among planktonic foraminifera species, which reach up 20% of the total foraminifera percentage. This percentage of meso-epipelagic species fits the post-glacial Gibraltar hydrodinamic model.

Micropaleontological analysis and geoseismic data demostrate the importance of sediment flow from the shallow infra-circalittoral zones into the deeper abyssal plain, driven by gravity processes.



References

1 - Acosta J., Serra J., Herranz P., Canals M., Mateu G., Guillem J., Sanz J.L., Calafat A., San Gil C., Catafau H., Fornós J., 1986. Resultados preliminares de la campaña de Geología Marina "Geocarbal 85" realizada en la plataforma continental de las Islas Baleares. *Informes Técnicos Inst. Esp. de Oceanogr.*, 44: 1-26.

2 - Maldonado A., Canals M., 1982. El margen continental sur-balear: un modelo deposicional reciente sobre un margen de tipo pasivo. *Acta Geologica Hispanica*, 17(4): 241-254.

3 - Langer M., 1993. Epiphytic foraminifera. *Marine Micropaleontology*, 20: 235-265.

4 - Rothwell R.G., Thompson J., Kähler G., 1998. Low-sea-level emplacement of a very large Late Pleistocen "megaturbidite" in the Western Mediterranean Sea. *Nature*, 392: 377-380.

THE LAST GLACIAL MAXIMUM (18.000 – 14.000 y. B.P.) AND ITS MICROPALEONTOLOGICAL, PALEOGEOGRAPHIC AND PALEOCEANOGRAPHIC REGISTER IN THE BALEARIC SEA

G. Mateu [1] * J. Acosta [2], M.J. Viñals [3], M. Moreiro [1], G. Nadal [1], G. Mateu-Vicens [1]

[1] Laboratori de Micropaleontologia – Edifici Guillem Colom. Universitat de les Illes Balears, Spain - * guillem.mateu@terra.es
[2] Instituto Español de Oceanografía. Dept. Geología Marina , Madrid, Spain
[3] Universitat Politècnica de València. Dept. Ingeniería Cartográfica, Geodesia y Fotogrametría, Spain

Abstract

During the Last Glacial Maximum, the Emile Baudot Escarpment and the two submarine mounts, dels Oliva and Ausiàs Marc, formed a microarchipielago between the "Pitiusa" and the "Gran Balear". The benthic and planktonic forams of this microarchipielago sediments are studied here. It is a relictual benthic fauna that belongs to the infra-circalittoral during the Glacial Maximum. In the Mont Oliva and Ausiàs Marc these species represent a 25% over the total. The other 75% consists in recent planktonic fauna that fits the actual, post-glacial, mediterranean hydrodinamics. Otherwise, in the Emile Baudot Escarpment the benthic species are predominant as it occurs in the biofacies of the balearic infra-littoral.

Keywords: Foraminifera relicts, Last Glacial Maximum

In the oceanographic cruise Pitiusas I, on board R/V *Cornide de Saavedra,* June 74, 40 samples of 25.000 benthic and planktonic foraminifera were collected together with geomagnetic study of the submarine mounts of the Balearic Sea.

In 1999 on board R/V *Hespérides* the geologists of the Spanish Oceanographic Institute began a very good cartography (M14) which digital model has permitted the visualisation of the Balearic paleogeography of the last glaciation (18.000 – 14.000 year B.P.), when the sea level lowered around 130 m and the three mounts, now submerged 90 m deep, formed the archipielago called "Banc del Francès" between the SW of the "Gran Balear" and the E of the Pitiusa, the only two great islands then in the Balearic Sea. (1,2,3)

The "modern" planktonic species which reflect the "Iberian gyre" and the relict benthic ones of the Last Glacial Maximum when the "Banc del Francès" was an archipielago with Mont dels Oliva and Mont Ausias Marc surrounded by *Posidonia* meadows and algae which relict infralittoral benthic foraminifera now are part of the postglacial pelagic sedimentation.

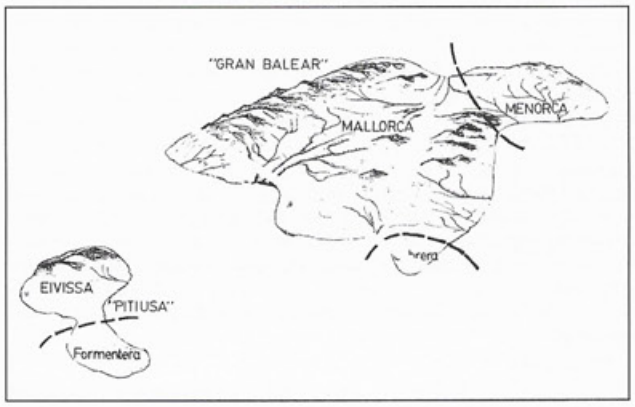


Fig. 1. The Balearic Islands in the Last Glacial Maximum.

In the present work we give some conclusions with the possible discussion of the data of which we can outline the following points:

1.- The present biofacies of the submerged islands between Eivissa and Mallorca are mostly consisting of glacier relict benthic foraminifera, of the old infralittoral ecosystem of the L.G.M. and of a 75% of postglaciar, atlantic-mediterranean, modern planktonic foraminifera, typical of the "Iberian Gyre".

2.- The taphocenosis is represented by 39 families, and 354 species, the biodiversity of which, correspond in great mesure, to the glacier climate of when the Emile Baudot, Mont dels Oliva and Mont Ausias Marc were islands, with a maximum length and width 5x1'5, 3x2 and 4'5x2 miles respectively (1,3). This microfauna original from old algal, Posidonia and psammic assemblages formed by *Cibicididae, Homotrematidae, Hauerinidae* (*Miliolidae*) and *Soritidae* and a part of the present hemipelagic Balearic Sea sediments (*Globorotalia inflata*, *Globorotalia truncatulinoides*, *Orbulina universa*, etc.).

3.- Comparing the biofacies of the 3 submerged mounts with the ones of Menorca and Cabrera channels, the psammic, epiphytic, oligobatimetric affinity of the microfauna can be observed. The hemipelagic character of the biofacies of the three submerged mounts can be seen in a 75% of planktonic forms in Mont dels Oliva and Mont Ausias Marc and in a smaller percentage in Emile Baudot. All in convergence with the mesoatlantic and northmediterranean water masses of the "Iberian Gyre" around Balearic Islands. In the Menorca and Cabrera channels there is a dominance of algal and posidonic species, with some presence of paralic lagoon species and an infralittoral holocenic consolidation specially after the Flandrien Transgression (7.000 – 6.000 y.B.P.). (4)

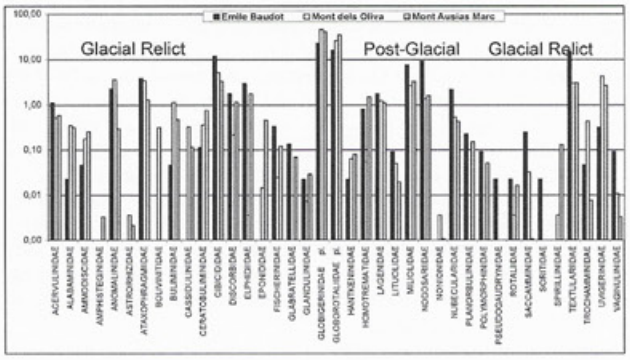


Fig. 2. Glacial and Post Glacial Foraminifera.

References

1 - Acosta J., Canals M., López-Martinez J., Muñoz A., Herranz P., Urgeles R. Palomo C., Casamor J.L., 2002. The Balearic Promontory geomorphology (western Mediterranean): morphostructure and active processes. *Geomorphology,* 49 (2002): 177-204.

2 - Mateu G., Rey J., Díaz del Río V., 1985. Les paleolits de la Baie de Pâlma de Mallorca. Interpretation sismique et datation biochronologique. *Rapp. Comm. Int. Mer Médit.*, 29(2): 43-53.

3 - Palomo C., de Miguel J., Acosta J., Sanz J.L., Herranz P., 1974. Estudio geomagnético de tres montes submarinos en el Mar Balear. 1ª Asamblea Nacional de Geodesia y Geofísica, Madrid V. II, pp. 895-923.

4 - Mateu G., Viñals M.J., Moreiro M., Nadal G., 2001. La Transgresión Flandriense a través de los Foraminíferos bentónicos del Mar Balear. In: Pons G. y Guijarro J.A. (ed.). El canvi climàtic. Soc. Hª Nat. Balears. Monografia 9.

THE VAR TURBIDITIC SYSTEM: SEDIMENT SUPPLIES, SLOPE INSTABILITIES AND MASS WASTING

Sébastien Migeon [1] *, Nabil Sultan [2], Olivier Sardou [1], Bruno Savoye [2]
[1] Géosciences Azur, Observatoire de Villefranche, Villefranche/Mer, France
[2] Lab. Env. Sédim., IFREMER, Plouzané, France

Abstract
The Var turbidite system is a small sandy system located on the Ligurian margin and basin. Still active during the present sea-level highstand, the system has been fed through time by the Var and Paillon canyons. Three major processes allow the transport and distribution of particles from the shelf to the deep basin: (a) large-sized failure-induced turbidity currents, (b) small-sized turbidity currents, (c) and hyperpycnal currents triggered at the Var-river mouth during high-magnitude floods. The continental slope of the Baie des Anges is also affected by numerous surficial failures, such as the 1979 event initiated during the extension of Nice airport. Small-sized failures are abundant at relatively shallow water depth, in areas where sediment supply from the Var and Paillon rivers has been high through time. Larger-sized failures occur at greater water depth, probably triggered by seismic activity.

Keywords: Ligurian Basin, Var system, turbidity current, 1979 event, failures

The Var turbidite system: geological setting and morphology

The Var turbidite system is a small sandy system, extending seaward of Nice and the Var prodelta to the base of the continental slope nearby Corsica. The Var system has been built during the Pliocene-Quaternary in a flat-floored basin formed during the Messinian salinity crisis (1).

The Var system was fed through time by the Var and Paillon canyons that connect directly to the Var- and Paillon-river mouth. Only the Var Canyon is thought to be still active nowadays. The two canyons deeply incise the slope and coalesce at about 1500 m water depth to form the Upper Valley. At 2000 m water depth, the Upper Valley abruptly passes into the east-trending Middle Valley which extends 50 km eastward till a water depth of 2500 m where it reaches a continuous trend of salt diapirs and then bends to the southeast. The Lower Valley extends 100 km southwestward, feeding a sandy distal lobe at a water depth of 2700 m water depth. Along the whole system, gradient slope decreases from 11% in the canyon to 0.3% in the Lower Valley. The main morphological feature of the system is the well-developed right-hand levee called the Var Sedimentary Ridge (1, 2). Ridge height above the channel floor decreases from 400 m in the west to less than 30 m to the east. The morphology of the system suggests that significant deposition has been produced by both sandy and muddy turbidity currents (3). Evidence of recent erosive currents has been observed on deep-tow side-scan sonar images collected in the distal part of the Ridge (4).

Processes of sediment supply

During the present highstand three major sediment transfert processes are active in the Var system:

- Large failure-induced turbidity currents, such as the "1979 event" when part of the Nice airport collapsed. Failures are generally induced by the conjunction of earthquakes and of an under-consolidated state of slope-sediment, although the "1979 event", had anthropic causes. The resulting current is a short-duration (a few hours), catastrophic and fast surge. On the canyon steep slopes inferred velocities are estimated at 30 m/s and are still in the order of 6 m/s 150 km away from the canyon head (4). As a consequence, cobbles and boulders can be transported near the bed over hundred of kilometres. Fine to medium sand are transported up to the distal lobe, more than 200 km from the continent.

- Small-sized turbidity currents; those are generated by retrogressive shallow failures on the slope or reconcentration process of particles near the shelf break during storms. Several day-long currents are common, as recorded by Gennesseaux *et al.* (5) in the Var canyon. These low-velocity currents are able to transport and deposit fine-grained particles on the slope and on the Var Ridge.

- Hyperpycnal turbidity currents ; triggered at the Var-river mouth during high-magnitude floods, when critical discharge is close to 1250 m^3/s and sediment concentration about 42 kg/m^3. The Var river discharge curve is typically bimodal and flash floods can occur both in spring and autumn, owing to snow melt and convective rainfalls. Using the rating curve of the Var river, return period of floods triggering hyperpycnal flow is about 4 years (using instantaneous discharge values) and 21 years (using daily discharge values). Such currents transport significant amount of both fine-grained and coarse-grained particles. Typical hyperpycnite-deposits are found in the distal part of the Var Ridge where they exhibit thickness of about 5 to 20 cm.

The detailled analysis of one core collected on a terrace near the base of the Upper Valley indicates that during the last 100 years, 70% of the deposits result from hyperpycnal-flow activity, 5% result from failure-induced turbidity currents and 25% are the hemipelagic background. During the Holocene-Pleistocene time, failure-induced turbidity currents were as common as hyperpycnal flows (4).

Slope failures

On october 16 1979, a large failure, involving at least 8 x 10^6 m^3 of material, occurred at shallow water depth during infilling operations related to the enlargement of Nice airport. *In situ* observations and modelling results have indicated that the slide transformed into a debris flow then in a surge that reached the Var Ridge and probably the distal lobe. The surge broke two submarine cables located at about 80 km and 107 km from the failure area. On the upper slope, the failure generated a tsunami 2 m in height that caused damage and people death in the Antibes region.

Recent high-resolution multibeam survey of the Nice upper slope allowed detailed observation of the 1979 event and also revealed the degree of destabilisation of the area. Failures are more abundant near the Var- and Paillon-river mouth (about thirties of events) than in the central slope domain (about tens of events), but they are globally smaller (about one km^3 against several km^3 in the central zone). The 1979 failure appears as a medium-size slide. Failures are generated at shallow water depth, near the shelf break, in areas close to the Var- and Paillon-river mouth, and at greater water depth in the slope central zone. Failures are easily triggered in areas where sediment supply is important through time. This results in thick under-consolidated accumulations, deposited near steep slope, that can be destabilised under the action of gravity, or during episodes of flash floods reworking deposits at river mouth. In the central zone, where sediment supply is lower, external mechanismes such as horizontal or vertical acceleration during an earthquake seem to be necessary to trigger failures. In that case, volume of remobilised sliding sediment is more important.

References

1 - Savoye, B., D.J.W. Piper, L. Droz, 1993. Plio-Pleistocene evolution of the Var deep-sea fan off the French Riviera. *Marine and Petroleum Geology*, 10: 550-571.

2 - Migeon, S., B. Savoye, J.-C. Faugères, 2000. Quaternary development of migrating sediment waves in the Var deep-sea fan: distribution, growth pattern and implication for levee evolution. *Sedimentary Geology*, 133: 265-293.

3 - Piper, D.J.W., B. Savoye, 1993. Processes of late Quaternary turbidity current flow and deposition on the Var deep-sea fan, north-west Mediterranean Sea. *Sedimentology*, 40: 557-582.

4 - Migeon, S., B. Savoye, E. Zanella, T. Mulder, J.-C. Faugères, O. Weber, 2001. Detailed seismic-reflection and sedimentary study of turbidite sediment waves on the Var Sedimentary Ridge (SE France): significance for sediment transport and deposition and for the mechanisms of sediment-wave construction. *Marine and Petroleum Geology*, 18: 179-208.

5 - Gennesseaux, M., Guibout, M., Lacombe, H., 1971. Enregistrement de courants de turbidité dans la vallée sous-marine du Var (Alpes Maritimes). *Compte Rendu de l'Académie des Sciences de Paris*, 273: 2456-2459.

VERTICAL EVOLUTION OF THE ALBANIDES: FIRST RESULTS OF A FISSION-TRACKS THERMOCHRONOLOGICAL STUDY

B. Muceku [1, 2] *, G. H. Mascle [1], A. Tashko [2]

[1] LGCA, UMR-CNRS 5025, Maison des Géosciences, UJF Grenoble, Grenoble, France
[2] Faculty of Geology, Polytechnic Universiy of Tirana, Albania

Abstract

Fission track analysis provides detailed information on the low-temperature thermal histories of rocks. Here we apply fission track analysis to characterize the recent evolution of the Albanian orogenic belt and its long-term denudation.

Keywords: Albania, vertical evolution, fission tracks thermochronology

Introduction

The Albanides show a rather complex structural evolution) (1, 2). To the West and North, tectonic units belonging to the Apulian paleo-margin were progressively emplaced in a subduction geodynamic environment and characterize a in-sequence thrust sytem. Thrusting was active during Eocene time in the internal part of the structure, and affected the more external zones during Pliocene times. Eastern and Central Albania show oceanic units (ophiolitic Mirdita nappe) and their tectonic substratum (Korabi and Rubik nappes). Emplacement of the ophiolitic nappe (obduction) on the Korabi has been dated between 162 and 174 My, both using stratigraphic and geo-chronologic methods (Ar/Ar on the metamorphic sole of the ophiolitic nappe) (1, 3). The tectonic pile (Mirdita/Korabi) has been itself thrusted onto the Apulian nappes during Tertiary times. The whole structural prism has been later faulted and fractured. Different large structure were emplaced like the NNW-SSE oriented Albano-Thessalian depression, which represents a neogene intra-mountainous basin, and the two major NE-SW striking fracture sets of Scutari-Pec and Vlora-Berati. However there is a general lacking of precise data allowing to a correct kinematic quantification of the recent geodynamic evolution of the Albanides. That's why we have perfor-med a thermo-chronologic program (NATO supported program) using Apatite and Zircon fission-tracks. This method allows to obtain geochronologic data on temperature intervals between 240/270°C (Zircon) and 60/120°C (Apatite) (4).

Methodology

Three sampling expeditions have been performed, and allowed to recuperate a total of 92 samples of about 70 localities from different tectonic units of the Albanides. The samples were crushed, and minerals were separated using Frantz separator and dense liquors in order to obtain Apatite and Zircon in the 80-160 µm granulometric fraction. Finally Apatite and Zircon were separated optically, sticked on a thin glass lamellae, polished, and submited to chemical attack in order to reveal the natural fission-tracks. After counting and measuring of the natural tracks, an external detector (mica) was sticked on the preparation, and the sample became irradiated in the Orphée reactor at Saclay. Induced fission tracks became counted and measured on the external detector after revelation.

Results

The first new data arise from samples of the internal units of Albania. In the Gashi zone, the Trokuzi granitoïd gives an Apatite age of 39.1 ± 4.4 My and a Zircon age of 108 ± 6 My. In the Mirdita zone a granitoïd intrusion (Fierza granitoïd) of the Rubik nappe gives an Apatite age of 52 ± 2.6 My. In the Korabi (Pelagonian) zone, 4 samples of monzonite and lamprophyre, intrusive in the Paleozoic basement , provide a very coherent Apatite age, near 11.5 My (11.6 ± 0.5 ; 12.4 ± 0.6 ; 11.2 ± 0.7 ; 11.4 ± 1.3), and a Zircon age of 126 ± 6.5 My.

The results of the Trokuzi granitoïd are in good agreement with the Late Eocene age for thrusting of the Gashi (Durmitor) nappe. Those for the Fierza granitoïd indicate that the substratum of the ophiolitic nappe (Rubik unit) remained buried at depth of about 4 km until 50 My, and exhumed since that time. In Albania the ophiolites have been submited to erosional process immediately after their thrusting in Middle Jurassic time, as shown by the intense lateritisation suffered in Late Jurassic times. Our results suggest that the thickness of the ophiolitic nappe remained still close to 4 km at 50 My at Fierza. This is compatible with the actually observed thickness of the ophiolitic nappe, which reach 4 km and 12 km respectively in the Bulqiza and the Tropoya massivs.

Modelisation

A thermal modelisation using the AFTsolve software (5) have been performed using the results of the Korabi zone, and suggest the following thermal behaviour: tracks began to be registered (T~110-120°C), corresponding to a depth of the order of 4 km, at about 16 to 15 My; the rocks then suffered a long period of constant low rate cooling (T~85-75°C), corresponding to a depth of the order of 3 to 2.5 Km, which ended at about 2.5-1.5 My, and more recently (T~15-0°C), cooling became faster suggesting a high rate of denudation and rapid uplift in an extensional tectonic regime.

References

1 - ISPJ-IGJN, 1983. Harta Gjeologijke e RPSSH, 1/200.000, Tirana.

2 - Meço S. and Aliaj S., 2000. Geology of Albania. *Beiträge Reg. Geol. Erde*, 28, 246 p., Geb. Borntraeger Ed., Berlin.

3 - Vergely P., Dimo A et Monié P., 1998. Datation des semelles métamorphiques ophiolitiques d'Albanie par la méthode $^{40}Ar/^{39}Ar$: conséquences sur le mécanisme de leur mise en place. *C.R. Ac. Sc. Paris*, 326 : 717-722.

4 - Gallagher K, Brown R and Johnson C., 1998. Fission track analysis and its applications to geological problems. *Ann. Rev. Earth Planet Sci*, 26 : 519-572.

5 - Galbraith R.F, Laslett G.M., Green P.F. and Duddy I.R., 1990. Apatite fission track analysis ; geological thermal history based on a three-dimensional random process of linear radiation damage. *Proc. R. Soc. London*, A, 332 : 419-438.

NEW INSIGHTS ON THE KOS-NISYROS VOLCANIC FIELD FROM THE MORPHOTECTONIC ANALYSIS OF THE SWATH BATHYMETRIC MAP

Nomikou P. [1] *, Papanikolaou D. [1], Alexandri S. [2], Ballas D. [2]

[1] Dept. of Geology, University of Athens, Greece, [2] Hellenic Centre for Marine Research, Athens, Greece - * evi@ncmr.gr

Abstract

The recent volcanic activity at the eastern edge of the Aegean volcanic arc is limited within a neotectonic graben structure which is developed in an E-W general direction, between the alpine basement of Kos Island to the north and the alpine basement of Tilos Island to the south. In between the major boundary faults of the neotectonic graben there is an extended volcanic area comprising several individual volcanic centers. The detailed bathymetric map, constructed by recently acquired high resolution multibeam data permitted the distinction of the main morphotectonic structure of the area comprising a number of basins with average bottom depth of –600m in between several volcanic centers separated by minor active faults.

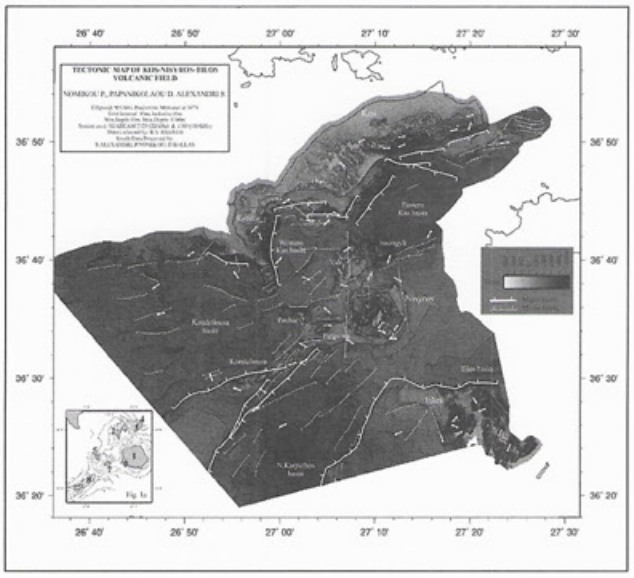
Keywords: swath mapping, volcanic centers, Aegean Sea, tectonics

Geodynamic setting

The eastern sector of the Aegean volcanic arc, including the islands of Kos, Nisyros and associated islets, is the result of northeastward-directed subduction of the Eastern Mediterranean lithosphere below the active Hellenic margin of the European plate. It is geodynamically very active since it comprises large volumes of volcanic products within Late Pleistocene-Holocene. Major magmatic activity began at least 160 Ka ago producing the largest eruption in the Eastern Mediterranean manifested by the "Kos ignibrite" which covered an area of more than 3000 Km^2. The centre of this eruption is not known with accuracy but it is probably located in the submarine area north of Yali islet. This major caldera structure has been obscured by the younger volcanic activity and eversince several volcanic structures have been developed in the area.

Swath bathymetry

The offshore studies in the area of Nisyros-Kos islands comprise detailed multibeam bathymetric mapping carried out onboard R/V *Aegaeo* in three successive cruises during 2000, in the framework of the EC project Geowarn (IST 1999 123210). The SEABEAM 1180 (180 kHz) system was used, for depths <500m and the SEABEAM 2120 (20 kHz) system, for depths >500m. Operating the systems for totally 12 days with an average speed of 5 and 10 knots respectively, 3.500 Km^2 were covered from very shallow depths to great depths of 2200m. After elaborating data processing, the swath bathymetric map of Kos-Nisyros volcanic field has been created with 50m grid interval using 10m isobaths at scale 1/100.000, georeferenced to a WGS-84 ellipsoid and a Mercator projection at 38ON. Merging the two bathymetric data sets and combining the swath data with land DEMs the new DTM model of the Kos-Nisyros volcanic field has been created (Fig.1).



Morphotectonic structure of Kos-Nisyros Volcanic Field

A neotectonic graben structure which is developed in an E-W general direction, between the alpine basement of Kos Island to the north and the alpine basement of Tilos Island to the south, is formed by a subsidence of the alpine basement rocks, of the order of 2,5 Km due to the marginal fault zones of Southern Kos and Northern Tilos. Within the tectonic graben of Nisyros and surrounding islets, there is a number of faults (1), which are limited mainly in the central part of the area creating a minor internal tectonic horst structure which is better expressed in the area of Kondeliousa islet, producing a median platform, with NE-SW and ENE-WSW general trend. The western part of this horst is composed of Mesozoic limestones in Kondeliousa islet while the eastern part, both offshore and onshore, is constructed by Quaternary volcanic formations. In the area of Nisyros and Yali islands minor faults overprint the previous ENE-WSW horst structure.

Five distinctive basins can be distinguished on both sides of the median platform of Kondeliousa and its eastern prolongation to the volcanic islands of Nisyros, Yali, Pachia, Pergousa and Strongyli. North of Kondeliousa-Nisyros platform occur: a) The Kondeliousa basin, expanding up to the western Kos platform with depths of about 550m, b) the Western Kos basin, with an average depth of 520m, among Kefalos peninsula and the islets of Yali and Pachia and c) the Eastern Kos basin, with an average sea-bottom depth of 630m separated from Western Kos basin by a relatively shallow rise between Yali and Kos with a depth of approximately 400m. South of Kondeliousa-Nisyros ridge occur: d) the northern end of the large Karpathos basin, reaching more than 2000m towards the south and e) eastwards the Tilos basin between Tilos and Nisyros with depths more than 600m.

A number of volcanic centres has been described around Nisyros Island (2, 3), developed within the neotectonic graben, in shallow areas. These are (Fig 1a): 1) The Nisyros caldera with a top of the rim at +580m and a bottom at +80m 2) The Yali Volcano which exhibits a partly submerged caldera (bottom –300m, top +170m), 3) The Strongyli Volcanic Cone, which starts from –650m depth of the sea-bottom up to +120m 4) The submarine caldera northeast of Strongyli in the depth of -670m up to –590m, 5) The Pergousa Volcanic Cone (bottom –400m, top +100m), 6) The domes of Prophitis Ilias (bottom –270m, top +698m), 7) The volcanic domes of Pachia Islet (bottom –250m, top +150m), and 8) the submarine volcanic domes to the east of Kondeliousa Islet (bottom –400m, top -80m). The lack of sediments overlying the volcanic domes indicates their very young age, ranging between Upper Pleistocene and Holocene.

References

1 - Nomikou, P., Papanikolaou, D., 2000. Active geodynamics at Nisyros, the eastern edge of the aegean volcanic arc: emphasis on the submarine survey. Proceedings of the 3rd Int. Conf. Geology East. Mediterranean, Sept. 1998, pp. 97-103.

2 - Papanikolaou D., Nomikou P., 2001. Tectonic structure and volcanic centres at the eastern edge of the Aegean Volcanic Arc around Nisyros island. Bulletin of the Geological Society of Greece, Vol. XXXIV/1, pp. 289-296, Proceedings of the 9th International Congress, Athens, September 2001.

3 - Nomikou, P., Papanikolaou, D., Alexandri, M., 2003. Variating modes of submarine volcanism within the Kos-Nisyros volcanic field. Abstracts IUGG, July 2003, Sapporo, Japan.

MONITORING BARCELONA CITY BEACHES USING VIDEO (ARGUS) AND LASER (LIDAR) METHODS

Elena Ojeda [1] *, Jorge Guillén [1] and Antoni Ruiz [2]

[1] Dept. de Geología Marina y Oceanografía Física - Instituto de Ciencias del Mar (CMIMA-CSIC), Barcelona, Spain
* eojeda@icm.csic.es

[2] Institut Cartografic de Catalunya, Barcelona, Spain

Abstract

This contribution presents video camera and laser techniques describing the coastline evolution in Barcelona city beaches over a 4-month period during 2002. LIght Detection And Ranging (LIDAR) measurements were obtained by the Institut Cartografic de Catalunya in April, 17 and July, 23, whilst Argus measurements were obtained from Mapfre station by the Instituto de Ciencias del Mar hourly from April to July. Both techniques' ability to locate the coastline is compared, obtaining similar results. Argus high temporal resolution sampling in conjunction with LIDAR three-dimensional view of the emerged beaches, more spaced in time, appears to be a valuable procedure for monitoring the beaches.

Keywords: Argus, LIDAR, coastline evolution, Barcelona

Introduction

The objective of this study is to examine the evolution of three beaches of Barcelona (Barceloneta, Nova Icaria and Bogatell) using the technology provided by Argus and LIDAR (Fig. 1).

Coastal cartography is one of the main applications of LIDAR. It has many advantages over aerial photogrammetry in coastal areas, accuracies around 10 cm in height and sampling densities around 1 point/m^2 are easy to achieve with the system.

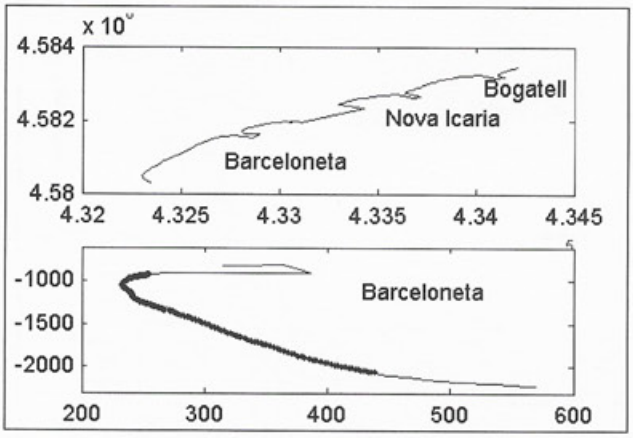


Fig. 1. *Top*: studied beaches in Barcelona (UTM). *Bottom*. LIDAR and Argus coastlines represented in local coordinates (meter). LIDAR in light black line, Argus in bolded line.

Two flights were done in 2002, at an altitude of 2,300 m over the coast of Barcelona to demonstrate the possibilities of this technique: on April 17 and July 23. In both cases the point density was 0.5 point/m^2 and a digital terrain model (DTM) of 1-m grid step was computed (1).

The ARGUS system (2) is an automated video station, comprising five video cameras connected to an image processor, which controls the communication to the outside world. The station placed on 21st October 2001, monitors Barcelona city beaches (3). It is located atop Mapfre building (approximately 146-m high) covering a 2-km radio and spanning a 180° view. Sampling every daylight hour in a ten minutes register (http://argus.cmima.csic.es).

Since Argus installation in October 2001, a highly energetic period occurred in the region with important storms (November, December 2001; January, March 2002) producing extensive sediment transport and severe erosion problems. Approximately a week prior to the first flight with LIDAR, a storm with E direction and significant wave height (Hs) of 2.6 m (4) took place in the region (April, 11-12). Moreover the beaches situation changed over the study period, due to a second storm coming from the East (May 7-8), with maximum Hs reaching 3.8 m (4). Finally, a beach nourishment (150 000 m^3) was carried out in Barceloneta and Bogatell beaches (June 13 to July 17).

Coastline evolution

The impact of single storm events is derived from Argus images. Extraction of coastlines and images examination reveals that, as pointed above, the coastline previous to the May storm find an eroded beach due to the unusually energetic wave pattern. This can explain the fact that the beach erosion was of the same magnitude than during the less energetic storm taken place in April.

The storm occurred in May produced three different erosion patterns on each of the beaches. Bogatell´s coastline suffered erosion/accretion, eroding 10 m in the northern side and accreting around 5 m in southern part. Nova Icaria did not show significant differences, whilst Barceloneta suffered a landward migration of about 5 m.

Nourishment took place from June 13 to July 5 in Bogatell and July 5 to 17 in Barceloneta. Using Argus images the nourishment effectiveness have been studied by means of temporal variations of the coastline in given locations of Bogatell and Barceloneta. It has been seen that the replenishment of the beaches evolves, with erosion happening until some stabilization is reached.

LIDAR *versus* Argus coastlines

An important point in this study is the comparison of the results obtained using both methodologies. Two different coastlines were derived from LIDAR. The first one using the texture of the DTM to discriminate the sand from the sea. A shadow map was computed from the DTM with a very low illumination source and the coastline was drawn from this image. The second coastline was derived from the intensity map of the pulse return. The most similar results were obtained using the second method (Fig. 1).

With LIDAR the volumes of sand displaced can be accurately measured from the differences of DTMs. As the sensor cannot take bathymetric measurements, the sand added or removed under water is not taken into account in the calculations. Using this method and the LIDAR-derived coastlines it has been estimated in Bogatell an increase in volume of around 24000 m^3 corresponding to an increase in surface of 12000 m^2. This corresponds to 2 m^3 /m of sand necessary to get a coastline accretion of 1m.

Conclusions

The study of Barcelona beaches using video images reveals that, despite the fact that they are closed beaches due to man-made structures, they have differential morphological evolution. Argus provides high-resolution information about shoreline changes after storms and beach nourishment.

Argus and LIDAR methods offer similar results for measuring the coastline position. LIDAR capability to measure 3D characteristics supplies accurate measurement of volume changes in the emerged beach.

Argus and LIDAR are complementary methods in morphodynamic studies. It is suggested to combine both techniques in order to obtain precise information of the beach evolution, persist in Argus continuous sampling, adding 3D information from specific LIDAR surveys.

References

1 - Ruiz A., Kornus W. 2003 Experiencias y aplicaciones del LIDAR. V Semana Geomática, 11.2.03 - 14.2.03, Barcelona.

2 - Holman, R.A., Sallenger, A.H., Lippmann, T.C., Haines, J., 1993. The application of video image processing to the study of nearshore processes. *Oceanography*, 6(3): 78-85.

3 - Guillén, J., Chic, O., Ojeda, E., Palanques, A., Aarnikhoff, S., 2003. Monitorización de las playas de la ciudad de Barcelona utilizando imágenes de video: evolución de la línea de costa en respuesta a temporales y regeneración artificial (2001-2002). VII Jornadas Españolas de Ingeniería de Costas y Puertos, Libro de Resúmenes, M. Losada, M. Castillo (eds.) pp. 254-256.

4 - Banco de Datos Oceanográficos de la Dirección General de Puertos y Costas. Modelo WANA de generación de oleaje. Punto 2066051.

ON THE ORIGIN OF THE OOIDS OF THE CLEOPATRA BEACH OF SEDIR ISLAND, AEGEAN SEA, TURKEY

Hüseyin Öztürk

Istanbul University, Department of Geology, Avcilar, 34100, Istanbul, Turkey - ozturkh@istanbul.edu.tr

Abstract

The unique calcitic ooids occur in a very restricted area at Cleopatra Beach at the Sedir Island, along southern coast of Turkey. The cores of the ooids consist of biogenic matters, such as algae, and rock fragments such as gneiss and granite, while their cortex consist of calcitic rims. The core materials of the ooids are exogenic and they possibly were brought here from the Egyptian coast, by Marcius Antonius as the ancient story being told.

Key words: Oolites, Aegean Sea, Turkey

Introduction

The unique calcitic ooids that occur in a very restricted area at the northwest coast of Sedir Island in Gökova Bay (Fig. 1), SW Turkey, have recently been investigated by several authors with respect to their inner structure as well as to the conditions of formation (1). On the other hand, there is an anecdotal history on the origin of the sands of the Cleopatra Beach that reveals the ooids were brought here by the Marcus Antonius for his lover Cleopatra from the Egyptian coast, during the Roman time.



Fig. 1. The ooid formation places on the Sedir Island and the Egyptian shore.

Geological setting

The geology of the coastal area lying behind the Sedir Island consists of silicified carbonates of Cretaceous ages. The rock associations of the island consist of conglomerates of Pliocene age, comprise well rounded pebbles of limestone and hematite in carbonate matrix (2).

The Oolites

The Cleopatra Beach is covered by white-cream colored ooids as 40 m length, 7 m width and average 0.4 m in thickness dimensions. The ooids are also seen nearly a hundred meters elongation and 0.3 m average in thick as a fan geometry at bottom of the sea (Fig. 2). Joint or fault-controlled trenches have been detected under the sea in 2m-7m depth, which lie parallel to the beach. It is interpreted that these trenches prevent the ooids from going into the sea. The oolites are scavenged by wave actions from the trenches and carried back to the beach.

The ooids of the Cleopatra Beach consist of two sectors as core or nuclides and cortex or rim. The nuclide matter of the oolites is composed of biogenic matter as nearly being 80 %, and the other 20 % are rock fragments. The biogenic matter is composed of clasts of the algae and small amount of pelecepoda, foraminifera, gastropod and echinid. The rock fragments as nuclides consist of quartz schist, gneiss as metamorphic rocks. The granitic and the metamorphic rock fragments as a nuclide matter are exotic to the rock associations of the region. Similar rock fragments in nuclides of the ooids have been reported for the Egyptian shore formations (3).

The petrographic study from the ooids indicates that ooids has been formed in an area where metamorphic-granitic rocks were cropping out. Absence of the ooids in the cement material among the stones of the historical built of the island indicated that the ooids was brought here during or later than civilization at the island. The presence of a very local ooid formation at the study area despite similar ecological-geological conditions such as rock associations, nutrient input, temperature and salinity of the sea water also support exogenic origin.

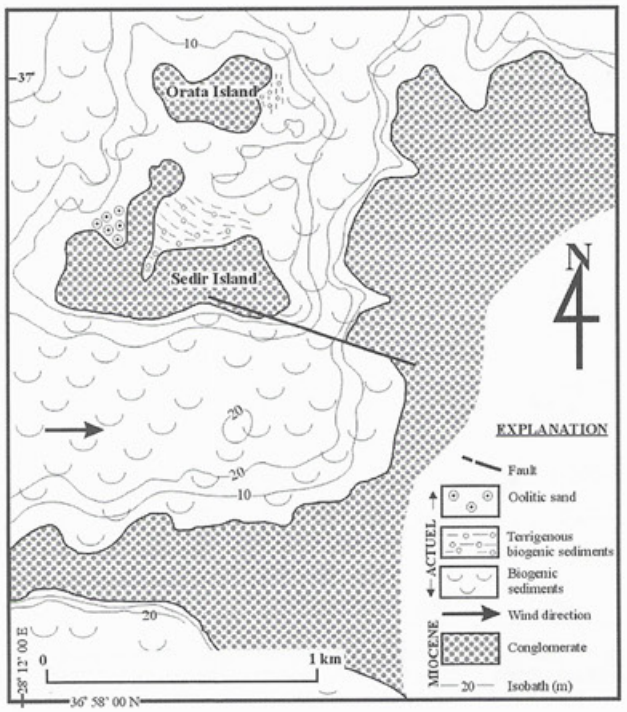


Fig. 2. The geology of the Sedir Island and location of the ooids.

Acknowledgements. Thanks go to Turkish Marine Research Foundation (TÜDAV) for diving organization during the study.

References

1 - Üşenmez Ş., Varol B., Friedman G.M., and Tekin E., 1993. Modern ooids of Cleopatra Beach, Southern Aegean Sea, Turkey: Results from petrography and scanning electron microscopy. *Carbonates and Evaporates*, 8: 1-8.

2 - Öztürk H., Öztürk B., and Öztürk A. A., 1998. Characteristics and the formation of the oolites of the Cleopatra Beach, Congress on Underwater Science and Technology, Istanbul University, pp. 98-104.

3 - Boulis S.N., Atia A.K., Hanna K.M., and Marei A.R., 1983. Evaluation of the oolitic limestone west of the Nile Delta for cement production. *Bulletin of the Faculty of Science,* Mansoura University, Faculty of Science, 10: 283-301.

SEDIMENT GRAVITY FLOWS INDUCED BY TRAWLING IN THE PALAMÓS (FONERA) SUBMARINE CANYON

Albert Palanques *, Jacobo Martín, Pere Puig, Jorge Guillén, Joan B. Company and Francesc Sardà

Institut de Ciències del Mar (CSIC). Passeig Maritim Barceloneta, 37-49
08003 Barcelona, Spain - * albertp@icm.csic.es

Abstract

Seven mooring arrays equipped with sediment traps, current meters and turbidimeters placed near the bottom and in intermediate waters were deployed in the Palamós canyon. During the study period, frequent sharp turbidity peaks along with current speed increases were recorded in the canyon axis at 1200 m depth during spring and summer. These events have been identified as sediment gravity flows caused by trawling activities in the canyon walls.

Keywords: submarine canyons, sediment gravity flows, sediment fluxes, trawling

Introduction

Particulate matter fluxes have been measured in submarine canyons during the last decades (1, 2, 3, 4). Fishing activities often represent an issue when deciding mooring locations as they can damage the instruments. Usually, efforts are made in order to avoid interactions with fishing activities and to record natural processes. However, unexpected flux increases have been sometimes related with trawling activities causing resuspension around the mooring sites, although direct evidences relating them had not been obtained before. In this study, we were able to record sediment gravity flows produced by trawling activities in the Palamós canyon, also known as Fonera canyon. This submarine canyon is deeply incised in the Northern Catalonia continental shelf (North-Western Mediterranean) which favours an active shelf-slope sediment transfer.

Methods

To study sedimentary dynamics in this canyon, seven moorings arrays with current meters, turbidimeters and sediment traps installed near the bottom (25 m above bottom) were deployed along the main canyon axis at 470, 1200 and 1700 m depth, on both canyon walls at 1200 m depth and on the adjacent slope at 1200 m depth. One set of these instruments was also installed in intermediate waters (400 m depth) in the mooring located in the canyon axis at 1200 m depth

Results

In the Palamós canyon, the higher near-bottom turbidity signal, as well as downward particle fluxes, was not recorded in the canyon head, as expected, but in the mid-canyon axis at 1200 m depth. At this mid-canyon site, several events (more than 10 per month) of sharp turbidity increases, ranging between 5 and 40 mg l^{-1} took place mainly during late spring and summer (Fig. 1). Some of these events were also recorded in the canyon axis at 1700 m depth in late August but not correlated with those at 1200 m depth. The duration of these events ranged from 1 to 6 hours and they were associated to significant current increases. The current direction during these events was either downcanyon or across-canyon (i.e. coming from the walls). The fact that they practically did not occur in the canyon axis near the canyon head region indicates that these events were produced in the canyon walls and later were reoriented along the canyon axis. These high-turbidity events were correlated with periods of high downward total mass fluxes that were not recorded in intermediate waters at the 1200 m mooring site and did not show any direct relation with storms or river avenue periods.

Discussion and conclusions

The random occurrence of the high-turbidity events suggest that they are not produced by periodical processes such as internal waves and tides. The fact that they are mainly observed during late spring and summer, when wave energy and river discharge tend to decrease, makes difficult to relate them to a natural mechanism. The fact that all the turbidity peaks were produced in working days and during fair weather conditions, made us to investigate a possible relationship with trawling activities. Information supplied directly by fishermen showed that the northern canyon wall, just above the 1200 m canyon axis site, was intensively affected by trawling and that the working depth of the trawlers significantly increased during late spring and summer. In addition, a canyon gully intersects the main canyon axis right at the mooring site. All this indicates that trawling in the canyon walls can trigger sediment gravity flows that are channelled through this gully, and when they are produced deeper in late spring and summer, they reach the canyon axis. Thus, these man-induced sediment gravity flows could be a common process affecting submarine canyons at present times, which could be influencing sediment fluxes in these particular environments.

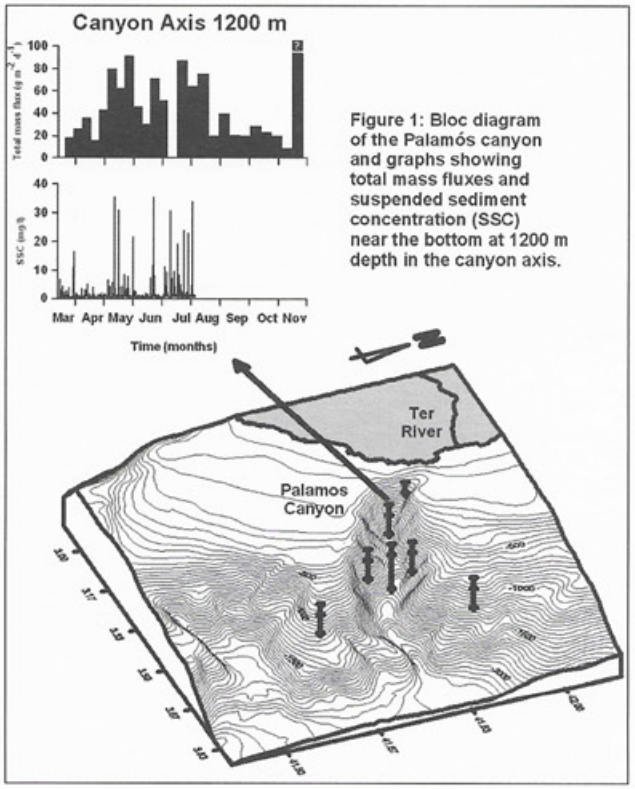


Figure 1: Bloc diagram of the Palamós canyon and graphs showing total mass fluxes and suspended sediment concentration (SSC) near the bottom at 1200 m depth in the canyon axis.

References

1 - Monaco A., Courp T., Heussner S., Carbonne J., Fowler S.W., Deniaux B., 1990. Seasonality and composition of particulate fluxes during ECOMARGE-I, western Gulf of Lions. *Cont. Shelf. Res.*, 10: 959-989.

2 - Gardner W.D., 1989. Baltimore canyon as a modern conduit of sediment to the deep sea. *Deep-Sea Res.*, 36: 323-358.

3 - Puig, P., Palanques, A., Guillén, J., García-Ladona, E., 2000. Deep slope currents and suspended particle fluxes in and around the Foix submarine canyon (NW Mediterranean). *Deep-Sea Res.*, 47: 343-366.

4 - Heussner, S., Durrieu de Madron, X., Radakovitch, O., Beaufort, L., Biscaye, P.E., Carbonne, J., Delsaut, N., Etcheber, H., Monaco, A., 1999. Spatial and temporal patterns of downward particle fluxes on the continental slop of the Bay of Biscay (northeastern Atlantic). *Deep-Sea Res. Part-II*, 46: 2101-2146.

THE SHALLOW SEISMIC INVESTIGATION IN THE IZMIT BAY, TURKEY

B. Pekcetinoz, E. Ozel, M. Duman, M. Avci, A. Ulug *
Institute of Marine Sciences and Technology, Inciraltı, 35340, Izmir, Turkey

Abstract
The North Anatolian Fault System plays a significant role on the neotectonic structure of Anatolian. The system causes changes on the morphology of the Anatolia as well as intensive earthquakes with large magnitude during these movements. The shallow seismic investigation was done in Izmit Bay in 1994 and the high resolution seismic cross-sections were obtained on the same profiles following 17 August 1999 Kocaeli earthquake for obtaining tectonic differences. According to the seismic evaluation, new broken fragment enters from the eastern end of the Bay and passes along the southern Coastline of Izmit Bay end terminate around Karamürsel area on the sea.

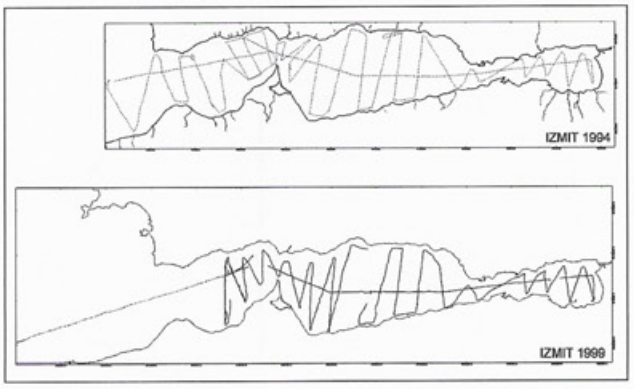
Key words: Kocaeli earthquake, shallow seismic, neotectonic, Izmit Bay, North Anatolian Fault

Introduction

The northern branch of the NAF system which starts from Erzincan Karlıova at east passes through the Marmara Sea at west and ends at the Aegean Sea. The north Anatolian Fault has a right lateral strike-slip fault activity (1; 2; 3). This situation was caused by pushing of the Anatolian block to the west route by the Arabic plates. However, the Avrasian plate blocks this westward, furthermore, forces this movement to slide towards south-west contributing affection of the earth at the north-south expansion today (2; 4; 5).

This southwestward route of the fault system caused branching of the north Anatolian Fault starting from Sapanca. The northern strand passes the Izmit Bay and the Marmara Sea and then finally enters into the Aegean Sea from Saros Bay. Therefore, the Izmit Bay is affected both by the transform movement to the West and the expansion tectonism.

Following the earthquake of August 17, 1999 broken segment of NAF was developed in the Izmit Bay. It continues with a line route starting from the eastern of the Bay (Fig. 1).



Material and methods

After the Kocaeli 1999 earthquake, the shallow seismic investigations were repeated on the very same seismic profiles satellite navigation system was used for positioning Tectonic changing has been observed by comparing the both seismic studies.

During both of shallow seismic studies (1994-1999), 0.65 lt of air gun were used as an energy source and 1 sec. were chosen as a record time on profiles (Fig. 2). A single-channel streamer with 10 elements was used as a receiver. Thermal analogue recorder was used for hard copies and the analogue data were stored on the magnetic band.

Results and discussion

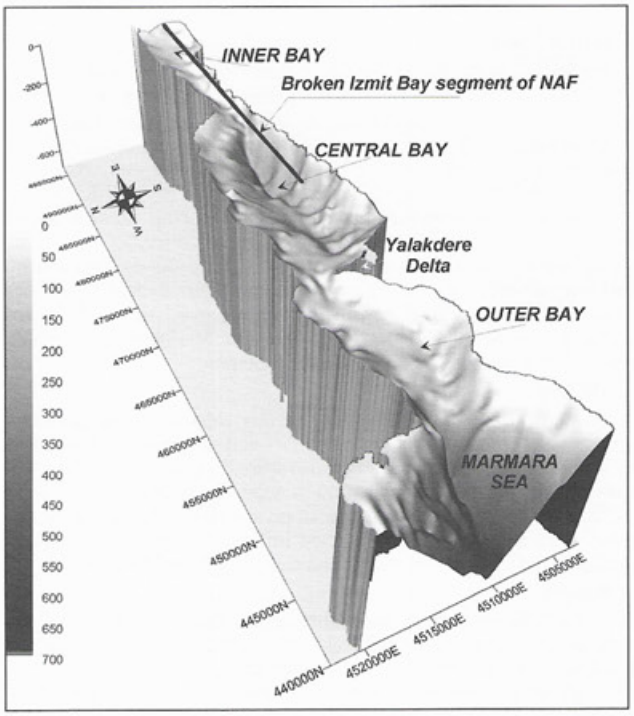
According to this study, these findings are determined as below :

a) The Sapanca-Karamursel segment which was ruptured at Kocaeli 1999 Earthquake between Karamursel and Ulaslı.

b) The new segments of the north Anatolian Fault partly pass through the south shoreline of the Izmit Bay, therefore, this phenomena caused opening and expanding the south route of the Bay.

c) If it is considered that the fault segment movement still continues west word at the Karamursel and Cınarcık basins, there is a new earthquake risk between Karamursel and Yalova.

d) It can be considered that the pull-apart structures at the surface and their basins were developed as negative flower structures which were formed by the deep strike slip fault. Since there is no deep seismic records available yet, it is difficult to correlate these phenomena.



References

1 - Canıtez N., and Üçer B., 1967. Computer determinations for the fault plane solutions in and near Anatolia. *Tectonophysics,* 4: 235-244.

2 - McKenzie D.P., 1972. Active tectonics of the Mediterranean Region. *Geophys. J. R. Astron. Soc.,* 30: 109-185.

3 - Barka A.A., and Kadinsky-Cade K.,1998. Strike-slip fault geometry in Turkey and its influence on earthquake activity. *Tectonics,* 7:663-684.

4 - Ketin I., 1948. Uber die tektonisch-mechanischen Folgerungen aus den grossen Anatolischen Erdbeden des letzten Dezenniums. *Geol. Rundsch.,* 36: 77-83.

5 - Şengör A.M.C., 1972. The north Anatolian transform fault: its age, offset and tectonic significance, *J. Geol. Soc.*, 136: 269-282.

RECENT FAULT ACTIVITY AND THE INTERACTION WITH CARBONATE DEPOSITIONAL SYSTEMS IN THE ALBORÁN SEA (WESTERN MEDITERRANEAN SEA) BY SUBBOTTOM PROFILERS

K. Reicherter [1] *, Ch. Betzler [2], Ch. Hübscher [3]

[1] Institut für Geophysik und Geologie, Universität Leipzig, Leipzig, Germany - * reicherter@dkrz.de
[2] Geologisches-Paläontologisches Institut, Universität Hamburg, Hamburg, Germany
[3] Institut für Geophysik, Universität Hamburg, Hamburg, Germany

Abstract

An ultra-high resolution seismic study in the Alborán Sea was carried out with the Parasound system to study the recent tectonic activity of prominent fault systems and their interaction with Quaternary carbonate systems. Since the Late Miocene, the Alborán Sea and surrounding areas are subject to compression, which influences the depositional history including coastal Quaternary carbonates. The western Mediterranean is characterized by a moderate seismicity, generally tracing major sinistral strike-slip faults, which cut the entire basin. These faults, the Carboneras and Palomares Faults, truncate and warp the Quaternary sediments pointing to recent fault activity in the Gulf of Almería.

Keywords: active tectonics, Alborán Sea, earthquakes

The Alborán Basin located within the Eurasian-African Convergence Zone that is an approx. 500 km wide corridor with distributed seismicity (Fig. 1) which exhibits several structures related to neotectonic deformation. Regions of adjacent coeval compression and extension in an overall dextral transpressional setting are found in the Alborán Basin which is dominated by strike-slip faulting.



Fig. 1. Tectonic map of the Alborán Sea, with the recent seismicity (dots, filled dots = deep earthquakes). Inset shows study area and section of Fig.2. CF = Carboneras Fault, PF = Palomares Fault.

In order to image late Quaternary depositional and tectonic processes in the Alborán Sea the German research vessel R/V *Meteor* operated along the Almería coast in the year 2001 (M51/1 cruise). The area has been previously investigated by a number of high- and low resoluton seismic studies (1; 2 Fig. 3A), which outlined the complex Neogene tectonics in the western Mediterranean region. Two active left-lateral strike-slip faults, the NE-SW striking Carboneras Fault and the N-S trending Palomares Fault, control the depositional conditions of the carbonate prism of Cabo de Gata region (Fig. 2).

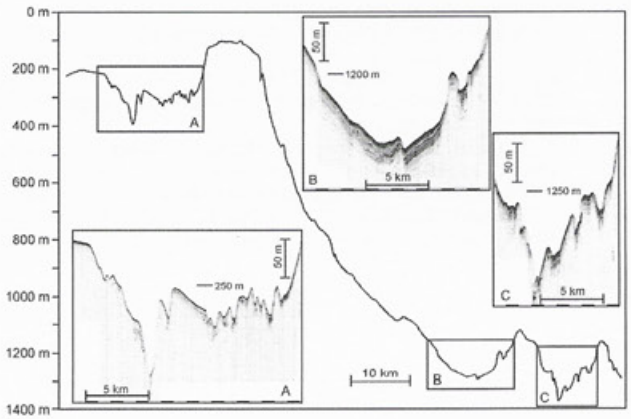


Fig. 2. Parasound section (topography and sediments) across the Gulf of Almeria and the Cabo de Gata (see. Fig.1)

Historical data point to major earthquakes during the last 1000 years (3), which occurred along the major strike-slip faults. The last earthquake with a magnitude > 6.2 occurred on 15. September 1522, destroying Almería. On-shore paleoseismic evidence with surface ruptures is missing (4), the epicenter is unknown. In Parasound investigations, we have found several fault strands in the Gulf of Almería (deep channels in Fig. 2), some of which are associated with faults, folds and onlap-patterns (Fig. 3B). The faulted recent sediments in an area of relatively high sedimentation rates, lead us to the conclusion that off-shore faulting must be very recent. An off-shore epicenter related with the earthquake of 1522 is also corroborated by historical tsunami drawings. Hence, we contribute to a seismic hazard assessment of the Western Mediterranean region.

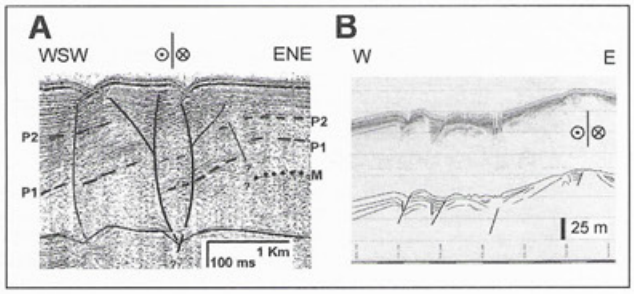


Fig. 3. A seismic section from Estrada *et al.*, 1997; B Parasound section (location on Fig.2 platform left of A). Note folding and faulting of the recent sediments.

References

1 - Ercilla, G., Alonso, B., Baraza, J., 1994. Post-Calabrian sequence stratigraphy of the northwestern Alboran Sea (southwestern Mediterranean). *Marine Geology*, 120: 249-265.

2 - Estrada, F., Ercilla, G., Alonso, B., 1997. Pliocene-Quaternary tectonic-sedimentary evolution of the NE Alboran Sea (SW Mediterranean Sea). *Tectonophysics*, 282: 423-442.

3 - Reicherter, K., 2001. Paleoseismological advances in the Granada Basin (Betic Cordilleras, southern Spain). *Acta Geol. Hisp.*, 36: 267-281.

4 - Reicherter, K., Reiss, S., 2001. The Carboneras Fault Zone (southeastern Spain) revisited with Ground Penetrating Radar - Quaternary structural styles from high-resolution images. *Netherlands Journal of Earth Science*, 80: 129-138.

LATE QUATERNARY EVOLUTION OF THE ALKYONIDES GULF BASIN, CENTRAL GREECE

Sakellariou D. *, Lykousis V., Kaberi H., Alexandri S., Rousakis G., Nomikou P., Georgiou P. and Ballas D.
Hellenic Centre for Marine Research, Athens, Greece - * sakell@ncmr.gr

Abstract
Swath bathymetry, seismic profiling, coring and down-core radiometric analyses in the Gulf of Alkyonides basin provided new data on the evolution of the basin. According to them initiation of the basin took place 350-400kyr BP. Acceleration of slip rate on the south-bounding faults since 120-150kyr BP resulted to the present asymmetric character of the basin. The formation of the basin coincides with the onset of the third phase of the Gulf of Corinth evolution.

Keywords: Alkyonides, asymmetric graben, subsidence rate, sedimentation rate

Introduction

The Gulf of Alkyonides is a semi-enclosed marine basin located to the east of the Central Gulf of Corinth. Detailed structural investigation of the 1981 reactivated fault segments revealed extension in N-S direction accompanied by dextral component (1). The extension rate at the western part of the Gulf is 5 ± 3 mm/yr and becomes illegible at the eastern edge (2). Paleo-seismological investigation on the N-dipping Skinos fault (3) revealed a periodicity of 330 yr for 1981-type earthquakes.

Faulting

Two E-W trending fault segments form the active southern margin of the Alkyonides basin. They dip with 40º-45º northwards and are separated by a relay zone. The western, Strava fault segment is 14-15 km long and forms the southern bounding fault of the narrow Strava graben. The eastern segment constitutes the offshore, westward prolongation of the Psatha fault (4,5). The north-dipping fault segments form a 30km long fault zone, which controls the evolution and the structure of the basin.

Several E-W running, S-dipping fault-segments run along the northern margin of the Alkyonides basin parallel to the rocky northern coast of the Gulf. Intra-basinal faults are responsible for the formation of the shallow ridge between the main Alkyonides basin and the Central Gulf of Corinth.

Sequence stratigraphy

Single channel seismic profiling enabled the detailed investigation of the sedimentary infill of the basin. Swath bathymetric survey of the area provided excellent information on the seafloor morphology (6). Gravity and box coring, sedimentological description of the cores and ^{210}Pb down-core radiochemical analyses provided information on the nature of the recent sediments and the actual sedimentation rates.

The sediment strata dip gently southwards, forming a monocline in the hanging wall of the main, N-dipping faults. The dip gradient increases with depth below the sea floor indicating the direct control of the southern fault zone on the tectonic subsidence of the basin. The maximum thickness was observed close to the trace of the south-bounding fault and coincides with the maximum depth of the basin. A total thickness of 400m has accumulated in the depocenter. The sediment thickness decreases gradually towards the northern margin of the basin.

Basin-wide seismic packages, characterized by strong, continuous reflectors, alternate with transparent packages and represent the bulk basin infill. Lens-like bodies of chaotic seismic character intercalate between the basin-wide reflector packages. In accordance to the nature of the sedimentary infill of the adjacent central Gulf of Corinth basin (7), we interpret the above seismic-stratigraphic sequence as accumulation of silt-sand turbidites alternating with mud turbidites and hemi-pelagic mud. Correlation of the basin-wide reflector packages with major high- and low-sea level stands of Late Pleistocene indicates that, the entire, 400m thick sediment pile of the Alkyonides basin may have accumulated within the last 350-400 kyr under a mean sedimentation rate of 1-1,2m/kyr.

Nevertheless, detailed interpretation of the basin-wide reflector packages indicates that subsidence rate was not uniform throughout the basin and for the entire time since its formation. The thickness of the seismic packages in the lower part of the basin infill is more or less constant between the southern and the northern margin of the basin. This observation point out that slip rate on the southern main fault zone was compensated by the regional subsidence of the northern margin. On the contrary, seismic packages of the upper part of the basin infill thicken significantly southwards, indicating increased vertical slip rate on the southern faults. Acceleration of the slip rate on the southern faults should have taken place about 120-150 kyr BP.

^{210}Pb radiometric analyses on two cores yielded actual mean sedimentation rates of 16mm/yr for the depocenter and 12mm/yr between the depocenter and the northern margin. These rates are slightly higher than the ones observed for the mean sedimentation rate during the last 350-400 kyr and support the two-stage evolution of the basin. Similar relationship between radiometrically estimated actual sedimentation rates and geologically observed mean sedimentation rates over long periods was also found for the central Gulf of Corinth and was verified by long piston coring (7).

Conclusion - discussion

The Gulf of Alkyonides basin is an active asymmetric graben developed at the eastern prolongation of the Gulf of Corinth basin. Correlation of basin-wide reflector packages with low and high sea-level stands on Late Pleistocene indicate that subsidence and basin formation initiated 350-400 kyr BP. Tectonic subsidence was uniform throughout the basin during the early period of its formation. Acceleration of the slip rate occurred on the main, southern faults about 120-150 kyr BP and is responsible for the present asymmetric character of the basin. Actual mean sedimentation rate of 16mm/yr was found for the depocenter of the basin, close to the southern margin and becomes lower toward the northern margin. The age of the basin formation coincides with the onset of the third phase of the Gulf of Corinth evolution, as proposed recently (7,8).

References

1 - Jackson J.A., Gagnepain J., Houseman G., King G.C.P., Papadimitriou P., Soufleris C., Virieux J., 1982. Seismicity, normal faulting and the geomorphological development of the Gulf of Corinth (Greece): the Corinth earthquakes of February and March 1981. *Earth & Planetary Science Letter*, 57: 377-397.
2 - Clarke P.J., Davies R.R., England P.C., Parsons B.E., Billiris H., Paradissis D., Veis G., Denys P.H., Cross P.A., Ashkenazi V., Bingley R., 1997. Geodetic estimate of seismic hazard in the Gulf of Korinthos. *Geophys. Res. Lett.*, 24: 1303-1306.
3 - Collier R., Pantosti D., D'Addezio G., De Martini P.M., Masana E., Sakellariou D., 1998. Paleoseismicity of the 1981 Corinth earthquake fault: seismic contribution to extensional strain in central Greece and implications for seismic hazard. *Journal of Geophysical Research*, 103: 30,001-30,019.
4 - Sakellariou D., Lykousis V., Papanikolaou D., 1998. Neotectonic structure and evolution of the Gulf of Alkyonides, Central Greece. *Bull. Geol. Soc. Greece*, 32/1: 241-250.
5 - Sakellariou D., Lykousis V., Papanikolaou D., 2001. Active faulting in the Gulf of Corinth, Greece. *Rapp. Comm. int. Mer Médit*, 36: 43
6 - Alexandri M., Nomikou P., Ballas D., Lykousis V., Sakellariou D., 2003. Swath bathymetry map of Gulf of Corinth. Geoph. Res. Abstracts, Vol. 5, 14268, EGS 2003.
7 - Lykousis V., Sakellariou D., Moretti I., Kaberi H. (in press). Late Quaternary basin evolution of the Gulf of Corinth: sequence stratigraphy, sedimentation, fault-slip and subsidence rates. *Marine Geology.*
8 - Moretti I., Sakellariou D., Lykousis V., Micarelli L., 2003. The Gulf of Corinth: an active half graben? *Journal of Geodynamics*, 36: 323-340.

IDE-COSTES: A LOCAL INFORMATION SYSTEM FOR MANAGING THE COAST IN CATALUNYA (SPAIN)

Serra J. [1] *, Guimet J. [2], Montori C. [1], Roca E. [1] and Gelizo O. [1]

[1] Institute of Environmental Science and Technology (ICTA), Autonomous, University of Barcelona, Spain - gr.eurosion@uab.es
[2] IDEC (SDI of Catalonia, Barcelona, Spain - JGuimet@icc.es

Abstract

The lack of information and coordination among administration, research centres and socio-economical sectors is one of the main problems in coastal erosion management at local level. One of the aims of the EUROSION project (www.eurosion.org), is to improve or implement a local information systems that should provide quality and complete information of the coastal area, and facilitate the decision making process in coastal erosion. (1) Four pilot sites are selected for the design, realisation and set-up a local information system (2). This paper aims at describing the local information system set-up for the Catalan site of Sitges in Spain, with its goals and functionalities.

Keyworkds: Coast, metadata, map server, Catalonia

Introduction

One quarter of the European Union's coast is currently eroding despite availability of a wide range of measures to protect shorelines from eroding and flooding. Therefore the DG Environment commissioned a consortium led the Dutch National Institute for Coastal and Marine Management (RIKZ) to carry the EUROSION project. One of the aims is to produce results of immediate value for policy-makers, managers and researcher to deal with coastal erosion in the most sustainable way. One example of such a product is a local information system that will provide *"a set of technological, human, organisational, financial, and information resources organised in such a way to improve archiving, retrieval, representation, exchange and dissemination of information produced by institutions involved in shoreline management and on a specific area"* (3).

During the project several pilot sites were selected where an in-depth study and analysis was executed towards several assessment levels (4). The lack of access to useful information and coordination among administration was highlighted and the proposal of a local information system was pointed out as a valuable tool to provide quality and complete information of the coastal area, and facilitate the work for policy makers and managers.

This paper introduces the case study of Sitges in Spain, where a LIS was designed in the frame of a Catalan initiative called IDEC (SDI of Catalonia). It is a consolidated initiative of the autonomous government of Catalonia, financed by the Secretary of Information Society and managed by Catalan Institute of Cartography, which aims at creating an Infrastructure of Spatial Data for Catalonia, through a catalogue of Metadata of georreferenced information under Standard ISO 19.115. Local information system for the coast will be hold under the umbrella of IDEC as a sector IDE called IDE-COSTES. Next the main components of IDE-COSTES are going to be described.

Ide-costes description

The main services that IDE-COSTES offers are contained in a web site (www.geoportal-idec.net/idecostes/) with a friendly user interface, free accessible. A part from the usual services such as News, Links, Documents, Information and Forum, main specific services are directly accessible except for the upload module, which is a stand-alone software component downloadable from it.

IDE-COSTES is oriented to a broad group of user so it has a multilingual interface in Catalan, Spanish and English languages.

Metadata capture, editing and export-import function

The information providers and all those who have information about the coast will have to be able to describe it properly so its is possible for interested third parties to locate it, discover it and find out about its characteristics. This involves the generation of metadata. To fulfil this aim a stand-alone software component, called MetaD, has been created in the frame of the whole IDEC initiative. It is made using Visual Basic and an Access database, which can be installed in a PC or network using Windows 98, 2000, XP or NT. The capture formulas are based on the standard ISO 19115.

After user generates metadata, it is exported in XML format and stored in an Oracle BdData, which is also connected to ArcSDE and ArcIMS software to support the spatial searches.

Metadata search (internet catalogue server)

The software component called Catalogue Server, which complies with OGC interoperative specifications (WCS 1.0 OGC), enables access and consultation to the catalogue of metadata. It forms part of the services accessible via the IDE-COSTES geoportal.

Access to geographical data (map server)

This function enables access to and display and consultation of (simple or combined) cartographic data. This is based on a specialised component of the system, a WMS Client that complies with OGC specifications.

Conclusion

The idea of establishing IDE-COSTES is to improve and increase access to the information by the whole community so its participation in the decision making process can be more active and better-informed, providing it with the suitable tool for this purpose.

Several drawbacks have to be mentioned however, such as the maintenance and continuous manual generation of metadata records and costs for maintenance of the system.

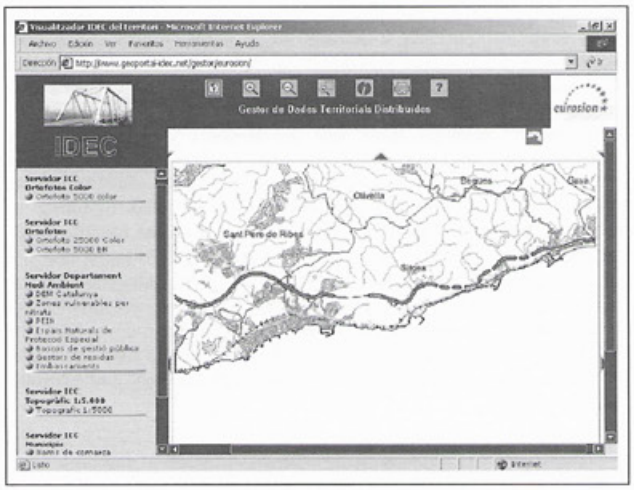


Fig 1. Screenshot of the map server of IDE-COSTES.

References

1 - Lombardo, S., Niesing, H., Salman, A., Lucius, I., 2002. Capitalising knowledge for managing coastal erosion: the EUROSION initiative. Proceedings of the 6th Conference Littoral 2002: The Changing Coast, vol. I, eds. Eurocoast, pp. 77-84, 2002.

2 - H. Niesing, Serra J., Montori C., Villares M., Roca R., Gelizo O., 2003. Local Information System as a Tool for the Coastal Erosion Management. Proceedings of the Sixth International Conference on the Mediterranean Coastal Environment, MEDCOAST 03. E.Özhan (Editor), Ravenna-Italy, 7-11 October, vol. I, pp. 179-183.

3 - EUCC-The Coastal Union, 2002. Coastal Erosion Policies: Defining the Issues. Scoping study. EUROSION project. Leiden-The Netherlands.

4 - Serra J., Montori C., Villares M., Roca R., Gelizo O. , 2002. Eurosion: Assessment on local information system for coastal erosion management. Littoral 2002. The changing Coast,EUROCOAST/EUCC, Porto-Portugal, 22-26 September, vol. 3, pp. 271-275.

APPLIED NEOTECTONIC MAPPING TO THE CIVIL ENGINEERING: FAULT ACTIVITY MAP OF THE BOLONIA AREA (THE GIBRALTAR STRAIT TUNNEL, SOUTH SPAIN)

P.G. Silva [1] *, J.L. Goy [2], C. Zazo [3], T. Bardaji [4], J. Lario [5], L. Somoza [6], L. Luque [2] and F.M. González-Hernández [2]

[1] Depto. Geología, Universidad de Salamanca, Escuela Politécnica Superior de Ávila, Avila, Spain - * pgsilva@gugu.usal.es
[2] Depto. Geología, Universidad de Salamanca, Fac. Ciencias, Salamanca, Spain
[3] Depto. Geología, Museo Nacional de Ciencias Naturales (CSIC), Madrid, Spain
[4] Depto. Geología, Universidad de. Alcalá de Henares, Madrid, Spain
[5] Depto. Ingeniería Geológica y Minera, Univ. Castilla – La Mancha, Fac. Ciencias del Medio Ambiente, Toledo, Spain
[6] División de. Geología Marina, IGME, Madrid, Spain

Abstract

A map of Fault Activity has been developed for preliminary engineering planning related to the construction of an underwater fixed link-route between Africa and Europe at the Gibraltar Strait Sector, in South Spain (The Gibraltar Tunnel). The criteria management is mainly focused on the establishment of the seismic or aseismic character of individual fault traces. From this study, the Cabo de Gracia strike-slip fault (NE-SW) can be catalogued as active during at least the last 128 ka BP, and as a probable seismic source of moderate events (Mb ≤ 5), with relevant incidence in the ancient Roman city of Baelo Claudia (AD 40-60 and AD 350-395).

Keywords: Neotectonic mapping, fault activity, ground Instability, Gibraltar Strait, Spain

Preliminary planning for the establishment of a permanent link-route between Europe and Africa (Gibraltar Strait Tunnel), promoted by the EU and supported by the National Companies SECEG S.A. (Spanish) and SNED (Moroccan), was completed in 1995. Among the set of research projects carried out during this phase, a neotectonic analysis of the Gibraltar Strait was developed devoted to the implementation of an onshore 1:100.000 Neotectonic Map of the Spanish coast (1). Research was mainly focused on the identification of regional neotectonic hazards related to the construction and future use of a high-sensitive installation like an underwater tunnel of more than 20 km long and therefore to identify those areas subject to potential (pure and induced) seismotectonic hazards. For this last topic detailed fault mapping (sc. 1:25.000) of selected pilot zones was also performed.

One of the selected areas was the Bolonia Bay (Cádiz). Late Quaternary faulting, large landslides, and swelling clayey units occur at this small sector of the Gibraltar Strait coast, constituting an excellent zone to test the performance of detailed mapping of neotectonic hazards. Mapping has been focused on the identification, and preliminary characterisation, of potentially active faults and unstable terrains for later engineering planning. Map presented here is mainly based on the neotectonic mapping guidelines established for the Spain (2 and 3) and France (4) and consequently it came from the integration of neotectonic, seismic, and paleoseismic data, on a graphic background generated by the Quaternary geology and geomorphology (Fig. 1).

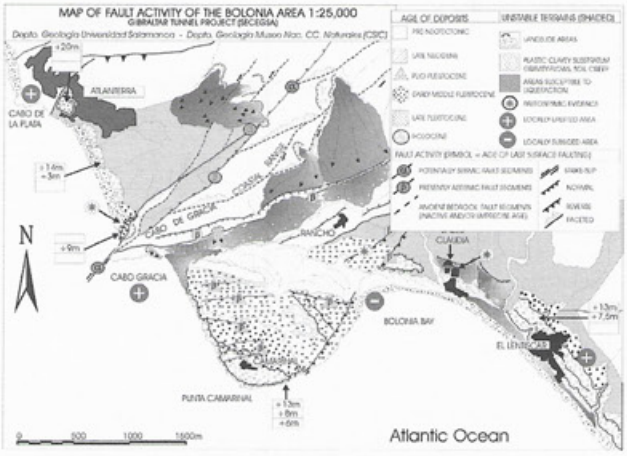


Fig. 1. Pilot Fault Activity Map of the Bolonia area.

The final purpose is the development of comprehensive methodology for the graphic representation (chart-format) of geo-hazards related to ground conditions, seismicity and fault activity. For this the age of the last deformational event, and slip rates (where possible) are taken into account, but their classification as active or inactive structures is avoided. In the map, the different fault segments have been differentiated according to the age of the last known deformational event: Late Pleistocene-Holocene (circles); Middle-Early Pleistocene (pentagons); Plio-Pleistocene (triangles); Pliocene, and Pre-Pliocene (no symbol). In addition, fault segments of different ages have been subdivided into two categories, α and β faults following the proposals of (4) and (5). *α fault segments* are seismic (or seismogenic) segments, in other words, fault segments which can be linked to present seismic activity and display deformations in Late Quaternary deposits and/or landforms. *β fault segments* are presently aseismic segments, but displaying evidences of paleoseismic deformations (of Quaternary age) and therefore potentially seismic segments.

Aside from these linear seismotectonic hazardous features, the uplift/subsidence trends of the different coastal sectors have been also highlighted by means of specific symbols, in order to illustrate the more recent vertical behavior of the different coastal sectors (Fig. 1). Finally, as evidenced by the geomorphic analysis, landscape dynamics holds a major sensitivity to more localized phenomena of both, mass-movements favored by the occurrence of low-cohesive bedrock clayey units (Almarchal and Facinas fms), and near-surface liquefaction on unconsolidated littoral sandy deposits and deep weathered Pliocene conglomerates. Since the recognition of unstable grounds is critical for large-scale engineering planning, units prone to suffer surface-destabilization by an expected moderate earthquake have been also highlighted in the map through specific patterns. As indicated by several authors (6 and 7) 0.16g are large enough to promote slope failure close to the coast, but also near-surface destabilization on unstable ground, as evidenced by the geologic, geomorphologic and archeological records (7).

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References

(1) - Goy, J.L., Zazo, C., Silva, P.G., Lario, J., Bardají, T., Somoza, L., 1995. Evaluación geomorfológica del comportamiento neotectónico del Estrecho de Gibraltar (Zona Norte) durante el Cuaternario. In: M. Esteras, (ed..), El Enlace Fijo del Estrecho de Gibraltar, SECEGSA, Madrid, Vol. 2, pp. 51-69.

(2) - Goy et al., 1991 Goy, J.L., Silva, P.G., Zazo, C., Bardají, T., Somoza, L., 1991. Model of Morpho-Neotectonic map and legend. *Bull. INQUA N.C.*, 14 : 19-31.

(3) - Baena, J., Barranco, L.M., Zazo, C., Goy, J.L., Estevez, A., Sanz de Galdeano, A. Bardají, T., Silva, P.G. Somoza, L., Rodríguez-Estrella, T., 1994. Mapas Neotectónico, Sismotectónico y de Actividad de Fallas de la Región de Murcia, Madrid, Spain. ITGE-CARM, 101 p.

(4) - "REGINE Group": Beles, J.L., Colleau, A., Fourniget, J., Godefroy, P., Lênotre, N., Sauret, B., Combes, P., Dubie, J., Vaskou, P., 1991. Proposal for classification of fault activity in an intraplate collision setting definitions and examples. *Tectonophysics*, 194 : 279-293.

(5) - Mariolakos, I., Silva, PG., Fountdoulis, I., Nassopoulos, S., Kranis, H., 1998. Evaluation of Questionnaire for Large-scale neotectonic mapping. Abst. 1st Int. Workshop on Formalization of Neotectonic Maps, Patra, Greece.

(6) - Baraza, J., Ercilla, G., Lee, J., 1992. Geotechnical properties and preliminary assesment of sediment stability on the continental slope of the Nortwestern Alboran Sea. *Geo-Marine Letters*, 12 : 150-156.

(7) - Silva, P.G., Borja, F., Zazo, C., Goy, J.L., Luque, L., Lario, J., Dabrio, C.J. and Bardají, T. (in press). Paleoseismic record at the ancient Roman City of Baelo Claudia (Cádiz, South Spain). *Tectonophysics*.

OBSERVATIONS OF PHYSICAL AND BIOLOGICAL ROUGHNESS ON THE EBRO DELTA INNER SHELF

Soriano S. *, Guillén J. and Demestre M.
Institut de Ciències del Mar (CSIC), Barcelona. Spain - * ssoriano@cmima.csic.es

Abstract
Time series of video observations of the sea bottom in the Ebro Delta inner shelf were analyzed in order to estimate the bottom roughness associated with both physical and biological morphological components. Video images display, for the most of the time, the ripples development on the bottom as active or relict bedforms.. Biological roughness is mainly caused by ophiuroids and shells tanatocenosis that change their abundance through the study period. Bottom physical roughness associated to ripples ranges between 0 and 3.2 cm whereas the total biological roughness ranges between 0.27 and 0.81 cm.

Keywords: Ripples, Benthic communities, Bottom Roughness, Ebro Delta

Introduction

Bottom roughness could be understood as a measure of the morphological variability with respect to a flat bottom. The bottom roughness is a crucial parameter because it determines the shear stress of waves and currents on the bottom and, consequently, the rate of sediment transport in the bottom boundary layer.

It has been identified three kinds of roughness (1,2): grain roughness, moveable bed roughness and form drag roughness. In sandy bottoms and under high energetic conditions moveable bed roughness would be the most important type of roughness, while form drag roughness would be for intermediate-low ones. On the other hand, silty bottoms roughness is usually dominated by bioturbation and, as a consequence of that, form drag roughness would be the main type of roughness (2).

In this paper changes in the physical and biological bottom roughness in a sandy bottom of the Ebro Delta inner shelf are studied.

Materials and Methods

One benthic tripod was deployed and an oceanographic cruise was carried out in November 2001 in the Ebro Delta (NW Mediterranean) during 9 days. Bottom sediment grain size and time-series of waves, currents and time-lapse video images were monitored at 9 m depth. Using time-lapse video images morphological features and biological components on the bottom were analyzed in order to obtain bottom physical roughness values (K_b). The Grant and Madsen (1) expression was used for the estimation of the physical roughness: $K_b = 27.7\ \eta_r^2/\lambda_r$, being λ_r the observed ripple wavelength and η_r the ripple height (which has been measured by divers and considered constant (1 cm). On the other hand, the biological roughness (K_{bio}) was estimated from measurements of density and sizes of main biological components using a modified Grant and Madsen expression (2), η_{bio} (the biological obstacles height) was assumed constant ($\eta_{bio} = 0.3$ cm) and λ_{bio} (distance between biological obstacles) was calculated as the square root of the inverse obstacles density.

Results

Observed ripple wavelength varies between 8.6 and 12.9 cm. As a result of this, observed physical bottom roughness takes values between 2.14 and 3.23 cm. When the bottom was completely flat it was assigned to K_b the value of median grain size (D_{50}) (Fig. 1).

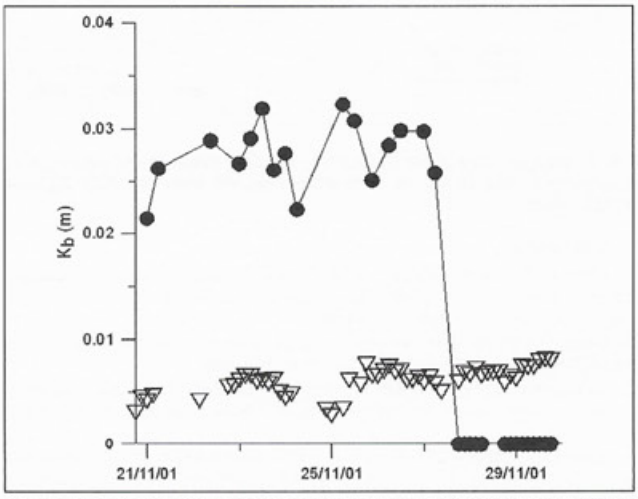

Fig. 1. Observed physical (●) and biological (▽) bottom roughness during the study period.

Ophiuroids and pieces of shells are the most important biological components that affect bottom roughness during the study period. Ophiuroids density has reached values near 170 individuals per square meter, causing a K_{bio} that oscillates between 0.05 and 0.32 cm. Pieces of shells are very abundant (maximum values near 650 pieces per square meter) and contribute to bottom biological roughness in ranges between 0.15 and 0.64 cm. Figure 2 shows tendencies in both kinds of biological roughness. Ophiuroids do not present a marked tendency through the study period while pieces of shells increase its values in time. Total K_{bio} (sum of K_{bio} obtained by ophiuroids and shells) displays values from 0.27 to 0.81 cm.

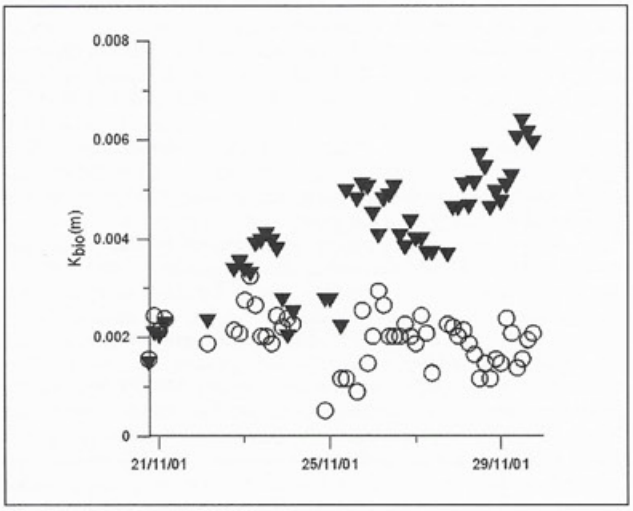

Fig. 2. K_{bio} for ophiuroids (○) and shells pieces (▼)during the study period.

Discussion and conclusions

The present work shows the relative contribution of biological components and sedimentary structures tothe bottom roughness. Ripple morphology remains relatively constant during the study period, although they are flattened by ophiuroids bioturbation. Ophiuroids density is rather steady during the study period whereas pieces of shells increase its abundance (and its contribution to the bottom roughness) as a consequence of being inert biogenic material appearing after storm periods in the bottom surface.

The biological roughness represents a subordinate but not negligible amount (about 20%) of the form drag roughness. Therefore, physical and biological roughnesses coexist and both should be taken into account for sediment transport studies.

References

1 - Grant, W.D., and Madsen, O.S., 1982. Movable bed roughness in unsteady oscillatory flow. *Journal of Geophysical Research*, 87: 469-481.
2 - Harris, C.K., and Wiberg, P.L., 2001. A two-dimensional, time-dependent model of suspended sediment transport and bed reworking for continental shelves. *Computers and Geosciences*, 27: 675-690.

THE NEOTECTONICS OF THE GULF OF GÖKOVA: SOUTHEAST AEGEAN SEA-SOUTHWESTERN TURKEY

Atilla Uluğ [1] *, Muhammet Duman [1], Şükrü Ersoy [2], Erdeniz Özel [1], Mert Avcı [1]

[1] Dokuz Eylul University Institute of Marine Science and Technology Baku Bulvarı, No: 10, 35340 İnciraltı, İzmir, Turkey
ulug@imst.deu.edu.tr

[2] Yıldız Technical University, Natural Science Research Center, Beşiktaş, İstanbul, Turkey - sersoy@ytu.edu.tr

Abstract

The Sedimentary and tectonic Late Quaternary evolution of the Gulf of Gökova, located at the southwest Anatolia–southeastern Aegean Sea region, has been interpreted from 3.5 kHz and single channel airgun seismic reflection profiles. The oldest part of the Gökova basin is bounded by mainly E-W trending faults, and filled by Miocene–Pliocene–Quaternary hemipelagic sediments with thickness up to 2.5 km. Younger active faulting, the so-called Gökova Transfer Fault, trends NE in the central part of the Gulf of Gökova basin and records sinistral strike-slip motion broadly parallel to the convergence motion of the Aegean-Anatolian and African plates.

Keywords: Aegean Sea, Seismic stratigraphy, Neotectonics

Introduction

In the Mediterranean the Aegean Sea is a region of active extensional tectonism within the overriding part of a convergent plate margin system (Africa with respect to Europe). The tectonic framework of western Turkey comprises numerous east-west trending graben, associated with the regional north-south extension of the Aegean plate (1). Detailed studies (2) in Aegean Sea show that there have been significant changes in the fault patterns during the Quaternary. The Gulf of Gökova is located in the southeast Aegean Sea, along the coast of southwest Anatolia, which is a region including most of the major rifts and grabens. The Gulf has about 90 km E–W length and 25 km N–S width and it is bordered by Datça Peninsula to the south, the island of Kos to the west and Bodrum Peninsula to the north. The Gökova region is a part of the western Anatolia–Aegean Sea area, which is presently submitted to an N–S regional extensional tectonic system. The imprints of this extensional regime are clearly seen in the geology and geomorphology of western Anatolia, as well as in the bathymetry of the Aegean Sea.

The Gökova province is mainly characterized by two successive tectonic regimes. These overlapping rift and graben systems are well seen in the land geology. The first one is the N–S compressional paleo-tectonic regime, possessing the later counter-clockwise rotation, and resulted in a NW–SE rift and graben system. The NW–SE-oriented paleotectonic rifts and grabens, i.e., Milas–Ören and Yatağan Muğla Rifts, are filled by mainly Middle Miocene to Quaternary deposits of continental origin. The second one is the neotectonic regime, possessing the N–S extension that has resulted in mainly E–W-oriented rift and graben systems, i.e., Gökova Rift (3). The Gulf of Gökova was mainly opened by an E–W-oriented, major normal listric Datça Fault (Fig 1). The estimated overall rate of extension in the gulf is at least 1.1 mm/y and the amount of total extension is at least 5.5 km (4).

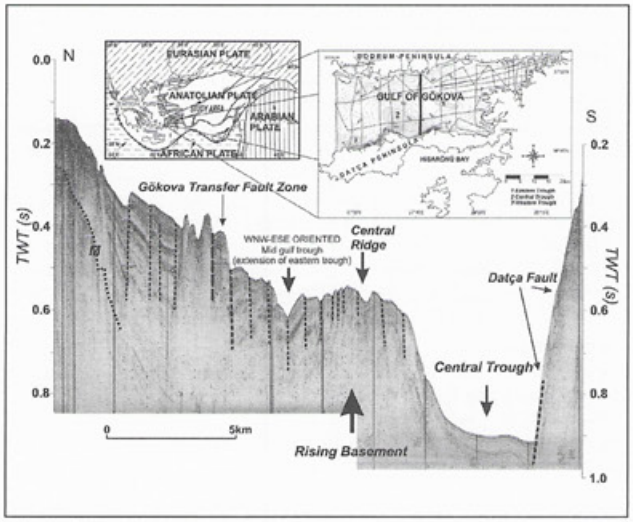

Fig. 1. Airgun profile from the Gulf of Gökova. Inset shows the survey lines and the location of pofile as heavy line. Sub-vertical dashed lines=faults, M=Multiple. Profile is ca. 20 km long.

Results

At least five superimposed deltaic sequences, separated by major erosional unconformities, occupy the shelf and the basin slope region of the northeastern Gulf of Gökova. The oldest recognized delta sequence (DS5) probably dates from isotopic stages 10 (ca. 0.34 Ma). Marine isotopic stage 10 unconformity separates DS4 and DS5; and lies approximately 215 m below the present sea-level. The tentative age assigned to the delta sequences yields rates of tectonic subsidence to be appraised. In the northeastern slope of the basin the late Quaternary tectonic subsidence is about 0.3-0.4 m/1000yr and is probably related to basement graben structures.

Gulf of Gökova is mainly opened by the E–W-oriented, buried Datça Fault located at the south and its antithetic faults located at the north (Fig. 1). The Datça Fault might have begun to work in the Latest Miocene–Pliocene. In terms of local rather than regional effects, its activity has been decelerated, possibly since the Pleistocene. The continuing extension in the area may have initiated a second phase of faulting, e.g., WNW–ESE-oriented subgrabens in the central gulf and major WSW–ENE normal faulting at the northwest margin. Younger active faulting so-called Gökova Transfer Fault (GTF) (Fig. 2) trends NE in the central part of the Gulf of Gökova basin and records sinistral strike-slip motion broadly parallel to the convergence direction of the Aegean-Anatolian and African plates.

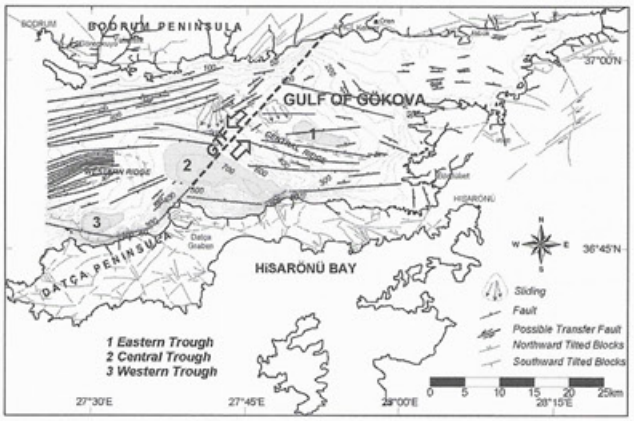

Fig. 2. Tectonic map of the study area, showing major faults with ticks at downthrows. The faults on land were adopted from (3). GTF Gökova transfer fault.

References

1 - Dewey, F.J., and Şengör, A.M.C., 1979. Aegean and surrounding regions: complex multiplate and continuum tectonics in a convergent zone. *Geol. Soc. Am. Bull.*, 90: 84-92.

2 - Piper, D.J.W. and Perissoratis, C., 2003. Quaternary neotectonics of the South Aegean arc. *Marine Geology.*, 198: 259-288.

3 - Görür, N., et. al., 1995. Rift formation in the Gökova region, southwest Anatolia: implications for the opening of the Aegean Sea. *Geol. Mag.*, 132: 637–650.

4 - Kurt, H., Demirbağ, E., Kuşçu, İ., 1999. Investigation of the submarine active tectonism in the Gulf of Gökova, southwest Anatolia–southeast Aegean Sea, by multi-channel seismic reflection data. *Tectonophysics*, 305: 477–496.

TRIGGERING MECHANISMS OF A MAJOR DEBRIS FLOW OFF THE EBRO MARGIN, NW MEDITERRANEAN: THE BIG'95

R. Urgeles [1] *, G. Lastras [1], M. Canals [1], D. Leynaud [2], N. Sultan [3]

[1] GRC Geociències Marines, Departament d'Estratigrafia , Paleontologia i Geociències Marines, Facultat de Geologia, Univ. de Barcelona, Spain - * urgeles@ub.edu

[2] Departement of Geology, University of Tromsø, Norway

[3] Département Géosciences Marines, Direction des Recherches Océaniques, IFREMER, Plouzané, France

Abstract

Geophysical, geotechnical and sedimentological data from the continental slope and rise off the Ebro margin, NW Mediterranean, are presented from an area that has undergone a major instability event, known as the BIG'95. The data depict accurate details of the debris flow deposit, the scar area and subjacent structure, and reveal the nature of both failed and unfailed sediments. Such an extensive data set allows to obtain a clear picture of the sequence of events that initiated the failure of this landslide. These included as major factors the existence of low shear strength materials and the growth of a volcanic structure beneath the headwall area.

Keywords: Debris flow, NW Mediterranean, geotechnical properties, triggering mechanisms

During the last decade a large effort has been put towards understanding the sediment processes and dynamics along the Ebro margin, NW Mediterranean, with a special emphasis on landslide driven processes. Such effort has included the collection of full coverage multibeam bathymetry and derived backscatter, high- and very high-resolution 3.5 kHz parametric and airgun seismic reflection profiles, deep-towed TOBI and MAK1-M sidescan sonar, and 17 cores which have been dated and several parameters have been analysed from, such as grain size, density, water content and undrained shear strength.

Such effort has made evident that the Ebro continental slope and rise are dominated by meandering channel-levee complexes, which evolve upslope into canyons and downslope merge into one single, mid-ocean type channel, the Valencia channel. It is also clear from the extensive multibeam data set that the Ebro slope is constituted by relatively little-incised canyons compared to its northwards Catalan margin counterpart, which also has a much narrower shelf.

Such a pattern is disrupted near the centre of the Ebro continental rise, where channels have been wiped out by a large, 2000 km^2, 26 km^3 mass-wasting event known as BIG'95 (1). In this area the base-of-slope down to the Valencia Channel shows a rougher aspect. The mosaics made from multibeam bathymetry show a series of low backscatter patches surrounded by a series of high backscatter stripes describing the shape of a horse tail. This pattern is believed to correspond to a debris flow with rafted blocks surrounded by the pathways of coarser sediment material (1).

At the head of the debris flow a sinuous scarp up to 200 m high is present. Upslope such scar minor scars also develop, while immediately downslope the ghost of a former channel is present strikingly parallel to the main headwall scar. In seismic reflection profiles the headwall scar appears closely linked to a subjacent structure, which is believed to correspond to a volcanic dome (2).

The geotechnical parameters analysed in the cores collected from the debris flow and nearby areas allow to distinguish an upper post-landslide unit, which shows a similar pattern through all the cores. This upper part shows high water contents (up to 80% of the total weight) and corresponding low densities, as expected from a recently deposited sediment. The post-landslide unit has much lower shear strengths (around 5 kPa) than that of the sediments below (3).

The landslide sediments, i.e. those involved into the debris flow, have lesser amounts of water, and thus their density is also slightly higher. Water content is also slightly lower (by about 10%) than that of the sediments that have not been affected by the passage of the debris flow (cores CLKS02 and CLKS03). On the other hand, at the same consolidation stress, shear strength appears to be higher for the sediments involved into the debris flow than for those pre-dating the BIG'95. However, the remoulded shear strength is similar (around 5 kPa) for both the BIG'95 and pre-BIG'95 sediments probably reflecting that increased pore water pressures at the source area were involved in the genesis of the landslide. Destructuration of the sediment into the debris flow and consolidation after deposition have been able to dissipate such pressures.

The most striking difference arises when comparing the two cores obtained from the area not affected by the landslide, CLKS02 and CLKS03, which, on the other hand, are probably the most interesting cores since their physical properties most probably match those of the sediments affected by the landslide before it took place. These two cores show quite distinct shear strength profiles, with CLKS03, collected on the open slope showing an increasing trend with depth and CLKS02, on the flank of the levee showing almost no increase with depth (3). This reflects a change in sedimentation rates according to the environmental setting, the ones on the levee, being probably much higher than those on the open slope, also probably reflecting that those of the levee are underconsolidated.

Since the Ebro margin is largely aseismic, earthquakes may have only played a secondary role in triggering the landslide. Thus, failure most probably occurred in a retrogressive fashion due to oversteepening of the slope associated to the presence of a volcanic dome , with failure initially occurring downslope, in the low shear strength channel-levee deposits. Due to the age of the landslide a climatic influence on triggering can not be discarded.

References

1 - Lastras, G., Canals, M., Hughes-Clarke, J.E., Moreno, A., De Batist, M., Masson, D.G., Cochonat, P., 2002. Seafloor imagery from the BIG'95 debris flow, western Mediterranean. *Geology*, 30: 871-874.

2 - Lastras, G., Canals, M., Urgeles, R., De Batist, M., Calafat, A.M., Casamor, J.L., in press. Characterisation of a recent debris flow deposit after a variety of seismic reflection data, Ebro margin, Western Mediterranean Sea. *Marine Geology*.

3 - Urgeles, R., Lastras. G., Canals, M., Willmott, V., Moreno, A., Casas, D., Baraza, J., Berné, S., 2003. The BIG'95 debris flow and adjacent unfailed sediments in the NW Mediterranean Sea: geotechnical-sedimentological properties and dating. Pp. 479-487. In: J. Locat and J. Mienert (eds.), Submarine Mass Movemens and their Consequences.

ON THE TECTONIC ORIGIN OF THE MAIN MORPHOLOGIC FEATURES IN THE ALBORAN SEA BASIN

Vázquez J.T. [1] *, Vegas R. [2], Maldonado A. [3] and Bárcenas P. [1]

[1] Departamento de Geología, Facultad de Ciencias del Mar, Universidad de Cádiz. CASEM, Campus Río San Pedro, Puerto Real, Spain
* juan.vazquez@uca.es

[2] Departamento de Geodinámica, Facultad de Ciencias Geológicas, Universidad Complutense, Madrid, Spain

[3] Instituto Andaluz de Ciencias de la Tierra, CSIC-Universidad de Granada, Facultad de Ciencias, Campus Fuentenueva s/n, Granada, Spain

Abstract

A new genetic model is proposed in order to explain the morphology of the Alboran Sea Basin. This model is based in the influence of significatives lateral crustal changes, the tectonic evolution, including neotectonics, and the Mediterranean-Atlantic water masses dynamics. The basin is situated in a continental margin context and the main physiographic region is a wide and complex slope. Its morphology is characterized for the presence of several stepped subbasins, and is basically controlled by the development of neotectonic structures of different types and scales: flexures, faults and folds.

Keywords: Morphology, Structure, Neotectonics, Alboran Basin, Western Mediterranean

Introduction

The Alboran Sea is the most western sector of the Mediterranean Sea and is located between the southern Spain and northern Africa coasts. It has been differenciated three main physiographic domains in the Alboran Sea Basin: margins, basins and structural highs (1, 2). This physiographic scheme partially differs from classic divisions in passive continental margins (shelf, slope, continental rise and abyssal plain), that can be considered as its morphologic equivalents.

Morphologic features

A new interpretative model of morphology is presented in Figure 1. This model considers that the Alboran Sea Basin is situated in a continental margin context with a complex stepped slope marked by the development of several sub-basins at different depths, and the adjacent abyssal plain corresponds to the South Balearin basin (3).

This model shows that the main margin type is the intermediate or stepped. The margin physiography is constituted by shelf and slope, the continental rise is absent and the slope ends to the main sub-basins floor in a progressive or abrupt way. The slope is the main physiographic unit and is marked by its stepped morphology with several structural highs and two important marginal plateau, one in the southern sector (Moulouya plateau) and the other one in the northern sector (Motril-Djibouti plateau).

There are numerous morphological highs with several: tabular, ridge, cone or truncated cone. Basically, they have a structural origin in relation to volcanic buildings or basement elevations, besides it has been described some highs in relation to folded sedimentary cover and diapiric structures (3). The most important high is the Alboran Seamount.

Basins, limited by margins and highs, are tilted eastwards in general (Fig. 1), The main basins are the western and eastern basins because they limits de lower slope. The other sub-basins are situated in an intermediate slope position (3). The Eastern basin show a marked flexure in the transition to the South Balearic basin eastwards (4).

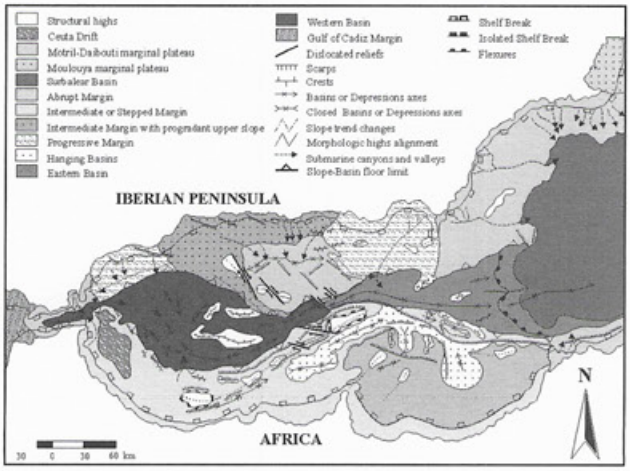

Fig. 1. Cartography of main morphologic domains distribution of the Alboran Sea Basin. Redrawed from Vázquez (3).

Morphology origin

The main morphologic features of Alboran Sea Basin are strongly controlled by three factors:

i) Lateral crustal changes. The basin is located mainly on thinned continental crust (5, 6), lateral changes are related to the transition between Betic-Rifean thicked continental crust (northwestwards and southwestwards) and the South Balearic oceanic crust eastwards. The basin shows a general elevation in comparation to marine basins with an oceanic crustal substract.

ii) Tectonic context. The basin has been generated in the back area of the Betic-Rifean arcuated orogen and is situated in its inner part. The last stage in the orogenic evolution has resulted from the collision of a platelet against the older Northafrican and Southiberian continental margins during late Oligocene and Miocene.

The Alboran sea basin has been generated in this stage since the Lower Miocene and has suffered a complex tectonic evolution (5), including a new basin configuration from the Upper Tortonian (2, 7), as well as te development of neotectonic structures (3).

iii) Mediterranean-Atlantic dynamics. The Alboran Sea region is submitted to gateways dynamics and water masses communication between the Mediterranean Sea and the Atlantic ocean since Lower Pliocene at least. In this sense, this factor has generated a strong marine dynamics constrainned by basin physiography as well as has produced a strong influence on the development of erosive and sedimentary proceses in the basin.

References

1 - Alonso, B., Ercilla, G., Baraza, J., Maldonado, A., 1992. Arquitectura y Evolución durante el Cuaternario de las facies del margen y cuencas septentrionales en el Mar de Alborán. Pp. 467-476. In: A. Maldonado (Ed.), III Congreso Geológico de España, Simposio El Mar de Alborán y el Golfo de Cádiz: conexiones atlántico-mediterráneo. Univ. Salamanca, Salamanca.

2 - Maldonado, A., Campillo, A.C., Mauffret, A., Alonso, B., Woodside, J., Campos, J., 1992. Alboran Sea Late Cenozoic Tectonic and Stratigraphic Evolution. *Geo-Marine Letters*, 12: 179-186.

3 - Vázquez, J.T., 2001. Estructura del Margen Septentrional del Mar de Alborán. Tesis Doctoral, Universidad Complutense de Madrid, Madrid, 422 p.

4 - Vázquez, J.T., Vegas, R., 1996. Estructura profunda de la Cuenca del Mar de Alborán: margen continental nororiental y zona de transición hacia la cuenca Surbalear. *Geogaceta*, 20(4): 962-965.

5 - Comas, M. C., J. P. Platt, J. I. Soto, A.B. Watts 1999. The origin and tectonic history of the Alboran Basin: insights from Leg 161 results, basement Pp. 555-579. In: Proc. ODP, Sci Results, 161: College Station, TX (Ocean Drilling Program).

6 - Torné, T., Fernández, M. Comas, M.C. Soto, J.I., 2000. Lithospheric estructure beneat the Alboran Basin: Results, from 3D Gravity Modeling and Tectonic Relevance. *J. Geophys. Res.*, 105, (B2): 3209-3228.

7 - Campos, J., Maldonado, A., Campillo, A.C., 1992. Post-Messinian Evolutional Patterns of the Central Alboran Sea. *Geo-Marine Lett*,. 12: 173-178.

HIGH-RESOLUTION IMAGING OF ACTIVE STRUCTURES OFFSHORE ON THE SOUTHWEST IBERIAN MARGIN: IMPLICATIONS FOR PALEOSEISMIC STUDIES

Alexis Vizcaino [1] *, Eulàlia Gràcia [1], Raimon Pallàs [2], Carlota Escutia [3], Susana Lebreiro [4], J.G. Orellana [5], J.J.Dañobetia [1]

[1] Centre Mediterrani d'Investigacions Marines i Ambientals, UTM-CSIC, Barcelona, Spain
alexis@utm.csic.es - egracia@utm.csic.es - jjdanobeitia@icm.csic.es
[2] Univ. Barcelona, Facultat de Geologia, Barcelona, Spain - raimonpallas@ ub.edu
[3] Instituto Andaluz de Ciencias de la Tierra (CSIC-UGR), Campus Fuentenueva, Granada, Spain - cescutia@ugr.es
[4] Instituto Geológico e Mineiro, Dpto. Geologia Marinha, Alfragide, Portugal - susana.lebreiro@igm.pt
[5] Laboratori de Radioactivitat Ambiental, Facultat de Ciències (Ed. C), Universitat Autónoma de Barcelona, Spain - Jordi.Garcia@uab.es

Abstract

The Southwest Iberian Margin is affected by large earthquakes in Western Europe as it hosts the boundary beween Eurasian and African plates. We identified several active faults which are potential sources of large magnitude earthquakes and tsunamis (Mw > 6). We have acquiered giant piston cores and TOBY mosaics, which allow us to investigate on the past activity of the faults, which has implications for seismic hazard assessment on the southwest Iberian Margin.

Keywords: active faults, turbidite, submarine landslides, TOBI sidescan sonar, earthquakes

The SW Iberian Margin hosts the present-day boundary between the European and African Plates (1, 2, 3). Convergence is accommodated along a wide and diffuse deformation zone characterized by an elevated seismic activity (4), source of the largest and most destructive earthquakes and tsunamis in Western Europe (e.g. 1969 Horseshoe Earthquake Mw=8, 1755 Lisbon Earthquake and Tsunami M=8.5, 5). Two marine cruises have been devoted to this purpose: the HITS cruise ("High Resolution Imaging of Tsunami genic Structures in SW Iberia") carried out on board the Spanish RV *Hesperides* during September-October 2001, was designed to determine the geometry of the active seismogenic structures in the SW Iberian Margin and their sediment instability associated processes. And during the PRIME-PICABIA cruise on board the French RV *Marion Dufresne* during July 2003, we acquired a total of 4 giant CALYPSO piston cores located on the Tagus and Horseshoe Abyssal Plains, and on the footwall (Active faults p.e. Marques de Pombal Fault) and they will be devoted to calculate their recurrance rate by dating of the turbiditic units generated by seismic events. This work is based in a combination of different survey methods and resolution: TOBI sidescan sonar, swath batimetry and acoustic backscatter, subbottom profiles TOPAS, high resolution seismic and CALYPSO giant piston cores.

Two high-resolution TOBI sidescan sonar mosaics were obtained covering the Marques de Pombal Fault area and the Cape San Vicente Canyon and Horseshoe Faults, totalling more than 550 nm of data. On the first area, we identified a NNE-trending lineament, corresponding to the rupture trace and escarpment of the 50 km long Marques de Pombal thrust fault, possible source of the 1755 Lisbon Earthquake and Tsunami (5, 6). Associated to this structure, we identified a large area (~260 km^2) of high acoustic backscatter in the southern half of the Marques de Pombal thrust front, which we interpret as the result of a recent complex submarine landslide. This landslide might have been generated during the last seismic event (1755?), and could have contributed to the devastating tsunami (7). High-resolution sub-bottom profiler sections across the toe of the landslide, allowed the identification of alternating seismic transparent units (interpreted as a landslides) and seismically well-stratified units (interpreted as pelagic sediments) suggesting cyclic activity of the Marques de Pombal fault (6).

On the second area, the TOBI and swath-bathymetry images show that the San Vicente Canyon is deeply carved into the seafloor, showing a clear asymmetry between its flanks. The linearity and sudden change of trend of these structures suggests that the canyon may be controlled by faults. The bottom of the canyon, barren of recent sediments, appears highly reflective with corrugated surfaces, which we interpret as corresponding to the outcrop of stratified Mesozoic rocks. At the southern end of the canyon, the NE-SW trending Horseshoe Fault is a steep east-dipping thrust below the eastern anticline which displaces the chaotic-seismic facies unit, of late Miocene age, referred to as the "giant chaotic body" (8). Tectonic activity has continued until the present, as evidenced by growth-strata deposits that are younger than late Miocene, and by steep escarpments along the thrust trace.

Four CALYPSO giant piston cores were recovered during the PICABIA cruise: Three along the Tagus and Horseshoe abyssal plains (MD03-2701, MD03-2703 and MD03-2704) and one on the footwall of the Marques de Pombal Fault (MD03-2702), to sample the most recent landslide deposits. Several turbidite events were distinguished based on sedimentological description correlated with MST data (magnetic susceptibility, p-wave and gamma-ray). The chronology of these events based on ^{210}Pb and ^{14}C AMS dating, relative paleointensities, will be used in the characterization of the past activity and recurrence rate of the SW Iberian Margin faults. Chronostratigraphy based on δ^{18}O and δ^{13}C will also be done and it will be compared to paleoceanographic records from the west Iberian Margin. We plan to correlate turbidites sampled near active faults, with the ones found at the neighboring abyssal plains, as regional and synchronous events are likely to be generated by large earthquakes. The identification and understanding of these active faults and associated deposits is fundamental for earthquake and tsunami hazard assessment in the SW Iberian Margin.

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References

1 - Grimison, N.L. and Chen, W.P., 1986. The Azores-Gibraltar Plate Boundary: Focal Mechanisms, Dephts of Earthquakes and their Tectonic Implications. *Journal of Geophysical Research*, 91, B2: 2029-2047.

2 - Buforn, E., C. Sanz de Galdeano and A. Udias, 1995. Seismotectonics of the Ibero-Maghrebian region. *Tectonophysics*, 248: 247-261.

3 - Gràcia, E., Dañobeitia, J.J., Vergés, J., an Bartolomé, R., 2003a. Crustal architecture and tectonic evolution of the Gulf of Cadiz (SW Iberian Margin) at the convergence of the Eurasian and African plates. *Tectonics*, 22 (4): 1033-1057.

4 - Gràcia, E., Dañobeitia, J.J., Vergés, J., and PARSIFAL Team, 2003b. Mapping active faults offshore Portugal (36ºN-38ºN): Implications for seismic hazard assessment in the SW Iberian Margin. *Geology*, 31(1): 83-86.

5 - Zitellini, N., Mendes Victor, L., Córdoba, D., Dañobeitia, J.J., Nicolich, R., Pellis, G., Ribeiro, A., Sartori, R., Torelli, L., and BIGSETS Team, 2001. Source of the 1755 Lisbon Earthquake and Tsunami Investigated. *EOS Trans. AGU*, 82: 285-290-291.

6 - Gràcia, E., Dañobeitia, J.J., and HITS cruise party, 2001. High-Resolution Imaging of Tsunamigenic Structures in the SW Iberian Margin (Eurasia-Africa Convergence): Implications for Seismic Hazard Assessment. *EOS Trans AGU*, 82(47), Fall meeting Suppl., San Francisco (USA), S51B-0610.

7 - Baptista, M.A., Miranda, P.M.A., Miranda, J.M., and Mendes Victor, L., 1998. Constrains on the source of the 1755 Lisbon Tsunami inferred from numerical modelling of historical data: J. *Geodynamics*, 25: 159-174.

8 - Torelli, L., Sartori, R., and Zitellini, N., 1997, The giant chaotic body in the Atlantic ocean off Gibraltar: new results from a deep seismic reflection survey. *Marine and Petroleum Geology*, 14: 125-138.

LA PHASE ARGILEUSE DES SÉDIMENTS SUPERFICIELS DE LA PLATE-FORME CONTINENTALE AU LARGE DE L'ESTUAIRE OUM ER RBIA (MAROC) : DONNÉES PRÉLIMINAIRES DE LA MISSION OCÉANOGRAPHIQUE PROTIT 1

B. Zourarah [1] *, C. Carruesco [2], M. Maanan [1]

[1] Laboratoire de Géosciences Marines - Faculté des Sciences d'El Jadida, Université Chouaib Doukkali, El Jadida, Maroc
* zourarah@ucd.ac.ma; kzourarah@hotmail.com
[2] Département de Géologie et d'Océanographie, Université de Bordeaux I, France

Résumé

La phase argileuse des sédiments de la plate forme continentale au large de l'estuaire Oum Er Rbia comporte par ordre d'importance décroissant, l'illite, la chlorite et la kaolinite. Ce cortège minéralogique est relativement identique à celui rencontré au niveau des sédiments sub-actuel estuariens, ce qui montre le rôle important que jouait l'Oum Er Rbia dans le transfert de la matière continent - océan.

Mots clés : Maroc, plate forme continentale, Oum Er Rbia, argiles, Protit

Introduction

L'Oum Er Rbia est le cours d'eau le plus régulier du Maroc (1). Son débit annuel moyen est de 117m^3/an soit un débit spécifique de 4 l/s/km. Ce bassin versant a été aménagé depuis le début des années 60 et un certain nombre de barrages hydrauliques y ont été construits. Les apports solides estimés dans la station la plus en aval du cours sont de l'ordre de 10.10^6 T/an (2). Une grande partie de ces apports est retenue dans les barrages situés en amont de l'estuaire et le transfert des sédiments vers le milieu marin est conditionné par les lâchés de ces barrages. Avant de se jeter en mer, l'oued Oum Er Bia draine les massifs montagneux du Moyen Atlas, du Haut Atlas central puis parcourt les plateaux des phosphates et une partie de la méseta marocaine. Cependant la nature des apports de l'Oum Er Bia reste mal connue.

L'objectif du présent travail est de déterminer le cortège argileux des sédiments superficiels de la plate forme continentale afin d'identifier leur origine.

Matériels et méthodes

Douze (12) échantillons de surface ont été prélevés par une benne lors de la mission océanographique PROTIT 1 (Fig. 1) à bord du Navire Ecole *Al Manar* de l'Institut Supérieur de Technologie de Pêche Maritime (Safi) en juillet 2001. La phase argileuse des sédiments a été déterminée par diffractométrie de rayon X (3).

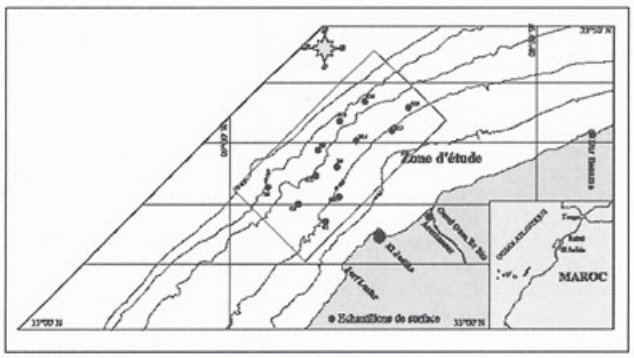

Fig. 1. Localisation de la zone d'études.

Résultats et discussion

Le cortège minéralogique de la fraction argileuse des sédiments de la plate forme continentale au large de l'estuaire Oum Er Rbia est constitué de trois minéraux essentiels (Fig. 2): l'illite, la chlorite et la kaolinite. L'illite constitue le minéral cardinal (de 50% à 57%). Les autres minéraux sont moins importants (30 à 40% pour la chlorite et 9 à 18% pour la kaolinite). Les taux les plus élevés de l'illite sont rencontrés au large de l'embouchure de Oum Er Rbia (57%). Cette phase argileuse est identique à celle trouvée dans les sédiments situés à la base des carottes prélevées dans la partie avale de l'estuaire Oum Er Rbia et datés avec le ^{210}Pb et le ^{137}Cs au début du 18ème siècle (4). Cette période, supposée antérieure aux aménagements hydrauliques dans le bassin versant de l'Oum Er Rbia, est caractérisée par des apports importants et un transfert continent-océan continue de l'ordre de 10^6 tonnes/ an (2).

L'ensemble de ces résultats montre d'une part, le sédiment la plate forme continental sont reliques et d'autre part, le rôle important que jouait l'Oum Er Rbia dans l'alimentation de la plate forme continentale adjacente

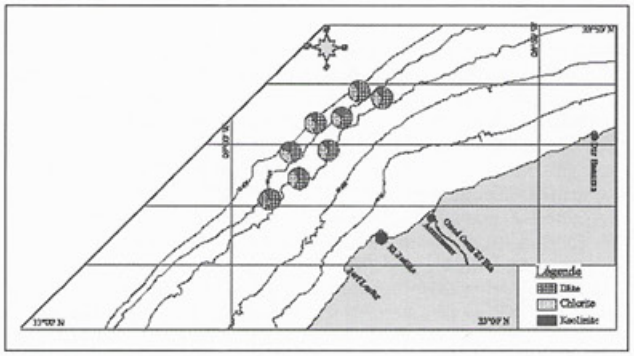

Fig. 2. Répartition des minéraux argileux dans les sédiments superficiels de la baie d'El Jadida-Azmmour.

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Références

1 - Givcovig, 1967. Bassin de l'Oum Er Rbia. Etude du régime de l'oued Oum Er Rbia et ses affluents. Rapport inédit. MTPC/DH/DRE, Rabat, 47 p., 41 tabl., 133 pl.

2 - Snoussi, M., 1989. Nature, estimation et comparaison des flux de matière issus des bassins versant de l'Adour (France), Sebou, Oum Er Rbia, Souss (Maroc) : impact du climat sur les apports. Thèse de Doctorat d'Etat 450 p. Université de Bordeaux I, France.

3 - Holtzapffel, T. 1985. Les minéraux argileux, préparations, analyses diffractométriques et détermination. *Soc. Géol. Nord*, 12: 136.

4 - Zourarah, B., 2002. Les processus côtiers actuels et leur impact sur l'environnement littoral des Doukkala (côte atlantique marocaine) : Approche hydrodynamique, morphologique, sédimentologique et géochimique. Thèse de Doctorat d'état, 232 p, Université Chouaïb Doukkali El Jadida (Maroc).

HOLOCENE FINE-GRAINED SEDIMENTS FROM THE BALEARIC ABYSSAL PLAIN

D. Zúñiga [1] *, J. García [2], N.B. Price [3], A. Calafat [1], M. Canals [1], A. Sanchez-Vidal [1], J. A. Sanchez-Cabeza [2] and P. Masqué [2]

[1] GRC Geociéncies Marines, Dept.d´Estratigrafia, Paleontología i Geociéncies Marines, Universitat de Barcelona, Barcelona, Spain
[2] Institut de Ciencia i Tecnologia Ambientals, Departament de Física, Universitat Autònoma de Barcelona, Bellaterra, Spain
[3] Dept. of Geology and Geophysics, University of Edinburgh, United Kingdom

Abstract

A high resolution sedimentological and geochemical study of Late Holocene sediments in the Balearic Abyssal Plain illustrates the influence of early diagenetic processes and the supply of fine particles escaping from hundreds of kilometres distant continental margins by advective transport.

Keywords : Balearic Abyssal Plain, fine sediment characterization, particle sources, advective transport

Previous studies on Holocene fine sedimentation from the deep Northwestern Mediterranean Sea were carried out on slope and rise environments of the Gulf of Lions, the Catalan and the Balearic margin, most often in relation to canyon / open slope comparative studies [1, 2, 3, 4].

Here we present the results from the analysis of three 30-40 cm in length sediment cores labelled A, B and C, collected in the deep open sea environment of the 2,850 m deep central Balearic Abyssal Plain. The sampling stations occupy the vertices of a triangle that is at the greatest distance from the nearest landmasses, the Balearic Islands to the east and the Corsica / Sardinia block to the west. Accelerator Mass Spectrometry ^{14}C datings show that the upper 30 cm in each of the cores correspond to the last 4,600 years, which implies an averaged accumulation rate of 0,57 cm per 100 years of all cores.

The sediments are yellowish brown and show two 1 cm thick pteropod ooze layers. The upper layer forms the uppermost centimetre in all cores while the lower layer appears 13-14 cm, 19-20 cm and 14-15 cm in cores A, B and C, respectively. The lower pteropod layer represents the base of a graded turbidite lacking of foraminifer tests.

Organic carbon contents (0,19%-0,63%) are low if compared with those from the superficial sediments on the river-influenced Gulf of Lions and Catalan continental margins to the north and northwest of the study area [1, 2]. The C/N ratio oscillates around mean values of 5.7, again lower than the values recorded in the above mentioned margins where C/N>12 [2]. This shows that continental inputs contribute less to sediments than planktonic fluxes in the study area. A remarkable feature has been noticed in the turbidity unit, which upper and lower boundaries show a step in organic carbon contents.

Since biogenic silica contents are considered negligible in the Balearic Basin [5], Si and other geochemically inert elements such as Al and Ti were used as proxies for aeolian terrigenous inputs. The lowest concentrations have been measured at the base of the turbidite while concentrations of these elements were fairly constant in the hemipelagic sections.

The K/(K+Si) index has been used [6] to investigate the origin (fluvial vs aeolian) of the lithogenic fraction. Variations of this index as measured along core C showed minor variations except for the turbidite unit, where a moderate increase was observed. Therefore, terrigenous materials are efficiently transferred to the deepest parts of the basin carried by gravity-driven processes. This viewpoint is further supported by the lutitic terrigenous character of most of the sediment in the Balearic Abyssal Plain as described in the literature [7]. The surrounding continental margins, even if far away from the study area, seem to be the most important source area. This suggests that advection of fine material from river-fed continental margins plays a fundamental role in the formation of the sediments infilling the Balearic Abyssal Plain.

Acknowledgements. The authors would like to thank the financial support from the EU ADIOS multidisciplinary project (EVK3-2000-00604), and also from the USA National Science Foundation for the ^{14}C dating of samples at NOSAMS (Woods Hole Oceanographic Institution).

References

[1] - Accornero, A., Picon, P., De Bovée, F., Charriere, B. and Buscail, R., 2003. Organic carbon budget at the sediment-water interface on the Gulf of Lions continental margin. *Cont. Shelf Res.*, 23: 79-92.

[2] - Giresse, P. *et al.*, 2001. Biotracers and geotracers of depositional events in NW Mediterranean margin over the past two centuries. *Oceanol. Acta*, 24 (6): 581-597.

[3] - Sanchez-Cabeza, J.A. *et al.*, 1999. Sediment accumulation rates in the southern Barcelona continental margin (NW Mediterranean Sea) derived from ^{210}Pb and ^{137}Cs chronology. *Prog. Oceanog.*, 44: 313-332.

[4] - Zuo, Z., Eisma, D., Gieles, R. and Beks, J., 1997. Accumulation rates and sediment deposition in the northwestern Mediterranean. *Deep-Sea Res. Part II*, 44(3-4): 597-609.

[5] - Weldeab, S., Siebel, W., Wehausen, R., Emeis, K-C., Schmiedl, G., Hemleben, C., 2003. Late Pleistocene sedimentation in the Western Mediterranean Sea: implications for productivity changes and climatic conditions in the catchment areas. *Palaogeogr. Palaeoclimatol. Palaeoecol.*, 2963: 1-17.

[6] - Moreno, A., Cacho, I., Canals, M., Maarten, A.P., Sánchez Goñi, M., Grimalt, J.O., Weltje, G.J. Saharan dust transport and high-latitude glacial climatic variability: the Alboran Sea record. *Quatern. Res.*, 58 (3): 318-328.

[7] - Leclaire, L., 1972. Aspects of the Late Quaternary Sedimentation on the Algerian Precontinent and in the adjacent Algiers-Balearic Basin. Pp. 561-582. In: Stanley D.J. (Ed.), The Mediterranean Sea: A Natural Sedimentation Laboratory. Dowden, Hutchinson and Ross, Inc., Stroudsburg, PA.

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PHÉNOMÈNE DE REMONTÉES D'EAUX PROFONDES DURANT LA PÉRIODE HIVERNALE AU LARGE DES CÔTES LIBANAISES (MÉDITERRANÉE ORIENTALE)

Marie Abboud-Abi Saab*, Milad Fakhri

Conseil National de la Recherche Scientifique, Centre National des Sciences Marines, B.P 543, Batroun Liban - * mabisaab@cnrs.edu.lb

Résumé

Des profils thermiques d'eaux côtières (0-100m) ont été réalisés mensuellement dans le bassin oriental de la Méditerranée (Batroun-Liban) entre juin 1999 et octobre 2003. L'évolution annuelle de la structure hydrologique aboutit à un phénomène annuel de remontée d'eaux profondes entre janvier et février. Les valeurs annuelles élevées des nitrites dans toute la colonne d'eau durant cette période et la présence d'espèces de profondeurs très variées sont en faveur de cette hypothèse.

Mots clés : Côtes libanaises, Méditerranée orientale, séries hydrologiques, nutriments, remontées d'eaux.

Introduction

Dans le but de détecter un effet de changement climatique possible et extraire une tendance à long terme, des séries régulières sont devenues fréquentes dans plusieurs régions de la Méditerranée (1, 2, 3). Ces séries régulières ont permis de découvrir des phénomènes annuels, des anomalies possibles et des variations interannuelles. Ainsi depuis 1999 des séries verticales régulières ont été suivies dans le but de connaitre l'évolution hydrologique des eaux côtières libanaises où peu d'informations sont disponibles. On admet (4) que le bassin levantin est une région de convergence et de convection causée par une salinité d'eau élevée spécialement en hiver ; cette situation tend à éloigner tout apport nutritionnel du plateau continental vers les eaux du large ; en est-il de même pour les eaux profondes ?

Matériel et méthodes

Les mesures ont été prises mensuellement, entre juin 1999 et octobre 2003 au point B2 (N 34° 14.856; E 35 36.067), situé à 4 milles de la côte. Les températures et les salinités ont été mesurées entre 0 et 100 m à 5 m d'intervalle lors de la descente d'une ligne instrumentée avec un capteur ANDERAA pour la température associé à un capteur de conductivité (Sensor Model 3230 : Salinité 0-40ppt; précision : ±0.2 ppt. Température de -8 à 41°C; précision : ± 0.1°C. Pression : 0-11bar, 0.2% de la mesure). Des échantillons d'eau ont été collectés en surface, 40 m, 60 m et parfois 20 m pour l'analyse des nutriments et des populations microplanctoniques.

Résultats et discussions

Sur le plan thermique trois situations différentes ont été bien détaillées (5). Le refroidissement et les tempêtes hivernaux conduisent à une homothermie verticale. La période février-mars marque la température minimale de 17°C sur toute la colonne d'eau. Cette période d'homogénéité se prolonge jusqu'à la fin du mois d'avril. Cependant à partir du mois de mars, un léger réchauffement superficiel commence, mais les vents violents du secteur perturbent considérablement l'évolution temporelle de la température. Ces perturbations contribuent ainsi à l'entretien d'une instabilité hydrologique dans la zone.

Le réchauffement superficiel n'arrive à s'installer qu'à partir de début mai, la température atteint alors environ 20°C. A partir de cette date, la température augmente rapidement et commence la formation de la thermocline par une stratification thermique à partir des couches superficielles. Elle gagne progressivement la profondeur jusqu'à 45-50 m. Il faut alors plus de 3 mois pour que le bas de la thermocline atteigne ce niveau. Le réchauffement des eaux superficielles aboutit à la formation d'un gradient vertical. L'évolution normale de l'hydrologie au large de la côte libanaise conduit à l'établissement d'une thermocline séparant deux couches d'eau relativement chaude et d'eau froide (situation de bicouche).

Durant la période estivale, le niveau supérieur de la thermocline varie entre 30 et 50 m. La thermocline est généralement limitée par les isothermes 20 et 26°C. Cette situation est stable. La direction du vent par rapport au rivage durant cette période d'une part, et la forte stabilité des couches, due aux différences de température entre les deux couches d'autre part, éloignent la possibilité d'un upwelling côtier ou autre phénomène de mélange d'eau. La différence de T°C entre la surface et le bas de la thermocline est aux environs de 10-12°C. L'établissement sur les côtes libanaises d'une thermocline quasi permanente séparant une couche d'eau chaude de 28-29°C et une couche froide de 17°C pendant plus de la moitié de l'année a des conséquences sur la structure thermique et biologique des eaux.

A partir de septembre, le refroidissement, associé à des hautes salinités dans les couches superficielles, entraîne une stabilité faible ou nulle. Les eaux froides superficielles ont tendance à gagner les couches profondes suivant un mouvement de conviction, ce qui aboutit à une homogénéisation thermique dans les masses d'eau. Le refroidissement est remarqué sur toute la colonne d'eau ce qui nous amène à avoir une homothermie de température autour de 18°C. La thermocline disparaissait toujours au cours du mois de novembre. Le refroidissement continue tout en conservant l'homogénéité thermique verticale de toute la masse d'eau qui aboutit à l'homothermie de 17°C de température et ainsi l'homothermie hivernale est retrouvée et un nouveau cycle thermique commence.

La structure verticale de la salinité suit un certain cycle de façon qu'en hiver, il y a une certaine homogénéité haline 39.24 ppm, puis les couches superficielles entre la surface et 50-60 m sont moins salées que les couches sous jacentes : 39.19 contre 39.24. Avec la progression thermique, les salinités en surface atteignent 39.33 contre 39.15 vers 100 m et en été les couches infrathermoclinales ont une salinité inférieure à celles des couches suprathermoclinales de 0.3-0.5 ppm. Vers la fin de l'année, la situation s'inverse et la différence entre les bouts de la colonne d'eau est 0.1 ppm. Avec le refroidissement automnal, les couches inférieures de la colonne 0-100 m, légèrement moins salées montent en surface car la stabilité thermique s'affaiblit et il paraît que d'autres masses d'eau plus profondes montent vers les surfaces. Cette idée peut être appuyer par les valeurs élevées des nitrites sur les différents niveaux étudiés uniquement en janvier et parfois en février, de 0.01-0.013 contre 0.139-.16 µatg/L selon les années. Le refroidissement automnale qui provoque des mouvements de conviction conduira à la remontée des espèces plus ou moins profondes vers la surface et aura comme conséquence une diversité spécifique très élevé et un nombre d'espèces maximal dans différents groupes microplanctoniques (6).

Références

1 - Chevaldonné P. & Lejeusne C., 2003. Regional warming-induced species shift in north-west Mediterranean marine caves. *Ecology Letters*, 6: 371-379.

2 - Romano, J.C., Bensoussan N., Younes W.A.N. & Arlhac D., 2000. Anomalie thermique dans les eaux du golfe de Marseille durant l'été 1999. Une explication partielle de la mortalité d'invertébrés fixés ? *C. R. Acad. Sc. Paris, Sc. Vie*, 323: 415-427.

3 - Salat J. and Pascual J., 2002. The oceanographic and meteorological station at L'Estartit (NW Mediterranean), pp.31-34, *CIESM Workshop Series* n°16 *: Tracking long-term hydrological change in Mediterranean Sea*, 134 p.

4 - Wüst G; 1960. Die Tiefenzirkulation des Mitteländischen Meers in den kernschichten des Zwischen-uns des Tiefenwassers. *Deutsch. Hydrograph.*, z. 13 :105-131.

5 - Abboud-Abi Saab M., Romano J.-C., Bensoussan N. & Fakhri M. (soumise). Suivis temporels comparés de la structure thermique d'eaux côtières libanaises (Batroun) et françaises (Marseille) entre juin 1999 et octobre 2002.

6 - Abboud-Abi Saab, M., 2002. Annual cycle of the microzooplankton communities in the waters surrounding the Palm Island Nature Reserve (north Lebanon), with special attention to tintinnids. *Mediterranean Marine Science*, 3(2): 55-76.

MISSING DATA RECONSTRUCTION OF A SST CLOUDY DATA SET OF THE ADRIATIC SEA USING EMPIRICAL ORTHOGONAL FUNCTIONS.

Alvera-Azcárate A. [1*], Barth A. [1], Rixen M. [2] and Beckers J.M [1]
[1] G.H.E.R. University of Liège, Belgium - * A.AlveraAzcarate@ulg.ac.be
[2] SACLANT Undersea Research Centre, Italy

Abstract
A method for the reconstruction of missing data in oceanographic data sets is presented. The method, DINEOF (Data INterpolating Empirical Orthogonal Functions) is based on an EOF decomposition. It has been applied to a realistic case, a data set on the Adriatic Sea. In order to optimize the computational time, a Lanczos method has been used for the EOF decomposition. The results are accurate, as can be seen from different tests realized with the data. The error of the reconstruction in relation with the original data is of about 0.6°C, as depicted for a cross validation analysis. The temperature distribution is reliable, and realistic physical features are obtained.

Keywords: missing data, EOF decomposition, Adriatic Sea

Introduction

DINEOF (Data INterpolating Empirical Orthogonal Functions) is a method for the reconstruction of gappy data. When dealing with satellite images there are often gaps in the data, due to cloud coverage, technical malfunctions, noise and so on. Also when dealing with other oceanographic data sets there can be missing data due to some of these reasons. For many applications using these data sets, a complete set is necessary, with no missing data. Examples are an EOF analysis, a wavelet analysis, or feature tracking in the ocean. For recovering these data, DINEOF has been applied. This method has the advantage of no needing any *a priori* information, so no additional calibration is needed.

How the method works

DINEOF has been presented by Beckers [1], and it is based on an EOF decomposition. The mean value of the data is subtracted from the set and the missing values are initialized to zero. Then the EOF decomposition is done, with only one EOF, and a new value for the missing data is calculated from a truncated series of the EOF obtained. These two steps are repeated until convergence of the value for the missing data. Now the number of EOFs requested is increased to two, and the procedure is repeated. Finally, we have a series of missing data obtained with 1...*k* EOFs, and the optimal number of EOFs for the reconstruction of the data set must be calculated. This is done by a cross validation technique [1, 2]: a random data set is set aside from the initial valid data, and they are considered as missing. The optimal number of EOFs minimizes the error between the data set aside and the values obtained at these points with the reconstruction method.

The EOF decomposition itself has been carried out with a Lanczos method, presented by Toumazou [3]. This method allows to calculate a given number of EOFs in a small cpu time, so the computational time required by DINEOF has been optimized.

An application to the Adriatic Sea

The authors have applied the method DINEOF to a test case in the Adriatic Sea. A total of 105 Sea Surface Temperature (SST) AVHRR images have been treated, ranging from 09 May 1995 to 22 October 1995. The mean cloud coverage of this data set is 52%. In the reconstruction of this data set DINEOF keeps 10 EOFs as the optimal number for the reconstruction of the missing data. The cross validation gives an expected error of 0.6°C for this reconstruction. In Figure 1 one can see the reconstruction of one of the images, corresponding to September 3, 1995. Figure 1a is the original image, with blanks where there are initially no data. Figure 1b is the reconstruction of this image. As can be seen, the reconstruction gives realistic results. We can appreciate a cold filament detaching from the east coast. The signal of this kind of filaments has been studied by, e.g. [4].

Other tests have been carried out with this data set [5]. For establishing the capacity of DINEOF to reconstruct data sets with different amounts of cloud coverage, a subset of 15 images with a mean cloud coverage of 18% is used. Then, extra cloud coverage has been added, up to 40%, 60% and 80%. The reconstruction can be thus compared to the original data. The Root Mean Square (RMS) error obtained between the reconstruction of the 40%, 60% and 80% extra cloud coverage sets and the original data is of 0.89°C, 0.78°C and 1.25°C respectively. Also a validation with *in situ* data has been made. Data from the MEDAR/Medatlas database [6] have been extracted. The error between the reconstruction and those data is of 0.95°C. All the results and tests presented here are available at http://modb.oce.ulg.ac.be/alvera.

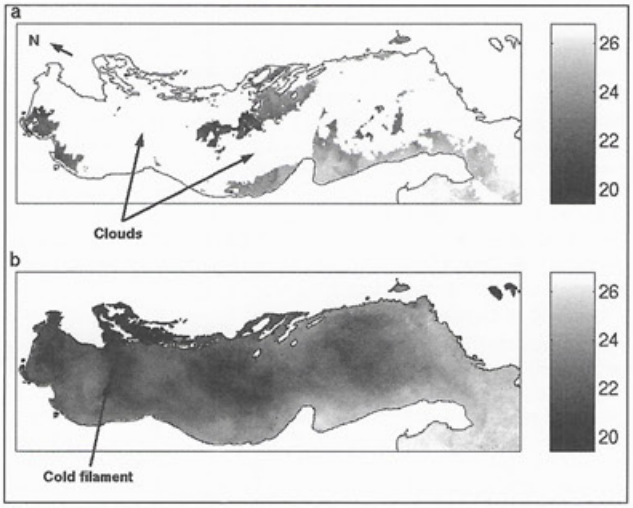


Fig. 1. Reconstruction of the 3 September 1995. (a) is the original image with blanks where there is no data. (b) is the reconstruction. We can see a cold filament detaching from the east coast and the warm temperatures at the south Adriatic.

References

1 - Beckers, J.M. and Rixen, M. 2003. EOF calculations and data filling from incomplete oceanographic data sets. Journal of Atmospheric and Oceanic Technology. In press.
2 - Brankart, J.M. and Brasseur, P. 1996. Optimal analysis of in situ data in the Western Mediterranean using statistics and cross validation. *Journal of Atmospheric and Oceanic Technology,* 16:477-491.
3 - Toumazou, V. and Cretaux, J.F. 2001. Using a Lanczos eigensolver in the computation of Empirical Orthogonal Functions. *Monthly Weather Review.* 125,5:1243-1250.
4 - Borzelli, G., Manzanella, G. Marullo, S. and Santoleri, R. 1999. Observations of coastal filaments in the Adriatic Sea. *Journal of Marine Systems.* 20:187-203.
5 - Alvera-Azcárate, A., Barth, A. Rixen, M. and Beckers, J.M. 2003. Reconstruction of incomplete oceanographic data sets using Empirical Orthogonal Functions. Application to the Adriatic Sea. Submitted to *Journal of Physical Oceanography.*
6 - MEDAR Group. 2002. Medatlas/2002 database. Mediterranean and Blach Sea database of temperature, salinity and bio-chemical parameters. Climatological Atlas. Ifremer Edition, 4 CD-ROM.

WAVELETS IN THE FORECAST VERIFICATION OF AN ASSIMILATION EXPERIMENT IN THE LIGURIAN SEA.

Alvera-Azcárate A. [1] *, Barth A. [1], Ben Bouallègue Z. [1], Vandenbulke L. [1], Rixen M. [2] and Beckers J.M. [1]
[1] G.H.E.R. University of Liège, Belgium - * A.AlveraAzcarate@ulg.ac.be
[2] SACLANT Undersea Research Centre, Italy

Abstract
The skill assessment of an assimilation experiment is presented. A 2D wavelet decomposition is used to decompose the model results and the observations into different spatial scales. This allows to establish the error between the model and the observations at those different spatial scales, and to identify the scale where the error is higher. At each scale, classical error measurements are applied, such as RMS. Special attention is paid to the land-sea boundaries, as they affect the wavelet analysis.

Keywords: Forecast Verification, Wavelets, Ligurian Sea.

The GHER 3D primitive equation model has been implemented in the Ligurian Sea in a two-way nested approach. A reduced order, optimal interpolation data assimilation scheme has been used for an assimilation experiment. Sea Surface Temperature (SST), Sea Surface Height (SSH) and CTD profiles are assimilated to realize the forecast [1]. This work presents the analysis of the results obtained by the model, in order to establish the benefits of the assimilation.

For the skill assessment of the model, a 2D wavelet decomposition is made [2, 3], in order to realize a multiresolution analysis of the results obtained. Wavelet Transforms are capable of localizing the signal variability simultaneously in both time and scale, something that Fourier Transforms, for example, are not able to do. The wavelet analysis allows to decompose the model and the observations into different spatial scales, ranging from ~1 km (the spatial scale of the model) to 128 km. At each scale, the model is compared to the observations, and the error is established. The scale where the highest errors are found can be identified, and studied in more detail, to find the causes of the error. The wavelet decomposition allows thus to make an analysis of the model results in a more detailed way. At each scale, the Root Mean Square (RMS) error and the Mean Square Skill Score (MSESS) are calculated. They can be derived from the Mean Square Error (MSE) [4]:

$$MSE = \frac{1}{M}\sum_{m=1}^{M}(X_f - X_o)^2 \quad [1]$$

$$RMSE = \sqrt{MSE} \quad [2]$$

$$MSESS = 1 - \frac{MSE}{MSE_{ref}} \quad [3]$$

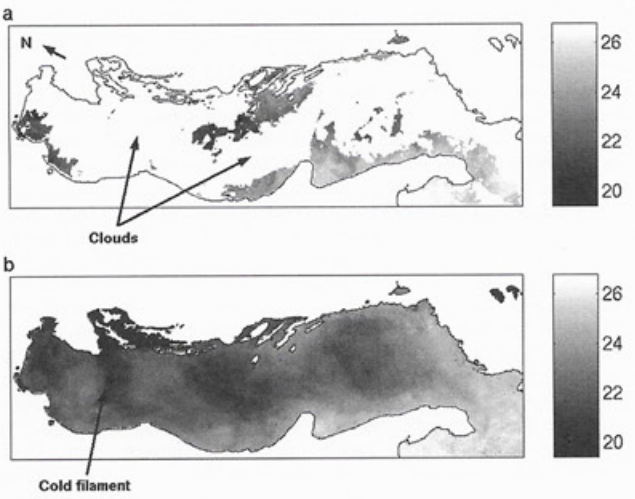
where Xo are the observations, Xf the model forecast at the observation points, and MSE_{ref} is the MSE calculated between the reference system and the observations. The RMS allows to establish the error between the model and the observations, and the MSESS measures the improvement of the model in relation to a reference system. There are several possibilities for the reference system, as climatology, the persistence forecast, or an output of an ancient version of the model. In this work we have used a free model run of the model to test its improvement.

The wavelet analysis presents a limitation when dealing with oceanographic data sets. They present often irregular land-sea boundaries. The wavelet will be affected by the boundaries and the result of the decomposition will show a high perturbation at the coast. This effect may be diminished by, first, a good choice of the mother wavelet, and second, a smooth passage between the sea and the earth.

The wavelet chosen for this work is the Haar wavelet, as its support width is 1, while the other wavelets have higher support width, as for example the Daubechies wavelet family, with a support width of 2N-1, with N the order of the wavelet. The small support of the Haar wavelet may help to reduce the effects at boundaries. High support wavelets "feel" the boundary earlier than small support wavelets.

The smooth passage between the land and the sea consists in a diffusion of the sea values towards the land values, such that the limit between them is less abrupt. This smoothing decreases the noise of the wavelet amplitudes at the boundaries.

The boundaries approach in the wavelet decomposition, as well as the analysis of the assimilation experiment results will be presented.



References

[1] Barth, A., Alvera-Azcárate, A., Beckers, J.M., Rixen, M., Vandenbulke, L. and Ben Bouallegue, Z. 2003. Data Assimilation in a two-way nested model of the Ligurian Sea (this issue).
[2] Briggs, W.M. and Levine, R.A. 1997. Wavelets and Field Forecast Verification. *Monthly Weather Review*, 125: 1329-1341.
[3] Daubechies, I. 1992. Ten lectures on wavelets. SIAM. 357 p.
[4] Jolliffe, I.T. and Stephenson, D.B. 2003. Forecast Verification. A practitioner's guide in Atmospheric sciences. Wiley. 240 p.

EVIDENCE THAT ALGERIAN EDDIES HAVE AN ANTICYCLONIC STRUCTURE THAT CAN EXTEND FOR MONTHS OVER THE WHOLE DEPTH (~2700 M)

E. Aubertin [1], C. Millot [1 *], I. Taupier-Letage [1] and J. Font [2]

[1] Laboratoire d'Océanographie et de Biogéochimie, Antenne LOB-COM-CNRS, BP 330, F-83507 La Seyne-sur-Mer, France
*cmillot@ifremer.fr

[2] Physical Oceanography Group, CMIMA – CSIC, Passeig Maritim, SP- 08003, Barcelona, Spain

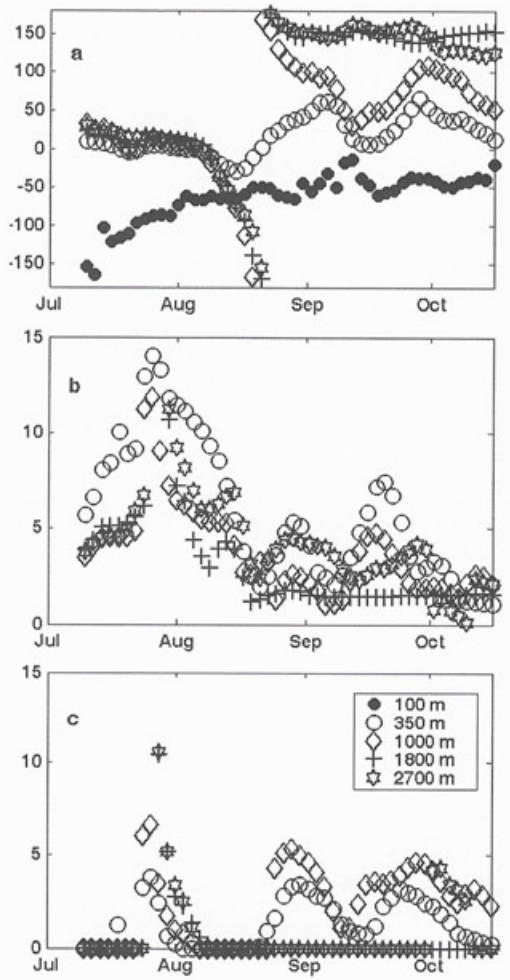
Abstract

The ~40 currentmeters deployed on 9 moorings for 1 year during the 1997-1998 ELISA experiment (www.com.univ-mrs.fr/ELISA/, 1) have shown that meso-scale Algerian Eddies (AEs) can extend over the whole depth. Simple realistic hypotheses about the linear combination of currents due to the AEs and to the large-scale circulation allow validating the hypothesis (2) that the AEs' structure can be anticyclonic for months over the whole depth with currents similar over the whole deeper layer (350 to 2700 m).

The Algerian Current (~50 km width, 100-200 m thickness, ~1 Sv transport) is markedly unstable (3). Infrared images (4) and current time series (5) have allowed specifying that two kinds of mesoscale features can be generated. One kind is considered as a series of paired cyclones and anticyclones (diameter up to 50-100 km) that propagate downstream at a few km/d and that do not have a large vertical extent (5). Simple analytical models (3), and sophisticated numerical computations as well (e.g. 6), suggest that these eddies result from a baroclinic instability process.

The other kind named event (5) is considered, in the surface layer, as a large meander (50-100 km amplitude) of the Algerian Current embedding an anticyclone and generating a short-lived (a few weeks) cyclone upstream from the meander's crest (2, 7, 8). Both in situ observations (5, 9) and laboratory experiments (7) support the hypothesis (2) that the circulation is anticyclonic in the whole deeper layer too. This is not consistent with a baroclinic instability process and might rather be created by a pressure gradient in the surface layer (i.e. a surface bump not compensated enough by the interface lowering; 7). Events are generated a few times a year only and can propagate downstream for months along the Algerian slope. They generally detach seawards at the entrance of the channel of Sardinia, and can then follow, during up to 3 years at least (10), an anticlockwise circuit in the eastern Algerian subbasin. Since the meander can then no longer be differentiated from the surface anticyclone, these eddies (diameters up to 200-250 km) are named Algerian Eddies (AEs).

The ELISA current time series have clearly demonstrated (11) that the mesoscale AEs sometimes extend down to the bottom (~2700 m) and are stronger than the large-scale circulation, thus reversing from eastwards to westwards the current measured at depth off Algeria. To better specify the deep structure of the AEs, we hypothesise that the meso- and large-scale currents combine linearly. We thus decompose, when possible, the currents measured at depth into a component oriented as the yearly mean current, expected to represent the large scale, and a component oriented as the current measured simultaneously at 100 m. The later being generally parallel to the surface isotherms, it mainly represents the mesoscale when within an AE. For instance, at point 3 in July-August (figure), currents measured at 350, 1000, 1800 and 2700 m are roughly oriented as the current at 100 m (**a**: direction at 100 m (0° for northwards and +90° for eastwards) and phases with respect to 100 m (positive when clockwise)). While the 100-m direction is changing due to the AE (96-1) propagation, the meso-scale components at depth remain in phase and have similar intensities (**b**, 5-15 cm/s) much larger than the large-scale ones (**c**, < 5cm/s). These features clearly account for the overall anticyclonic structure of 96-1 at that time (as supported by unpublished hydrological data). In September-October, while 96-1 was still over point 3, phases with respect to 100 m changed, but others (350/1000, 1800/2700) were rather constant, thus accounting for a coherent although more complex structure of 96-1 over the whole depth.



References

1 - Taupier-Letage I., I. Puillat, P. Raimbault and C. Millot, 2003. Biological response to mesoscale eddies in the Algerian Basin. *J. Geophys. Res.*, 108, C8: 3245, doi:10.1029/1999JC000117, 2003.

2 - Millot C., 1994. Models and data: a synergetic approach in the western Mediterranean Sea. Pp. 407-425. In: P. Malanotte-Rizzoli and A.R. Robinson Eds., Erice School Proceedings, "Ocean Processes in Climate Dynamics: Global and Mediterranean Examples".

3 - Millot C., 1985. Some features of the Algerian Current. *J. Geophys. Res.*, 90, C4: 7169-7176.

4 - Taupier-Letage I. and C. Millot, 1988. Surface circulation in the Algerian Basin during 1984. *Oceanol. Acta*, sp. n° 9: 119-131.

5 - Millot C., I. Taupier-Letage and M. Benzohra, 1997. Circulation off Algeria inferred from the Médiprod-5 current meters. *Deep-Sea Res.*, 44, 9-10: 1467-1495.

6 - Beckers J.-M. and J. Nihoul,1992. Model of the Algerian Current's instability. *J. Mar. Sys.*, 3, 4-5: 441-451.

7 - Obaton D., C. Millot, G. Chabert D'Hières and I. Taupier-Letage, 2000. The Algerian Current: comparisons between *in situ* and laboratory measurements. *Deep-Sea Res.*, I 47: 2159-2190.

8 - Salas J., C. Millot, J. Font and E. García-Ladona, 2002. Analysis of mesoscale phenomena in the Algerian Basin observed with drifting buoys and infrared images. *Deep-Sea Res.*, 49, 2: 245-266.

9 - Ruiz S., J. Font, M.Emelianov, J. Isern-Fontanet, C. Millot and I. Taupier-Letage, 2002. Deep structure of an open sea eddy in the Algerian Basin. *J. Mar. Sys.*, 33-34: 179-195.

10 - Puillat I., I. Taupier-Letage and C. Millot. Algerian eddies lifetimes can near 3 years, 2002. *J. Mar. Syst.*, 31, 4: 245-259.

11 - Millot C. and I. Taupier-Letage, 2003. Additional evidence of LIW entrainment across the Algerian Basin by mesoscale eddies and not by a permanent westward-flowing vein. *Progress in Oceanography*, accepted.

OBSERVATIONS OF BIO-OPTICAL SURFACE FEATURES IN THE MEDITERRANEAN AND BLACK SEA

Vittorio Barale

Institute for Environment and Sustainability, Joint Research Centre of the EC, Ispra, Italy - vittorio.barale@jrc.it

Abstract

Optical observations of the Mediterranean and Black Sea have been used to assess water constituents' distribution and abundance. A set of SeaWiFS images (1998-2001) was processed to obtain chlorophyll-like pigment concentration, tracing coastal plumes and filaments, fronts, mesoscale eddies and gyres. Small (coastal) features are transient, while larger (basin-scale) patterns are recurrent, over longer periods. Although scales and structures are similar in the basins considered, the average concentration of water constituents presents high variability between different seasons or areas. This can be interpreted in terms of the known oceanographic traits of the observed basins.

Keywords: Mediterranean Sea, Black Sea, bio-optical properties

Introduction

In the last three decades, orbital sensors have generated a novel view of the Mediterranean and Black Sea, expanding both synoptically and statistically the punctual information previously available from in situ data alone (1). Optical observations can be used to characterize basic ecological processes in the sea, over a wide range of space and time scales. In the following, the Sea-viewing Wide-Field-of-View Sensor (SeaWiFS) data set will be discussed, while analogous data, from the Coastal Zone Color Scanner (CZCS) historical archive, will be used to evaluate the SeaWiFS performance. An assessment of bio-optical features will be made, in terms of the known oceanographic traits of the observed basins.

Historical data sets

Observations performed by the SeaWiFS, in the visible spectrum, have been used to detect optical properties of surface waters, which depend on the distribution and abundance of water constituents. About 1800 SeaWiFS Local Area Coverage (LAC) scenes, covering southern Europe and northern Africa, in the period 1998-2001, compose the time series. Each individual image, taken when favorable meteorological conditions occurred over at least part of the Mediterranean basin, was processed to apply sensor calibration, to correct for atmospheric contamination, and to estimate Chlorophyll-like Pigment Concentration (CPC). The whole data set was processed using the SeaDAS software package (2), with additional modifications (3) (4). The CPC images, with a resolution at nadir of 1.1 km, were re-mapped on an equal-area projection grid (pixel size 2 km), covering the whole Mediterranean region. Composite fields, at ten-day and monthly scales, were derived from the re-mapped images, using simple weighted averaging techniques. Image data originated by the CZCS were also used, for comparison with SeaWiFS. About 2500 individual full-resolution (0.825 km at nadir) CZCS scenes, from the period 1979-1985, compose the time series (5), from which climatological CPC images (annual and monthly means) were derived (6).

Bio-optical features

The comparison of SeaWiFS images with those of the historical CZCS archive demonstrates a remarkable consistency of absolute values and bio-optical features, in the two periods considered. The SeaWiFS-derived CPC values are consistent with the CZCS-derived climatological means, even though they tend to be systematically lower in near-coastal areas. Such difference is due to the improved algorithms used for the SeaWiFS, with respect to those used for the CZCS – which tended to overestimate CPC within plumes and coastal waters, where the optical properties are influenced not only by planktonic pigments, but also by dissolved organic matter and suspended inorganic particles (7). The patterns in the SeaWiFS-derived CPC field are also similar to those in the CZCS climatology. In the Mediterranean Sea, complex structures (i.e. coastal plumes and filaments, frontal structures, mesoscale eddies, basin-wide gyres) can be found from local to basin scales. Normally, such patterns are traced by CPC higher than the background value, due to some event that produces mixing and/or enrichment of surface waters with nutrients coming from deeper layers or coastal margins. The result is a localized increase in pigments of bio-organic origin, which act as a marker of the event itself. A systematic analysis of the SeaWiFS archives suggests that small-scale (coastal) features, linked to local dynamical processes, are transient and appear only in individual images for a few days, while large-scale patterns, linked to basin-wide bio-geo-chemical processes, are recurrent and can persist over much longer time scales. Local transient structures, such as coastal filaments and eddies, develop along the shorelines, from pronounced headlands and over bathymetric relief interacting with the prevailing currents. The lifetime of such features varies from a few days to a few weeks. In the Black Sea, coastal plumes and fronts form similar structures, mostly as a result of interactions between river discharges over a shallow shelf and the basin's cyclonic circulation. The long-term CPC composites show large-scale features, with a lifetime of many months. This is the case of the main river plumes, of the surface inflow from the Atlantic Ocean, forming the gyre system in the Alboran Sea, and of the inflow from the Marmara Sea, forming a plume in the northern Aegean Sea. Other features appear to have a more pronounced seasonality, such as the blooming cycle in the Ligurian-Provençal Sea, the giant filament of Capo Passero, anchored at the southernmost headland of Sicily, and the Rhodes gyre in the eastern Mediterranean.

Conclusion

The features traced by CPC, in the SeaWiFS images, can be used to differentiate between geographical provinces of the Mediterranean and Black Sea shaped by bio-geo-chemical and dynamical processes (8). Although scales and structures of bio-optical features are rather similar in the Mediterranean sub-basins and in the Black Sea, the actual concentration of water constituents presents high variability between different seasons (as in the north-western Mediterranean) or between different areas (as in the south-eastern Mediterranean, regularly displaying an oligotrophic nature, and in the Black Sea, always characterized by extremely high pigments). In future work, this should be interpreted in terms of different geographical setting and climate, freshwater input and nutrient supply, water circulation and exchanges.

References

1 - Barale, V., 2001. The Mediterranean and Black Sea as observed from space. Pp. 1539-1546. In: Proceedings of the Fifth International Conference on the Mediterranean Coastal Environment, MEDCOAST 01, Vol. 3, E. Ozhan ed., MEDCOAST, METU, Ankara (TR).

2 - Fu, G., K.S. Baith, and C.R. McClain, 1998. SeaDAS: The SeaWiFS Data Analysis System. Pp. 73-79. In: Proceedings of the 4th Pacific Ocean Remote Sensing Conference, Qingdao (China), 28-31 Jul 1998.

3 - Melin, F., B. Bulgarelli, N. Gobron, B. Pinty, and R. Tacchi, 2000. An integrated tool for SeaWiFS operational processing. European Commission Publication, No. EUR 19576 EN.

4 - Sturm, B., and G. Zibordi, 2002. SeaWiFS atmospheric correction by an approximate model and vicarious calibration. *International Journal of Remote Sensing*, 23(3): 489-501.

5 - Barale, V., D. Larkin, L. Fusco, J.M. Melinotte, and G. Pittella, 1999. 'OCEAN' Project: the European archive of CZCS historical data. *International Journal of Remote Sensing*, 20(7): 1201-1218.

6 - Sturm, B., V. Barale, D.J. Larkin, J.H. Andersen, and M. Turner, 1999. *OCEANcode*: the complete set of algorithms and models for the level-2 processing of European CZCS historical data. *International Journal of Remote Sensing*, 20(7): 1219-1248.

7 - Barale, V., and D.J. Larkin, 1998. Optical remote sensing of coastal plumes and run-off in the Mediterranean region. *Journal of Coastal Conservation*, 4: 51-68.

8 - Barale, V., and I. Zin, 2000. Impact of continental margins in the Mediterranean Sea: hints from the surface colour and temperature historical record. *Journal of Coastal Conservation*, 6: 5-14.

DATA ASSIMILATION IN A TWO-WAY NESTED MODEL OF THE LIGURIAN SEA

A. Barth [1*], A. Alvera-Azcárate [1], J.-M. Beckers [1], M. Rixen [2], L. Vandenbulke [1], Z. Ben Bouallegue [1]
[1] GHER, University of Liege, Belgium, [2] SACLANT Undersea Research Centre, Italy - *A.Barth@ulg.ac.be

Abstract
A two-way nested model is applied to the Mediterranean Sea. The model grid is refined twice in order to achieve a 1/60° resolution grid of the Ligurian Sea. Sea surface temperature , sea surface height and CTD profiles are assimilated in this nesting system. The assimilation scheme is multivariate (temperature, salinity and surface elevation) and multi-grid, i.e. all nested models are assembled into one state vector.

Keywords: data assimilation, nested models, Ligurian Sea

The GHER 3D primitive equation model is implemented with three different resolutions: a low resolution model (1/4°) covering the whole Mediterranean Sea, an intermediate resolution model (1/20°) of the Liguro-Provençal basin and a high resolution model (1/60°) simulating the fine mesoscale structures in the Ligurian Sea. Boundary conditions and the averaged fields (feedback) are exchanged between two successive nesting levels. Further explications can be found in Barth *et al.* [1].

The nesting system is coupled with a reduced order, optimal interpolation data assimilation scheme. The state vector is composed by temperature, salinity and sea surface elevation.

Novel in the present approach is that these variables from the three nested model grids are assembled to one multi-grid state vector. This implementation allows to take into account the correlation of the variables across the nested model grids in order to avoid for example artificial gradients after an assimilation cycle.

The eigenvectors of the covariance matrix are constructed by an EOF analysis of the free model run. Cross-grid correlations especially in the overlapping domains are thus consistently represented. Horizontal correlations over long distances are suppressed by multiplying each error mode with a set of radial Gaussian functions. This procedure increases considerably the rank of the covariance matrix but ensures the local impact of each observation.

Corrections for the velocity are obtained from a linearised geostrophy relation, except near the coast where the velocity correction is gradually decreased to zero.

Sea surface temperature (SST, from the DLR EOWEB), sea surface height (SSH, from the CLS) and CTD profiles (SIRENA cruise from SACLANT Center and cruises from the MEDAR/MEDATLAS database [2]) are assimilated into the model. In overlapping model grids the measurements are related to the highest resolution grid. Since the SSH has a resolution of 1/8°, the surface elevation of the Ligurian Sea and the Liguro-Provençal model are filtered in order to be coherent with the space scales present of the observations. The assimilation scheme works only with spatially uncorrelated observations. This assumption is not true for representative error of the SST with a resolution of 1 km. The weight of this data is reduced in order to take into account the redundancy of the data. Another approach tested is the creation of data bins of mean temperature in a small rectangle.

Starting from the 1st January 1998 the low and intermediate resolution models are spun up for 18 months. The initial conditions for the Ligurian Sea are interpolated from the intermediate resolution model. The three models are then integrated until August 1999. During this period SST, SSH and the CTD profiles are assimilated. The results are compared with a free model run. In particular the model forecast just before the assimilation step are compared with the observations. The model forecast and the measurements are then independent and the difference is a measure of the model forecast skill and the impact of the previous assimilation cycles. The validation procedure is detailed in Alvera-Azcárate *et al.* [3].

References

1 - Barth A., Alvera-Azcárate A., Rixen M., and Beckers J.M.. 2003. Two-way nested model of mesoscale circulation features in the Ligurian Sea. *Progress In Oceanography*, accepted.
2 - MEDAR Group, 2002 - MEDATLAS/2002 database. Mediterranean and Black Sear database of temperature salinity and bio-chemical parameters. Climatological Atlas. IFREMER Edition (4 CDROMs).
3 - Alvera-Azcárate A., Barth A., Ben Bouallegue Z., Vandenbulke L., Rixen M. and Beckers, J.-M, Wavelets in the Forecast Verification of an assimilation experiment in the Ligurian Sea. 2003, this issue.

WIND INDUCED VARIABILITY IN THE WESTERN ADRIATIC CURRENT

J. W. Book [1]*, H. Perkins [1], R. Signell [2], A. Russo [3], E. Paschini [4]

[1] Naval Research Laboratory, Stennis Space Center, MS 39529-5004, U.S.A. - * book@nrlssc.navy.mil, hperkins@nrlssc.navy.mil
[2] NATO SACLANT Undersea Research Centre, 19138 La Spezia, Italy - signell@saclantc.nato.int
[3] Università Politecnica delle Marche, 60131 Ancona, Italy - a.russo@univpm.it
[4] Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine - Ancona, 60131 Ancona, Italy - paschini@irpem.an.cnr.it

Abstract

During the winters of 2000/2001 and 2002/2003, current-meter moorings were used to observe the West Adriatic Current (WAC). In the former deployment, the southeastward current of the WAC was enhanced during four bursts of current following large bora wind events. Correlation strength between along-shore currents and model wind stress formed a pattern similar to the bora wind strength pattern, thus suggesting the current enhancement was not locally induced. In the latter deployment, a nine mooring section was maintained across the Adriatic. The WAC transport variability was dominated by events of strong transport, associated with strong bora and sirocco wind events.

Key words : wind-driven currents, West Adriatic Current, bora, sirocco

The Adriatic Circulation Experiment (ACE) is a project to study the circulation response and the transfer of heat and momentum when strong winds impact a marginal sea. The Adriatic Sea was chosen for the setting of this work because of the numerous strong wind events that occur there during every winter. The two types of wind events that are the most common are the bora winds that blow from the northeast with complex shear patterns induced by orography and the sirocco winds that blow from the southeast along the axis of the Adriatic. The general ocean current circulation is cyclonic with a northwestward-flowing East Adriatic Current (EAC) on the east side of the sea and a southeastward-flowing West Adriatic Current (WAC) on the west side. Cushman-Roisin *et al.* (1) provide a general review of the Adriatic winds and currents.

The U.S. Naval Research Laboratory in collaboration with the NATO SACLANT Undersea Research Centre and with Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine – Ancona deployed a single Acoustic Doppler Current Profiler (ADCP) mooring during the winter of 2000/2001 in 57 meters of water near Senigallia, Italy in the pathway of the WAC. Book et al. (2) present the results of this pilot study and show that the non-tidal variability around the mean depth-average current of 10.4 cm/s toward 140∞ was dominated by bursts of currents that exceeded 30 cm/s during four events, and reached 45 cm/s during one event. These burst all followed bora wind events. Correlations between along-shore currents and simulated wind stress from the COAMPS™ model were calculated over the whole north Adriatic. The cross-covariance between currents and wind stress had a spatial pattern similar to the bora wind itself, reaching maxima along the northern Adriatic coast, off the southern tip of Istria, and near Ilovik Island. Wind stress in these regions had stronger correlation with currents at the mooring than did wind stress near the mooring, thus suggesting the bora current enhancement was not locally induced.

During the winter of 2002/2003, the ACE project combined with many other projects from Europe and the U.S. to focus on the physical oceanography of the northern Adriatic using current meter moorings, surface drifters, WERA radar, hydrographic cruises, towed vehicles, remote sensing, wind measurements, and numerical models. The group deployed three sections of current meter moorings from Italy to Croatia over the period of September 2002 to May 2003. One of these sections had nine moorings along a line between Senigallia, Italy and the Croatian island of Susak, across the location of the earlier pilot mooring deployment. Four of the ADCP moorings from this section crossed the path of the WAC along the Italian slope. The mean outward-directed volume transport of this sub-section was 0.15 Sv. The non-tidal transport of the sub-section is punctuated by numerous bursts of strong transport, each associated with a bora or sirocco wind event as modeled by the LAMI wind model. Events that produced non-tidal transports exceeding 0.3 Sv were the bora of September 23-24, December 7-10, January 6-12, January 25-26, February 1, February 12-19, and April 3-5, and the sirocco of November 16-19, and November 25-26. The highest observed non-tidal transport of 0.51 Sv occurred during the sirocco of November 16. Figure 1 shows the transport time series. The current-meter data from all the moorings show that strong bora and strong sirocco both strongly enhance the mean cyclonic circulation that crosses the Senigallia/Susak line.

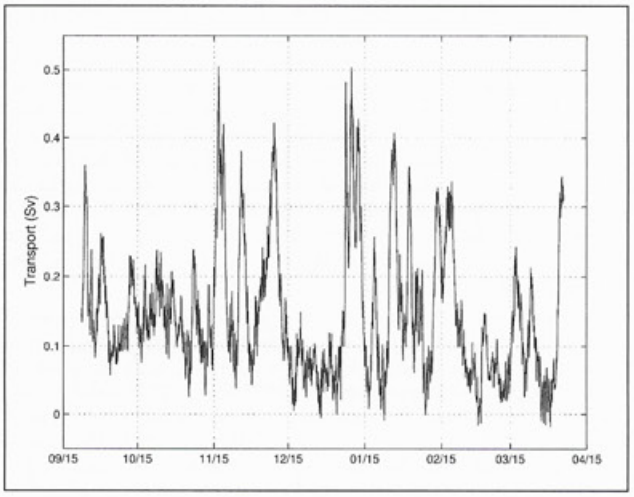


Fig. 1. Net transport directed out of the northern Adriatic (toward 138ºT) calculated from data measured by four ADCPs along a 25 km portion of the Italian slope off Senigallia. The measurements span the range of bottom depths from 25 to 66 m.

References

1 - Cushman-Roisin B., Gačić M., Poulain P.-M., and Artegiani A., 2001. Physical Oceanography of the Adriatic Sea: Past, Present and Future. Kluwer Academic Publ.

2 - Book J. W., Perkins H. T., Cavaleri L., Doyle J. D., Pullen J. D., in press. ADCP observations of the western Adriatic slope current during winter of 2001. *Prog. Oceanog.*

THE ANNUAL CYCLE OF SEA LEVEL IN THE WESTERN MEDITERRANEAN SEA

Catherine Bouzinac [1], Jordi Font [2] *, Johnny Johannessen [3]

[1] ESA-ESTEC, Postbus 299, 2200-AG Noordwijk ZH, The Netherlands - catherine.bouzinac@esa.int
[2] Institut de Ciències del Mar CSIC, Passeig Maritim 37-49, 08003 Barcelona, Spain - * jfont@icm.csic.es
[3] Nansen Environmental and Remote Sensing Centre, Edv. Griegsvei 3a, 5059 Bergen, Norway - johnny.johannessen@nersc.no

Abstract

An estimation of the annual sea level variations in the different basins of the western Mediterranean has been addressed using sea level anomalies derived from satellite altimeters and sea surface temperatures from infrared imagery. Empirical orthogonal function analysis on SLA allows estimating the seasonal dynamic height and the steric effect. The remaining signal is used to examine the annual cycles of sea level due to water mass budget variations, mesoscale oceanic variability and atmospheric forcing.

Keywords: Sea level variations, altimetry, SST, EOF

Satellite altimetry has become a powerful tool to understand the dynamics of the surface circulation in the Mediterranean Sea (1). At any location, the sea surface height is the sum of various components: geoid, astrophysical tides, mean dynamic topography, atmospheric forcing, steric effect, water mass budget and circulation variations. Annual cycles in sea level can be expected because the primary driving forces of ocean circulation, momentum and surface fluxes, have strong seasonal changes. As shown with altimetric data (2), the annual cycle of the Mediterranean Sea level has an amplitude of about 10 cm. The sea level variability in the Algerian basin is in 80 % due to the annual cycle, while standard deviations of 5 cm correspond to high mesoscale activity (3). The steric effect seems to play a significant role in the seasonal variation of the surface circulation between the Tyrrhenian and Ligurian basins (4).

This study aims at separating and evaluating the annual cycles of the western Mediterranean sea level variability due to the steric effect and seasonal dynamic height variations. The data used are sea level anomaly maps (SLA) derived from TOPEX/POSEIDON and ERS-1/2 altimeters (5) and sea surface temperatures (SST) from NOAA/AVHRR (6), obtained between 1992 and 1998. The annual variability in SLA and SST has been extracted with empirical orthogonal function (EOF) analyses. The EOF results and the combination of SST and climatological hydrology allow an estimation of the steric effect, taking into account the temporal and spatial variations of the temperature in the mixed layer despite a few uncertainties on the mixed layer thickness.

The time response of the steric effect is about 40 days and the contribution of the intermediate and deep layers is not significant except in some particular areas. The choice of the mixed layer thickness is an important parameter for the estimation of the steric effect. A better knowledge of the mixed layer, whose temporal and spatial evolution depends mainly on sea surface fluxes and local turbulent mixing, is clearly necessary. The use of thermocline depth values from a mixed layer model should give more reliable estimations than the parameterisation used here.

The largest dynamic height annual variation and steric effect (> 6 cm) are found in the Catalan and Tyrrhenian seas while the lowest amplitudes (< 3 cm) occur on the path of the Atlantic Water (AW) circulation, where the steric effect is expected to be weaker due to the smaller annual temperature variability. The annual cycles in the Alboran sea appear to be more complex than in the rest of the western Mediterranean. The large annual sea level variation observed there is likely due to other forcing effects such winds and AW inflow, inducing circulation variability, which could be only partially sampled by the seasonal climatology used.

After removing the dynamic height annual variation and the steric effect in the mixed layer, the remaining annual signal still represents about 50% of the residual sea level variability. The EOF analysis shows that one part of this signal is spatially homogeneous (3.5 cm) and can therefore be associated with the annual variation of water mass budget and some remaining annual steric and dynamic signal not correctly removed because of the too simple parameterisation of the mixed layer. The other part of the signal is mainly observed along the north African coast and could be associated with the annual variation of winds and fluxes at the Straits of Gibraltar and Sicily, and their impact on the regional mesoscale activity. To improve these results the mean sea level used to get the SLA should be computed on a time scale longer than 3 years to avoid any local persistent anomalies due to long-lasting eddies.

An extended version of this study has been published in *Journal of Geophysical Research* (7).

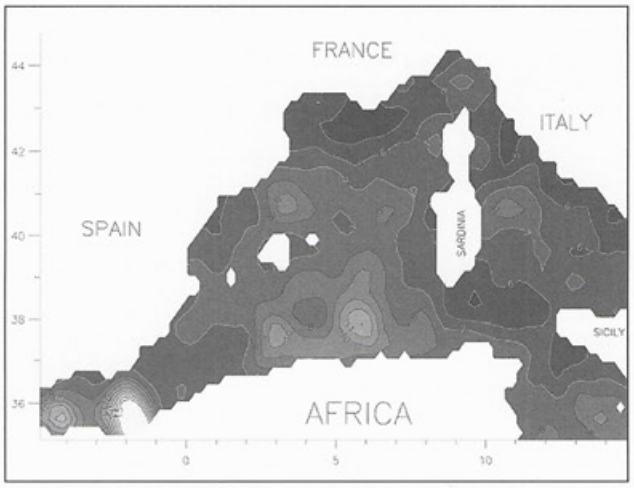


Fig. Western Mediterranean sea level anomaly standard deviation between 22 October 1992 and 30 December 1998 with a contour interval of 1 cm.

References

1 - Ayoub N., Le Traon P.Y., and De Mey P., 1998. A description of the Mediterranean surface variable circulation from combined ERS-1 and TOPEX/POSEIDON altimetric data,. *J. Mar. Sys.*, 18: 3-40.

2 - Larnicol, G., Le Traon P.Y., Ayoub N., and De Mey P., 1995. Sea Level Variability in the Mediterranean Sea from two years of Topex/Poseidon data. *J. Geophys. Res.*, 100: 25163-25177.

3 - Bouzinac C., Vazquez J. and Font J., 1998. CEOF analysis of ERS-1 and TOPEX/POSEIDON combined altimetric data in the region of the Algerian current, *J. Geophys. Res.*, 103: 8059-8071.

4 - Vignudelli S., Cipollini P., Astraldi M., Gasparini G.P., and Manzella G., 2000. Integrated use of altimeter and in-situ data for understanding the water exchange between the Tyrrhenian and Ligurian seas, *J. Geophys. Res.*, 105: 19649-19663.

5 - Le Traon P.Y., Nadal F., and Ducet N., 1998. An improved mapping method of multisatellite altimeter data. *J. Atmosph. Oceanic Technol.*, 15: 522-534.

6 - Vazquez J., Perry K., and Kilpatrick K., 1998. *Sea surface temperature data set. User's reference manual*, JPL Publ. D-14070

7 - Bouzinac C., Font J., and Johannessen J., 2003. The annual cycles of sea level and sea surface temperature in the western Mediterranean Sea, *J. Geophys. Res.*, 108: 3059, 10.1029/2002JC001365.

MEDITERRANEAN WARMING: ANALYSIS OF SEA TEMPERATURE TIME SERIES FROM THE BUOY ODAS ITALIA 1

R. Bozzano [1]*, S. Sparnocchia [2], P. Picco [3], A. Cappelletti [3], M.E. Schiano [4], C. Cappa [5]

[1] CNR ISSIA, Via de Marini 6 - 14149 Genova, Italy - *boz@ge.issia.cnr.it
[2] CNR ISMAR-TS, Viale Romolo Gessi, 2 - 34123 Trieste, Italy - s.sparnocchia@ts.ismar.cnr.it
[3] ENEA-CRAM, Forte di Santa Teresa, 19036 Pozzuolo di Lerici (SP), Italy - picco@santateresa.enea.it; capp@santateresa.enea.it
[4] CNR ISMAR-SP, Forte di Santa Teresa, 19036 Pozzuolo di Lerici (SP), Italy - elisabetta.schiano@sp.ismar.cnr.it
[5] CNR ISAC-TO, Corso Fiume 4, 10133 Torino, Italy - c.cappa@isac.cnr.it

Abstract

Starting from July 2002, hourly measurements of meteorological parameters and sea temperature in the layer between the surface and a depth of 35 m are recorded from the buoy ODAS Italia 1 in the Ligurian Sea. In this work we discuss the temporal evolution of the upper ocean thermal structure in relationship with the atmospheric forcings and the dynamic variability of the basin. Particular attention is also devoted to the investigation of the anomalous warming of the sea surface during summer 2003.

Keywords: air-sea exchanges, offshore buoy, surface ocean variability.

The ocean's effect on weather and climate is governed by processes occurring in the few tens meters of water close to the ocean surface. Nevertheless, in spite of its importance, the physics of this portion of the ocean is still poorly known.

In the conceptual models, the ocean surface has a very simple structure such as a well mixed layer of variable depth near the sea surface connected to the permanent thermocline by a seasonal thermocline. Reality is usually much more complex. The thermal structure of the surface layer depends on both local air-sea energy exchanges and main patterns of the regional dynamics. Therefore, its variability is very high at all time and space scales.

Some experiments have been carried out to determine the vertical thermal structure from satellite sea surface temperature (SST) observations. Such inverse methods make an aprioristic assumption about the truthfulness of a layered structure derived by climatological data sets. Even if this approach may have some useful applications, the use of climatologies, as representative of actual situation, prevents to evidence variations at any time scale. The long term changes will be hidden, as well as the short time variability (from daily to seasonal) of the vertical thermal structure, which has been showed to play important roles in upper ocean dynamics and heat transport.

Fixed offshore platforms provide a great contribution to the studies of the upper ocean supplying continuous long time series of both marine and atmospheric surface parameters under every weather conditions.

Due to its location within the Ligurian Basin, the ODAS Italia 1 buoy, moored at 73 Km far from the coast on a 1380 meter deep water, represents an offshore ideal measuring opportunity (1). It is a spar buoy, about 53 meters long, with a small laboratory on its top. The buoy was specifically designed as a stable measuring platform for air-sea interaction studies and it is equipped with a set of meteorological and marine sensors. In particular, five sea temperature sensors have been positioned along the buoy body at -0.5 m, -12.5 m, -20.0 m, -28.5 m, -35.8 m, respectively. The measurements from the sensors are collected each hour by the onboard acquisition system and transmitted to the station ashore. The buoy is operating in the present configuration since July 2002 (2).

The temporal evolution of the upper ocean thermal structure in relation with the atmospheric forcings and the dynamic variability of the basin is here investigated by means of the analysis of the available time series.

Since the buoy is located in proximity of a frontal region, the associated variability is also investigated. The comparative analysis of the thermal gradient in the marine layer from 10 down to 30 meters of depth and the surface water vapour density reveals a good correlation all year round. Moreover, sea temperature data well evidence the seasonal cycle due to the formation and erosion of the upper thermocline as well as other higher frequency processes. Daily variability is often confined to the upper 12 m, even though strong mixing events are able extend the signal at greater depths in the water column. In the lower layers, internal waves in the band of the inertial period prevail. Results from this analysis may also contribute to the definition of more effective strategies for monitoring the sea surface layer.

The anomalous warming period occurred during summer 2003, when the sea surface temperature of the Mediterranean Sea achieved the highest values of the last 50 years, is also considered. By comparing the temperature recorded in summer 2003 with the one acquired one year before, we deduce that surface heating was confined to the upper 10-15 m depth due to the presence of a strong stable stratification lasting several weeks thus preventing any relevant vertical mixing and consequently the heat redistribution along the water column. In fact, no relevant difference is detected below 15 m (Fig. 1). The persistence of calm weather conditions which did not allow vertical mixing processes lasted until the end of August when a strong storm was able to mix the whole layer.

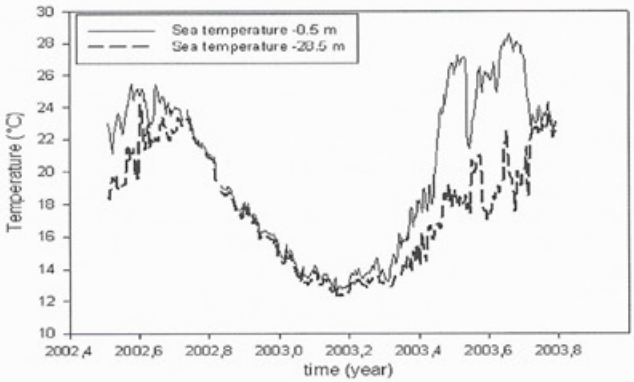


Fig. 1 Mean daily values of sea temperature at -0.5 m and -28.5 m depth from July 2002 to September 2003.

References

1 - Siccardi A., Bono R., Grosso F., Amore R., Mantovani R., Mistrangelo A., 1996. Open sea monitoring: ODAS Italia 1, an operational system and a challenge for the future. Oceanology International, Brighton, UK.

2 - Bozzano R., Pesce L., 2003. Detailed design specification of the W1-M3A system in the Ligurian Sea - Technical Report D23, European project MFSTEP.

THE INFLUENCE OF ATMOSPHERIC PRESSURE VARIATIONS ON THE CIRCULATION IN THE LEVANTINE BASIN

Stephen Brenner [1, 2] * and Zvi Rosentraub [2]

[1] Department of Geography, Bar Ilan University, Ramat Gan 52900 Israel
[2] National Institute of Oceanography, Israel Oceanographic and Limnological Research, PO Box 3080, Haifa 31080 Israel
* sbrenner@mail.biu.ac.il

Abstract

An analysis of the results from a previous high-resolution climatological simulation of the circulation in the southeastern Levantine Basin indicated that the model was able to reproduce the predominant alongshore direction of the flow and typical magnitude of the speed of the observed currents at various points along the shelf and slope, but missed the timing of the seasonal cycle of the speed. In order to identify the source of this problem, a coarser resolution basinwide model was run with atmospheric pressure forcing included. This additional surface forcing factor partially rectified this deficiency.

Keywords: coastal circulation, inverse barometer effect, eastern Mediterranean, numerical models

Introduction

Within the framework of the Mediterranean Forecasting System Pilot Project (MFSPP) (1), a high-resolution (2 km horizontal grid, 30 layer) model was run with climatological forcing for the southeastern corner of the Levantine Basin (2). The model was one-way nested in a coarser resolution (5 km, 30 layer) model of the Levantine, Aegean and part of the Ionian basins (3). Long term measurments at various points along the continental shelf and slope (4) indicate that the circulation in this regions is mainly alongshore (northward) with a distinct seasonal cycle in the current speed. Typical monthly mean values range from around 10 cm/s over the inner shelf to 20 cm/s and more over the outer shelf and slope. The inner shelf current speed had two maxima – in February and in July – while the outer shelf currents had a single pronounced peak in June/July. A comparison between the model results and the observed currents showed that he model was able to reporduce the predominant direction of the flow throughout the year as well as typical speeds. However there was a lag of one to two months in the simulated seasonal cycle of the speed. One possible factor that may account for this discrepency is the absence of atmospheric pressure forcing (the inverse barometer effect) in the simulations.

Model description and experiments

Atmospheric pressure forcing is not simply a localized affect due to the relatively large spatial scale of synoptic pressure systems. To properly account for this process the basinwide circulation must be studied. Therefore for the purposes of this investigation we used a model that covered the entire Levantine and part of the Ionian basins (the region east of 24°E and south of 37°N). The model used was the Princeton Ocean Model (POM) which is a three dimensional, primiitve equations, free surface model with a terrain following vertical (sigma) coordinate (5). The horizontal grid spacing was 0.05° (4.6 – 5.5 km) and 24 sigma layers were used in the vertical. Surface forcing consisted of monthly mean climatological wind stress and heat fluxes based on the 15 year ECMWF reanalysis as well as the monthly mean climatological fresh water flux as computed in (3). Monthly mean atmospheric pressure was computed from the same meteorological data set. Lateral boundary conditions at the open boundaries were specified from the eighth year of a climatological simulation with the MFSPP full Mediterranean model – the OGCM (1). Our model was first run for four years using initial conditions taken from 10 Jan of the OGCM simulation using the climatological wind stress and heat flux. In the control run, this simulation was continued for an additional two years. In the second simulation the model was also initialized from the end of the fourth year of the spin up run and again integrated for two years as in the control run but with the addition of the atmospheric pressure forcing.

Results

In both the high-resolution simulations of (2) and the coarser resolution runs of (3) the models were able to reproduce many of the obsrved climatological features of the circulation in this region including sub-basin scale features as welll as some of the mesoscale variability. Of particular interest were the variations in the free surface height with contrasts between cyclonic and anticyclonic eddies of as much as 10 – 20 cm. In the case of the inverse barometer effect an increase (decrease) of 1 hPa in atmospheric pressure corresponds to a lowering (rising) of the free surface of the sea by roughly 1 cm. Across the Levatine basin monthly mean horizontal pressure contrasts range from 1 – 2 hPa in the winter to as much as 5 – 6 hPa in the summer. Thus we would expect the influence of the atmospheric pressure forcing to be most pronounced during the months of July and August. Upon comparing the final year of our control and pressure forcing runs we find that indeed the largest domain wide mean and root mean square (rms) free surface differences occur in July with values of 2.8 and 4.7 cm, respectively. Over our previous high-resolution model domain in the southeastern corner the maximum mean and rms differences also occur in July with values of 2.2 and 3.3 cm, respectively. Furthermore, the mean free surface height differences between the eastern and western halves of the full domain were larger in the atmospheric pressure forcing run than in the control run throughout the year. Due to the lower pressure in the east, these differences were as much as 3 cm larger in the month of July. Finally, the simulated seasonal cycle of the current speed over the southeastern shelf and slope is in closer agreement with the observations than in our previous high-resolution simulations.

References

1 - Pinardi, N., Allen, I., and Demirov, E., 2003. The Mediterranean Ocean Forecasting System: the first phase of implementation. *Annal. Geophys.*, 21: 3-20.

2 - Brenner, S., 2003. High-resolution nested model simulations of the climatological circulation in the southeastern Mediterranean Sea. *Annal. Geophys.*, 21: 267-280.

3 - Korres, G. and A. Lascaratos, 2003. A one-way nested eddy resolving model of the Aegean and Levantine basins: implementation and climatological runs. *Annal. Geophys.*, 21: 205-220.

4 - Rosentraub, Z. and S. Brenner, 2003. Circulation over the southeastern continental shelf and slope of the Mediterranean Sea: direct current measurements. To be submitted.

5 - Blumberg, A.F. and Mellor, G.L., 1987. A description of a three-dimensional coastal ocean circulation model. Pp. 1-16. *In*: Heaps, N. (ed.), Coastal Ocean Circulation Models. American Geophysical Union, Washington DC.

MESOSCALE ACTIVITY IN THE SOUTHERN ADRIATIC AS EVIDENCED FROM A DEEP-SEA MOORING

Vanessa Cardin [1], Miroslav Gacic [1]* and Birgit Klein [2]

[1] OGS, Borgo Grotta Gigante, 34010 Sgonico (Trieste), Italy - vcardin@ogs.trieste.it
[2] University of Bremen, Institute of Environmental Physics, Bremen, Germany

Abstract

Deep-sea mooring recording temperature and salinity together with the upward looking Acoustic Doppler Current Profiler (ADCP) located at 300 m depth, was maintained from mid-October 2002 until 8 May 2003. The mooring was situated at a position where presumably an open-ocean convection in the Southern Adriatic takes place. In the pre-conditioning period rather smooth variations of the temperature and salinity were noticed. During the convection period high-frequency variations on the scale of about ten days, were very prominent. These were explained in terms of passage of mesoscale eddies formed along the border of the deep convection patch.

Keywords: Adriatic Sea, Acoustic Doppler Current Profiler record, mesoscale eddies

Introduction

The open-ocean vertical convection has been considered as the most important mechanism in forming the Adriatic Dense Water (AdDW) which then becomes the prevailing component of the Eastern Mediterranean Deep Water (EMDW). This process takes place in the South Adriatic Pit in the centre of the cyclonic gyre (1). The extension of the vertical mixing, which rarely in the last 15 years has reached the bottom layer, varies on the interannual and decadal time-scales in function of the air-sea heat fluxes and the pre-conditioning vertical density structure (2).

Material and Methods

A deep-sea mooring (41^{0}29.7N, 17^{0}42.1E) containing CT sensors at five depths (340, 540, 740, 1000 and 1100 m), an upward looking 300 kHz ADCP at 300 m depth and an Aanderaa current meter at 1124 m was located in the area where presumably the vertical convection takes place. The mooring was maintained in the period between mid-October 2002 and beginning of May 2003 covering the pre-conditioning and deep convection periods. Surface chlorophyll a obtained from the SeaWiFS data is a good indicator of the vertical mixing patch as demonstrated earlier (3), and here it has been used in determining the patch position and its geometry.

Results and Discussion

Low-pass filtered data of the potential density (Fig. 1) show rather smooth temporal variations of the density field in the period from October to December. From the end of December until the end of March the density variations are characterized by the occurrence of several events of sudden density decrease of the duration of about a week. These density variations are associated with the occurrence of the saltier and warmer water at the mooring site. The amplitude maximum of these events occurs at a depth of about 700 m. The vertical stratification variation is negligible during the entire studied period demonstrating that, at least at the mooring site, the vertical convection did not take place. Conversely, XBT surveys carried out on a monthly basis in the area during the same winter do show that the vertical convection took place in the Southern Adriatic area and reached the horizon of about 600 m. The only possible explanation for the lack of the vertical convection signal at the mooring site is that it was located out of the vertically mixed patch. Indeed from the SeaWiFS chlorophyll a horizontal distribution (Fig. 2) it is evident that the mooring was positioned northward of the high-chlorophyll patch. Presumably the high surface chlorophyll content corresponds to the vertically mixed patch since in that area the nutrients available for phytoplankton have much higher concentrations being brought to the surface by the vertical mixing. Furthermore, the events of strong density variations can be explained in terms of passages of mesoscale eddies formed along the rim current of the patch as evident from the chlorophyll distribution. These eddies are responsible for the water properties advection and re-distribution from the patch into the rest of the basin and have length scales of several tenths of kilometre.

Acknowledgments. We thank Elena Mauri for processing-producing the SeaWiFS image and Isaac Mancero-Mosquera for the help in processing-drawing the data.

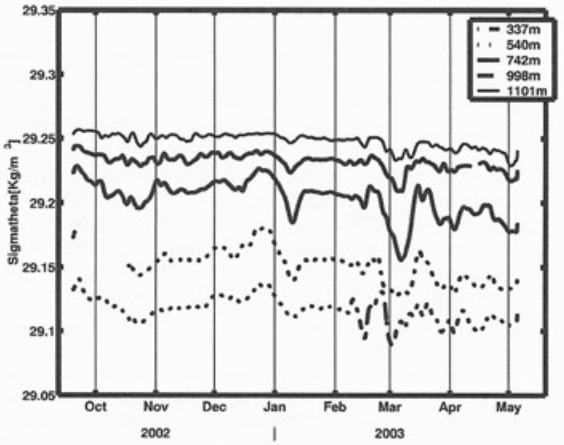


Fig. 1. Time-series of potential density at five measurement depths.

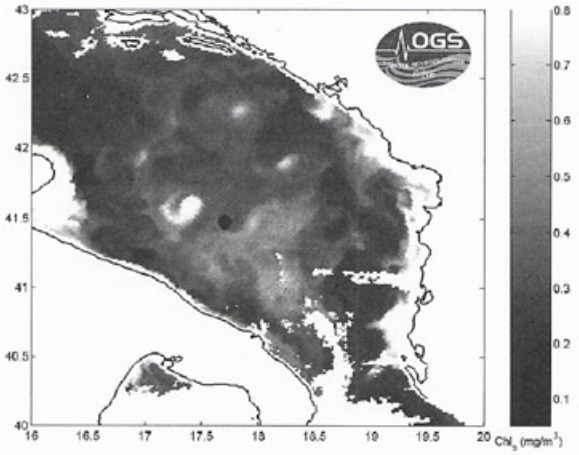


Fig. 2. Horizontal distribution of the surface chlorophyll a concentration (SeaWiFS data) for 16 April 2003. The mooring site is denoted by a thick dot.

References

1 - Gacic M., Lascaratos A., Manca B.B. and Mantziafou A., 2001. Adriatic deep water formation and interaction with the Eastern Mediterranean Sea Pp.111-142. In: Physical Oceanography of the Adriatic Sea, B. Cushman-Roisin *et al.* (eds.), Kluwer Academic Publishers.

2 - Cardin, V. and Gacic M., 2003. Long-term heat flux variability and winter convection in the Adriatic Sea. *J. Geophys. Res.*, 108, C9: 8103.

3 - Gacic, M., Civitarese G., Cardin V., Crise A., Miserocchi S. and Mauri E., 2002. The open-ocean convection in the Southern Adriatic: a controlling mechanism of the spring phytoplankton bloom. *Cont. Shelf Res.*, 22, 14: 1897-1908.

ATMOSPHERIC CONDITIONS DURING SEVERE WAVE STORMS IN THE NORTH-WESTERN MEDITERRANEAN. GENERATION, EVOLUTION, DECAY AND IMPLICATIONS

Jordi Cateura [1] *, Agustín Sánchez-Arcilla [1], Rodolfo Bolaños-Sanchez [1], Abdel Sairouni [2]

[1] Laboratri d'Enginyeria Marítima, LIM-CIIRC DEHMA. ETSECCPB Universitat Poltècnica de Catalunya
C/Jordi Girona, 1-3, Módul D-1, Campus Nord, 08034, Barcelona, Spain
* jordi.cateura@upc.es, agustin.arcilla@upc.es, rodolfo.bolanos@upc.es
[2] Servei Meteorològic de Catalunya, c/Berlín 38-46, 08029, Barecelona, Spain - asairouni@meteocat.net

Abstract

In this paper, data from weather charts, meteorological stations and waverider buoys are used to analyse the atmospheric conditions during two severe wave storms in the Catalan coast. Through the analysis of the development of the two severe wave storms, some common characteristics have been identified. This allows the future forecast of similar occurrences and gains in understanding for improving numerical wave forecasts.

Keywords: wave storms, wind waves, wave modeling, wave climate

The considered severe wave storms [1] have been the two most energetic measured by the XIOM (Xarxa d'Instruments Oceanogràfics i Meteorològics) network since operational wave prediction started as a joint venture between UPC-SMC (Universitat Politècnica de Catalunya-Servei Meteorològic de Catalunya). The analysis has been done using mean sea level pressure charts from MetOffice, 500 hPa geopotencial and wind field results from the meteorological model GFS (Global Forecasting System) [2]. The observations come from waverider buoy in Tortosa Cape (50 m depth) and some meteorological stations from the XMET (Xarxa METeorològica) network deployed along the Catalan coast.

The first wave storm (November 9th and 17th 2001) resulted from the intense high pressure Atlantic center, moving toward the British Islands. This causes first, a strong entrance of N and NE air fluxes in the NW Mediterranean. Nevertheless, the waves had significant wave height (Hs) of 2.0 m from the NW, according to the wind direction influenced by the orographic effect of the Ebre's valley (NW-SE). The wave field direction deflects towards NE, reaching 3.0 m Hs (although the wind direction remains from the NW). Then the cold air contribution, especially in atmospheric high levels (500 hPa), develops a low in the Balearic Sea supported by the relatively warm autumn sea. By the 11th, the wave field takes an E direction and reaching 5.5 m Hs in the Ebre's Delta region. The quick movement of the low-pressure center turns the wind to NE and N (NW direction in Ebre's Delta). However, the wave field remains E towards with Hs higher than 3.0 m, but losing height and turning to NW in the Tortosa Cape. Cold air fluxes from the N feeds the low-pressure center, leading to an intense gradient for some days in the Genova Gulf. Later, the high-pressure center moves to the British Islands which induces NE and E air fluxes.

The wave field deflects to E with 5.9 m Hs (the highest recorded in 10 years). The low's feeding is then interrupted with a transversal position of the high level pressure. However, air fluxes from NE and E with large fetch persists. This sequence keeps a NW strong wind in the Ebre's Delta area, and NE and E moderate, although persistent winds during several days, in NW Mediterranean Sea. This situation ended when the high pressure center moved back to an oceanic position, stopping the eastern air fluxes on the Catalan coast.

The second wave storm (March 28th and April 13th 2002) was not a single storm but a sequence of 3:

1. The initial one, with a blocking anticyclone moving from the British Islands towards the Center of Europe. There was a strong wind flux (79.6 km/h in Porbou, 77.8 km/h in Barcelona, 65.5 km/h in Illa de Buda) from E with a long fetch which inducing eastern waves with 3.0 m Hs. This situation lasted for 4 days.

2. Undefined surface pressure configuration co-existing with a trough in the 500 hPa geopotencial level. This situation is prone to ciclogenesis in the Mediterranean area, which ends up by generating a subtropical low in the Alboran Sea. Wind and waves appear as a response to the low center movement towards Italy. A high variability in wind and in wave field can be observed. The new wave storm evolves from S-E mild winds to moderate NE that becomes NW in the Ebre's Delta area. The corresponding wave field reached 3.0 m Hs with E direction. The low dissipates in 4 days.

3. A high level cold air pool deepening generates a new surface low, affecting the whole NW Mediterranean littoral area during 3 days, leading waves coming from the E and reaching 3.0 m Hs.

After the analysis of both storms it is possible to assume that this type of configuration is favorable for triggering such events since both had a similar pattern (Fig.1). That the E winds are responsible for the highest energy seas on the Catalan coast, as could be expected. However the conditions of both severe wave storms are the result of synoptic situations that flow in this E direction on the NW Mediterranean. The common synoptic configuration features are:

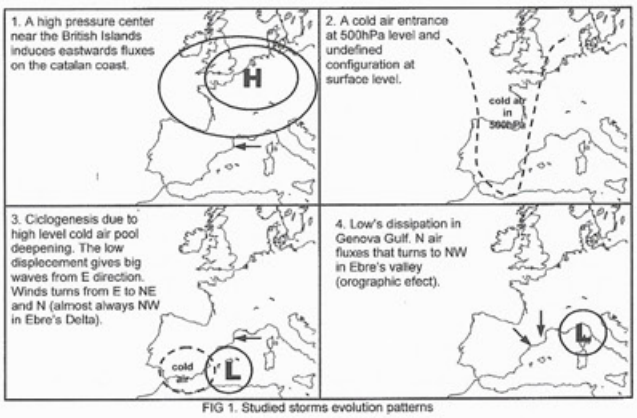


FIG 1. Studied storms evolution patterns

• The initial positioning of an intense high-pressure area on the British islands, leading to the NE and E air fluxes on the Catalan littoral.

• Mediterranean ciclogenesis due a to high level cold air pool deepening and the passage of the resulting low in front of catalan littoral. It generates E winds, except in Ebre's Delta area where the wind is coming from the NW due to orographic effects.

These results suggest a more detailed study of wave storm development on the Catalan coast is necessary. It is evident that they are associated to strong eastern events. However it is not well known which synoptic atmospheric situations support such wind fields. Moreover, it is necessary to analyze whether the most significant wave storms always follow the same pattern. In order to provide an index that allows an early warning for such situations with several days of anticipation, well outside the time resolution of operational wave models (WAM) [3].

References

1 - Bolaños-Sanchez, R., Sanchez-Arcilla, A., Gomez, J., Vilaclara, E., Sairouni, A. 2003. Prediccion de sucesos extremos en la costa Catalana, VII Jornadas españolas de Ingenieria de Costas y Puertos. Almeria 22-23 Mayo.

2 - Kanamitsu, M., 1989. Description of the NMC global data assimilation and forecast system. *Wea. and Forecasting*, 4: 335-342.

3 - The WAMDI Group, 1988. The WAM Model:-A Third Generation Ocean Wave Prediction Model, *Journal of Physical Oceanography*, 18:1775-1810.

SATELLITE OBSERVATIONS OF COLD FILAMENTS IN THE MEDITERRANEAN SEA

R. D'Archino [1], F. Bignami [2], E. Böhm [2], E. D'Acunzo [2], E. Salusti [3] *

[1] Dip. Biologia Vegetale, Università "La Sapienza", Rome, Italy
[2] ISAC-CNR Sezione di Roma, Rome, Italy
[3] INFN, Dip. Fisica, Università "La Sapienza", Rome, Italy

Abstract

Thermal satellite images relative to the years 1997-2000 are analyzed, in order to infer cold filament and surface jet dynamics in the Mediterranean Sea. The main zones in which these phenomena are seen to occur are characterised by upwelling and/or the funnelling of strong cold winds by a somewhat irregular coastal orography. In the Mediterranean Sea the geographical zones with a higher frequency in these jets are the two lobes of the southern Sicilian coast, the sea off Olbia in Eastern Sardinia, that south of the island of Crete, and the Balkanic coast of the Adriatic Sea.

Keywords: Filaments, entrainment, potential vorticity, Mediterranean Sea

The problem

Thermal and ocean color satellite imagery has recently allowed considerable progress in the observation and modelling of the response of coastal currents to strong air-sea interaction. A particularly interesting case is that of transient jets or cold filaments observed off coastal areas. For a detailed overview, see [1] and, more recently, [2]. In all these studies, filament space scales are found to be 100-300 km in length, 10-20 km in width, and 30-50 m in thickness; the time scales are of one-two weeks, and typical velocities are 10-50 cm s^{-1}, irrespective of the elementary physical mechanism originating the phenomenon. This regularity of filament characteristics, independently from the physical mechanisms at its origin, is an open and interesting physical problem. For all the above reasons, a set of thermal satellite images of cold filaments or jets in the Mediterranean Sea was examined .These images allowed to estimate the entrainment coefficient E^* from the analysis of along-flow warming.

The images

The entire set of NOAA AVHRR SST images relative to the period 1997-2000 was acquired, processed, archived and analyzed using the DSP software at the ISAC-CNR Sezione di Roma. The number of examined images is about 1500 for each year (4-5 daily passes, relative to the NOAA 14 satellite). The attention was focused on the southern Sicilian coast, the eastern Sardinian coast, the sea south of the island of Crete, and also the Balkanic coast of the Adriatic sea as these sites were found to be the most abundant in filament events.

A set of 44 images distributed between these relevant sites was finally chosen for a quantitative analysis. For each analyzed cold filament, at selected cross sections characterized by progressive numbers, the filament width $W(\xi)$ and the difference between the environment and filament mean temperatures $\Delta T(\xi)$ have been measured, ξ being the along-stream coordinate. Furthermore, the total along-stream length L, mean temperature T_m and mean width W_m have been measured, as well as the average along-stream temperature difference decrease $A = \partial[\Delta T(\xi)/\Delta T(\xi=0)]/\partial\xi$ between two given sections, hereafter referred to as 'thermal slope'. Time series of SST and chlorophyll images reveal that during their fully developed phase one can reasonably assume filament stationariety on a time scale of one-two days.

The analysis of only a few cross sections per filament scene has thus induced us to calculate a more reliable estimation of A, using the entire collection of filaments at each site, with a linear regression between ξ and $\Delta T(\xi)/\Delta T(\xi=0)$. We assume that this along-stream thermal variability of the filaments is due to entrainment of warmer ambient water and proceed to estimate an 'overall' entrainment coefficient E^* from the thermal images, after establishing the relationship between A and E^*. We adopt here the definition of E^* given by [3]), which assumes that the increment in filament thickness can be approximated by $E^*|\underline{u}|$, i.e. proportional to the filament's mean along-stream velocity modulus $|\underline{u}|$.

In synthesis, it is interesting to note that the order of magnitude of the overall E^*/h values stays the same, which suggests this value to be typical for Mediterranean Sea. The data show some low correlation coefficients indicative of large scatter in the regressions, as in the case of the north Adriatic (R=0.30) and eastern Crete (R=-0.13), which cannot be regarded as statistically significant. Finally, the use of satellite SST as ambient water temperature is among the limits of validity of this analysis, since T_a should be a lower 'bulk' average temperature. This is because entrainment occurs along the entire filament interface, which shoals only towards the edge of the filament; the same holds for h, which therefore is considered as a mean depth in our conceptual model.

It could also be of interest that during the SYMPLEX 99 cruise (21 October – 6 November 1999, carried out by ISAC-CNR Sezione di Roma) a CTD transect allowed to determine the thermal structure of the cold filament flowing off Cape Passero, at the southernmost tip of Sicily. The CTD transect is ≈ 25 km long; the thermal anomaly is $\Delta T \approx$ 2 °C, the potential density σ vertical section reveals that the filament is moving southward with a velocity ≈ 10-20 cm s^{-1}. In reality, this velocity estimate is a lower limit, expressing the bottom to surface shear. Indeed ADCP measurements during the cruise revealed absolute velocities up to 50 cm/s. A fact of general interest is that the filament is in contact with underlying colder waters, while only in the upper 20 m, say, it comes in contact with warmer waters. This gives an idea of our approximation in treating the filament as embedded in warmer homogeneous water.

References

1 - Barton, E.D., M.L. Argote, J. Brown, P.M. Kosro, M. Lavin, J.M. Robles, R.L. Smith, A. Trasvina, and H.S. Velez, 1993. Supersquirt: Dynamics of the Gulf of Tehuantepec, Mexico. *Oceanography*, **6**, 1: 23-30.

2 - Rienecker, M.M., and C.N.K. Mooers, 1989. Mesoscale eddies, jets and front off Point Arena, California July 1986. *J. Geophys. Res.*, **94**: 12,555-12,569.

3 - Turner, J. S., 1986. Turbulent entrainment: the development of the entrainment asumption, and its application to geophysical flows. *J. Fluid Mech.*, **173**: 431-471.

PRELIMINARY EXPERIMENTS TOWARDS CONTROLLING BIOFOULING EFFECTS ON THE M3A ARRAY'S OPTICAL INSTRUMENTS

Panos Drakopoulos [1], Vassilis Zervakis [2], Giannis Thanos [2], Kostas Nittis [2] *,
Panos Renieris [2], Gianna Assimakopoulou [2] and Christos Tziavos [2]

[1] Laboratory of Optical Instrumentation, Technological Educational Institute (TEI) of Athens, Greece
[2] Dep. of Oceanography, Hellenic Center for Marine Research, Anavissos, Greece

Abstract

For the needs of the EU MFSTEP project, and based on the experience gathered during its previous phase, various experiments have been planned to prevent biofouling of the optical instruments on the Mediterranean Moored Multi-sensor Array (M3A). Although the system, when operational, is deployed in oligotrophic open sea waters 22 N.M. north of the port of Iraklion Crete, severe fouling prevented the proper functioning of the optical sensors and sources after 30 days of deployment. These experiments are still underway, however, emerging initial results from a 50 day deployment in coastal waters, indicate that the introduction of a bromine canister and copper tubing in the flow system can result in almost fouling free instruments.

Keywords: marine optics, marine growth, operational oceanography, optical oceanography

Introduction

New trends in ocean observation approaches demand the deployment of moored instruments for large periods of time. Important processes such as ecological can be monitored by sensing various properties of the visible light field within the water column (both inherent and apparent). This is accomplished by means of optical sensors and sources, which however, tend to be severely affected by marine biofouling [1]. Such problem was encountered during the first stage of the Mediterranean Forecasting System project (MFS-PP) [2], and in particular for the optical instruments attached on the M3A array [3]. Thus, for the second phase of MFS, the MFSTEP, a special task was introduced in order to assess and mitigate this negative aspect.

Data and methods

The location of the experimental deployment was the protected surroundings of a fish-farm situated off the islet of Patroklos in Saronikos Gulf, Greece. It was chosen so having in mind the minimization of the deployment period since the waste of the farm results in relatively eutrophic waters.

The instruments deployed were four SBE-16s having the following optical sensors attached:

1. PAR sensors (model 193SA manufactured by LI-COR).
2. Fluorometers (WETSTAR by Wetlabs)
3. Transmissometers (C-star by Wetlabs) at 660 nm with a 25 cm path length.

In the current configuration, the PAR sensors are open (to the surrounding water column) while the fluorometers and transmissometers are closed by means of tubing and pump.

The experiment was set as follows: For the open instruments no particular action to prevent biofouling was taken. For the rest of the sensors four different configurations were deployed (no protection, copper, bromine, combination of both). The copper configuration simply included replacement of 10 cm of plastic tubing adjacent to the fluorometer and transmissometer with copper tubing (∅ 10 mm) of similar length. The bromine system included a vented canister, [4], with bromine tablets attached between the fluorometer and the transmissometer and above them, in order to slowly and constantly release bromine solution through diffusion towards both sensors. To avoid erroneous readings all sensors were flushed for 15 seconds prior to taking a measurement. The sampling interval was set to 1 h.

For the fluorometers, both pre-deployment and post-deployment calibration was performed. It was based on five samples of local phytoplankton populations which were nutrient-enriched and cultured for about 10 days to attain discrete chl-a concentration values. After a 15 minute sampling by the fluorescence sensors, a reference value was estimated by extracting phytoplankton by means of filtering and measuring its chl-α concentration with a TURNER AU-10 laboratory fluorometer.

Transmissometers were post deployment calibrated by obtaining several voltage readings after blocking the receiver to obtain (v_{dark}) and in de-ionized water to obtain a clean water offset (v_{ref}).

Results and discussion

The instruments were recovered after 50 days of deployment when scuba divers observed excessive external biofouling build up.

Inter comparison of PAR and incoming solar radiation time series after the removal of the daily cycle, showed a decrease of sensitivity in the order of 40% in 50 days with an accelerating trend towards the end of the deployment period.

The fluormeters recorded no obvious increase in chlorophyll-α concentration despite there external build up of organisms. Only the one with no antifoulant protection showed an increasing trend towards the end of the deployment. It should be noted here that the concentration as measured from bottle data was low and ranged from 0.06 to 0.09 μg/lt.

The transmissometers' records exhibited an exponential increase in all configurations with no bromine canister, indicative of optical window contamination. The one with the least bio-fouling was that which incorporated both copper tubing and bromine solution (see Figure 1). This was in contrast to the results reported elsewhere [1], where copper alone was sufficient.

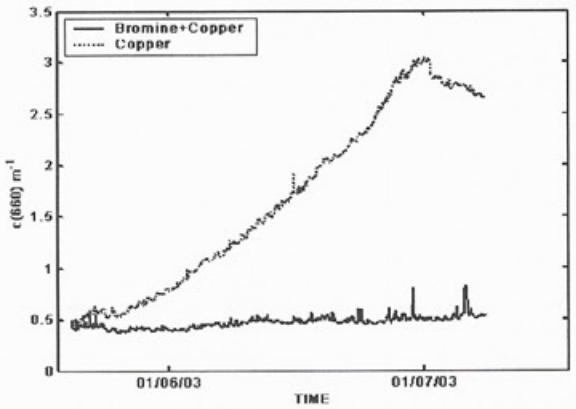


Fig. 1. Time series of c(660) (m^{-1}) beam attenuation coefficients for two characteristic configurations. Solid line corresponds to the one with bromine canister and copper tubing and the dashed line to that with only copper tubing.

A follow up experiment is planned either with a longer deployment period or during the spring bloom, so a better assessment of the fouling conditions on the fluorometers is achieved. Moreover additional steps will be taken towards protecting the open PAR instruments (i.e. copper collars).

References

1 - Manov D.V., Chang G.C., Dickey T.D. 2003. Methods for reducing biofouling of moored optical sensors. Unpublished manuscript.

2 - Drakopoulos P.G., Petihakis G., Valavanis V., Nittis K., Triantafyllou G., 2003. Optical variability associated with phytoplankton dynamics in the Cretan Sea during 2000 and 2001. "Building European Capacity in Operational Oceanography - Proceedings of the Third International Conference on EuroGOOS", in press.

3 - Nittis K., Tziavos C., Thanos I., Drakopoulos P., Cardin V., Gacic M., Petihakis G., Basana R 2003. The Mediterranean-Moored Multi-sensor Array (M3A): system development and initial results. *Ann. Geophysicae,* 21: 75-87.

4 - Davis R.F., Moore C.C., Zaneveld J.R.V., Napp J.M., 1997. Reducing the effects of fouling on chlorophyll estimates derived from long-term deployments of optical instruments. *J. Geophys. Res.* 102: 5851-5855.

CARACTERISTIQUES PHYSICO-CHIMIQUES DE LA LAGUNE MELLAH (ALGERIE NORD-EST)

Draredja B.* et Kara M. H.
Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie - * draredjab@yahoo.fr

Résumé
Cette étude est consacrée à l'hydrologie (température, salinité, pH et teneur en matières en suspension) de la lagune Mellah. Les différents paramètres mesurés montrent des variations saisonnières, toutefois une homogénéité spatiale est mise en évidence.

Mots-clés: hydrologie, lagune, Mellah, Méditerranée, Algérie.

Introduction

Le "Mellah" est l'unique lagune en Algérie et a suscité plusieurs investigations (1-5). Le rétrécissement progressif de son chenal de communication avec la mer s'est probablement répercuté sur la qualité des eaux. Nous décrivons ici ses caractéristiques physico-chimiques au cours de l'année 1998, soit une dizaine d'années après l'aménagement du chenal.

Matériel et méthodes

D'une superficie d'environ 865 ha, la lagune Mellah (8°20'E et 36°54'N) ne dépasse pas 6 m de profondeur. Elle communique avec la mer par un chenal long d'environ 900 m. Des apports d'eaux douces y sont assurés par trois oueds saisonniers.

Dans cette étude, nous avons suivi au cours d'un cycle annuel (de novembre 1997 à décembre 1998), et dans 12 stations couvrant l'ensemble du lac, cinq descripteurs différents du milieu: la température, la salinité, le pH et la teneur des eaux en matière en suspension et en carbone organique particulaire.

Résultats et discussion

La température montre une certaine homogénéité entre les eaux de surface et celles du fond avec une amplitude qui ne dépasse pas 1°C. Cette situation a déjà été signalée (3,5,8,9). Un minimum de 10°C est enregistré en janvier, alors qu'un maximum de 30,2°C est relevé en août (Fig. 1).

L'évolution de la salinité est caractérisée par deux phases (Fig. 1); la première est décroissante et s'étale de novembre à mars (période de crue) avec des valeurs qui passent de 34,8 à 25,4 psu; la deuxième est croissante, de mars à novembre (période sèche), avec des valeurs qui s'inversent (4, 5). Par ailleurs, on remarque (1, 2) une marge de variation annuelle de salinité comprise entre 25 psu en mars (fin de la période pluvieuse) et 32 psu en novembre (fin de la période sèche).

Le pH des eaux est légèrement alcalin avec des valeurs comprises entre 7 et 8,46. Ces dernières sont normales pour des eaux non polluées (8).

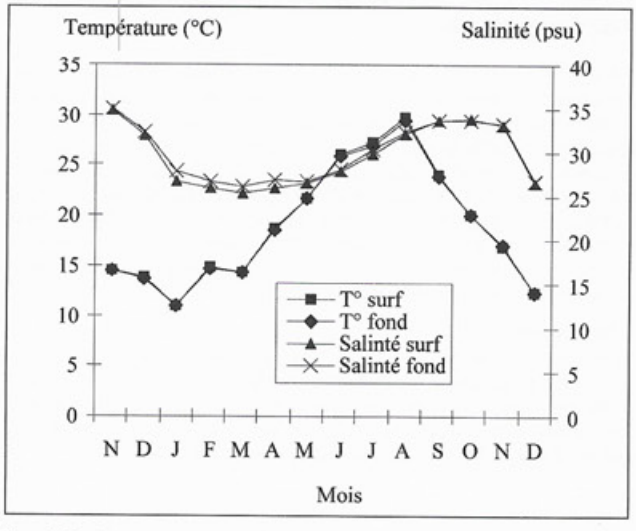


Fig. 1. Variations mensuelles de la température et de la salinité moyennes dans la lagune Mellah, de novembre 1997 à décembre 1998.

La teneur en matières en suspension varie selon les saisons (Fig. 2). Un maximum de 66,5 mg/l est enregistré en janvier près des embouchures des oued. Le carbone organique particulaire (C.O.P) est caractérisé par de grandes variations selon les saisons (Fig. 2). Celles-ci seraient en rapport avec les périodes de poussées phytoplanctoniques. En effet, un maximum de 2316 µg/l est enregistré durant le bloom printanier (9).

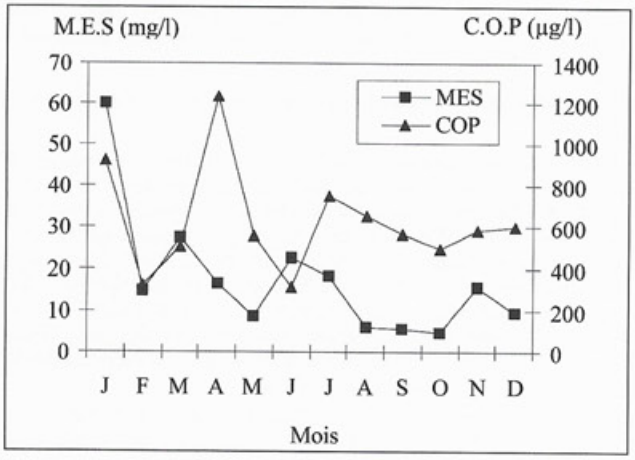


Fig. 2. Valeurs mensuelles moyennes de la teneur en matière en suspension (M.E.S) et en carbone organique particulaire (C.O.P) dans la lagune Mellah, de janvier à décembre 1998.

D'une manière générale, et pour la même période, les eaux de la lagune Mellah sont caractérisées par une homogénéité des paramètres physico-chimiques, aussi bien verticalement qu'horizontalement; ceci est favorisé par la faible profondeur moyenne de la lagune (inférieure à 3 m). Toutefois, les particularités saisonnières sont bien marquées.

Références

1 - Semroud R., 1983. Contribution à l'étude écologique des milieux saumâtres méditerranéens: le lac Mellah (El-Kala, Algérie). Thèse 3ème cycle, USTHB (Alger), 137 p.

2 - Casabianca De Chassany M.L., Samson-Kechacha F.L. et Bone C., 1991. Étude spatio-temporelle des sels nutritifs et des principales variables hydrobiologiques dans une lagune méditerranéenne: le lac Mellah (Algérie). *Mesogée, 51*: 15-23.

3 - Draredja B., 1992. Conditions hydrosédimentaires et structure de la macrofaune benthique en période printanière d'un écosystème lagunaire méditerranéen: lac Mellah. Thèse de magister en océanographie biologique, ISMAL (Alger), 147 p.

4 - Grimes S., 1994. Contribution à la connaissance des populations de *Cardium glaucum*, *Loripes lacteus* et *Brachydontes marioni* du lac Mellah (El-Kala, Algérie): Écologie et dynamique. Thèse de magister, ISMAL (Alger), 211 p.

5 - Refes W., 1994. Contribution à la connaissance de la population de *Ruditapes decussatus* du lac Mellah (El-Kala, Algérie): Écologie, reproduction, dynamique de la population et exploitation. Thèse de magister, ISMAL (Alger) 197 p.

6 - Guelorget O., Ximenes M.C., Frisoni G.F. et Perthuisot J.P., 1982. Diagnose écologique du lac Mellah (Algérie) pour l'évaluation de ses potentialités halieutiques et aquacoles. Rapport de la mission FAO, (PNUD/MEDRAP), octobre 1982, 130 p.

7 - Guelorget O., Frisoni G.F., Ximenes M.C. et Perthuisot J.P., 1989. Expressions biologiques du confinement dans une lagune méditerranéenne: le lac Mellah (Algérie). *Rev. Hydrobiol. Trop.*, 22(2): 87-99.

8 - Branes Z. et Draredja B., 2002. Degré de contamination bactériologique d'un site lagunaire à vocation aquacole: le lac Mellah (El-Kala, Algérie). *Synthèse,* 11: 115-125.

9 - Samson-Kechacha F.L. et Touahria T., 1992. Populations phytoplanctoniques et successions écologiques dans une lagune saumâtre: le lac Mellah (Algérie). *Rapp. Comm. Int. Mer Médit.,* 33: 103.

RELATIVE CONTRIBUTION OF EUTROPHICATION AND HYDROMORPHOLOGY TO BOTTOM OXYGEN DEFICIENCY: THE CASE OF THE MEDITERRANEAN AND BLACK SEAS

Jean-Noël Druon [1]*, Wolfram Schrimpf [1], Srdjan Dobricic [1], Elisaveta Peneva [1], Alex Lascaratos [2], Sarantis Sofianos [2], Pierre Garreau [3], Samuel Djavidnia [1]

[1] European Commission-Joint Research Centre, Institute for Environment & Sustainability, Inland & Marine Waters Unit, TP 272, I-21020 Ispra (VA) - Italy - * jean-noel.druon@jrc.it

[2] University of Athens, Ocean Physics and Modelling Group University Campus, Building PHYS-V, 15784, Athens, Greece

[3] IFREMER – Center of Brest, DEL/AO, BP 70, 29280 Plouzané, France

Abstract

As hydromorphology plays a key role in isolating bottom waters from vertical and horizontal supply of oxygen, its contribution to bottom oxygen deficiency is discussed relatively to eutrophication (oxygen sink). If nutrient over-enrichment of margins is largely responsible of cultural eutrophication and seasonal hypoxia or anoxia (northern Adriatic Sea and north-west Black Sea), permanent stratification leads to anoxia rather independently of the trophic conditions (deep Black Sea). In case climatic changes favour a decrease of the hydrodynamics, and particularly when stratification is reinforced in its extension or duration, the contribution of hydrology to bottom oxygen deficiency would significantly increase.

Keywords: oxygen deficiency, hydromorphology, eutrophication, Mediterranean Sea, Black Sea

Eutrophication is defined [1] as 'an increase in the rate of supply of organic matter to an ecosystem'. Besides this main direct effect and the causative factors, e.g. nutrient enrichment, a holistic assessment of eutrophication should include the supporting environmental factors, e.g. hydromorphological conditions, and the indirect effects, e.g. oxygen deficiencies or changes in benthic community structure. We propose here to investigate the influence of bathymetry and hydrology on bottom oxygen deficiency in the Mediterranean and Black Seas. The monthly mean data is extracted from 3D physical models based on climatology (or a mean of several years).

Bottom hypoxia is mainly controlled by the load of particulate organic matter (POM) that reaches the bottom and the physical capacity of the system to renew the near bottom oxygen [2].

These enclosed seas are mostly characterized by an important water column in which the POM degradation mainly occurs. However, in two important continental shelves, i.e. the northern Adriatic Sea and the north-west Black Sea, a significant fraction of the POM fuelled by the Po and Danube rivers reaches the sea bottom of the continental shelf. In both cases, poor hydrodynamical conditions limits the vertical (mixing) and horizontal (transport) oxygen supply to the bottom waters leading to seasonal hypoxia/anoxia. The summer stratification favours in these areas the primary production as nutrient and light are available near the surface. The stratification, together with low bottom friction (not shown), isolates bottom waters from the vertical supply of oxygen. The low advection near the sea bed (Fig. 1) contributes in reducing the horizontal supply of oxygen.

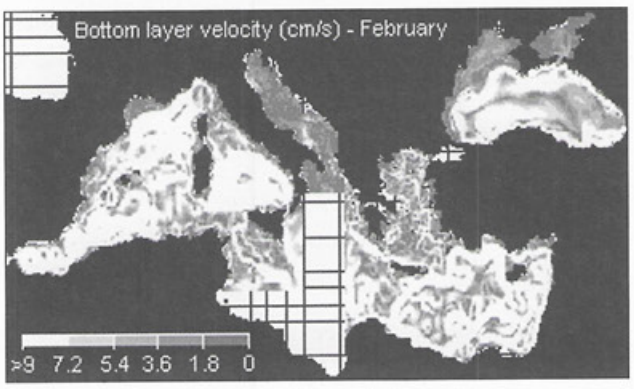


Fig. 1. Mean bottom advection of the benthic layer (cm s^{-1}) for August in the Mediterranean and Black Seas. Dark colours represent unfavourable conditions as regards to oxygen deficiency. Striped areas are regions not covered by the models.

The gathering of these unfavourable hydromorphological conditions in both continental margins of the Adriatic and Black Seas increases the effect of nutrient over-enrichment leading to seasonal oxygen deficiencies. In areas where the margin extension is small, the eutrophication-induced risk of hypoxia is limited in case the stratification is seasonal. The permanent halocline encountered in the Black Sea (Fig. 2) increases tremendously the physical sensitivity to oxygen deficiency. The bottom waters are permanently isolated and the oxygen bulk is consumed progressively even when the surface productivity is relatively low. It is thus suggested that the deep Mediterranean Sea is protected from oxygen deficiency by the absence of permanent stratification.

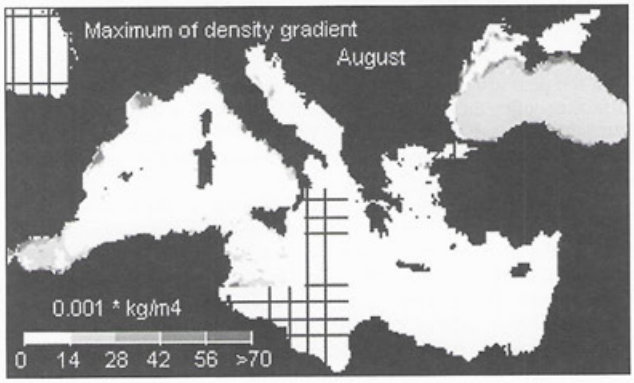


Fig. 2. Mean stratification intensity (kg m^{-4}) for February in the Mediterranean and Black Seas. Dark colours represent unfavourable conditions as regards to oxygen deficiency. Striped areas are regions not covered by the models.

Beside the nutrient loads from rivers, the impact of eutrophication is therefore largely controlled by the morphology of the receiving coastal area (semi-enclosed or open and water depth) and the regional hydrology (stratification, bottom friction, transport). In case of permanent stratification, anoxia can occur rather independently of the trophic condition. It is concluded that climatic changes which would lead to a decrease of the hydrodynamics, and particularly those which would reinforce the stratification either seasonally or permanently, would increase the sensitivity to bottom hypoxia and alter consequently the ecosystem functioning.

References

[1] Nixon S.W. (1995) Coastal marine eutrophication: A definition, social causes, and future concerns. *Ophelia*, 41: 199-219.

[2] Druon J.N., Schrimpf W., Dobricic S., Stips A. (submitted) Comparative assessment of large scale marine eutrophication: North Sea area and Adriatic Sea as case studies, *Mar. Ecol. Prog. Series.*

THE OCEANOGRAPHIC CONDITIONS NEAR THE CATALAN COAST DURING THE ANOMALOUSLY HOT SUMMER 2003. PRELIMINARY RESULTS OF TWO SUMMER CRUISES.

Emelianov M.*, Salat J., Sabatés A.

Institut de Ciencies del Mar CMIMA CSIC, Passeig maritim de la Barceloneta, 37-49, 08003 Barcelona , Spain - * mikhail@icm.csic.es

Abstract

The spatial distributions of temperature, salinity, density, zooplankton and ichtyoplankton were analysed on the basis of CTD sampling and plankton hauls performed during two oceanographic cruises in July and September 2003 along the Catalan coast. This summer season was anomalously long, hot and dry. The comparison of preliminary results with the data obtained in the same area in 1983 show higher temperatures and salinities at surface in July but not in September, while similar spatial distributions of the oceanographic parameters were found in both cases.

Keywords: temperature, salinity, surface layer, NW Mediterranean

Introduction

During the last 25 years it has been detected in the NW Mediterranean Sea an increment of the temperature, aproximately 0.7°C at sea surface, 0.4°C at 80 m depth [1], and 0.12°C between the years 1959 and 1989 at about 400 m depth [2]. Some authors [3, 4, 5] attributed the expansion of distribution ranges of fishes and benthos from the south Mediterranean to the warming process. They noted that they are more and more frequent in the NW Mediterranean Sea. At the same time some typical northern species abundances have decreased from the eighties until now [6]. These variations in the species distributions should reflect changes in the oceanographic conditions and they can be a first indication of the effect of the environmental changes in the mediterranean marine communities.

This study was designed to ascertain whether the observed changes, both in the species distribution and in the recurrent blooms of gelatinous zooplankton, are indicators of a trend in the long term, consequence of the global change, or, on the contrary, it is a response to the interannual variability in the physical characteristics. The present paper is a preliminary comparison between the hydrographic "normal" situation in 1983 and the anomalously "hot" summer 2003.

Materials and Methods

Two oceanographic cruises were performed in the summer season 2003 (July and September) in the shelf area extended along the Catalan coast, from the Ebro river Delta in the south to the Cape Creus in the north. The sampling stations, separated by 5 nautical miles, were located in 18 lines perpendicular to th coast, untils the shelf-break. Each station was sampled with CTD/Rosette equipped with a fluorometer. Current profiles in the first 300 m were continuosly registered with shipboard thermosalinograph and ADCP respectively. The sampling of fish larvae and zooplankton were carried out with a Bongo net from a maximum depth of 200 m until the surface. Also, in each station a neuston skate fishing was made.

Results

The comparison of the spatial distributions of temperature, salinity and specific density in the surface and 20 m depth obtained in July an September in 1983 and 2003 in the Catalan coastal area show that:

– In July 2003 the surface temperature was 1°C higher in the south and 0.5°C higher in the North than in 1983. In the 20 metres it was the opposite situation. Thus in July 2003 the first 20 m were 1 degree warmer than in July 1983. In the northern and southern areas, typically influenced by Rhone and Ebro rivers, salinity values at surface layer were 0.3 higher than in 1983.

– In September 2003 the spatial distributions of temperature, in the surface and at 20 m depth were similar to that obtained in September 1983. Salinities were again around 0.3 higher than in 1983 in the mentioned areas.

– The general trends of the physical distributions were similar. A N-S gradient of temperature in July and a surface intrusion of open sea waters, above the pycnoline, in September.

– In general, ichtyoplankton abundances were lower, especially in September. A quick survey of abundances of certain warm water species (*e.g. Sardinella aurita*) indicates a relative increment from 1983 in July. It is however a qualitative impression because samples are not still deeply analysed.

Discussion

Summer 2003 was anomalously long, hot and dry. Air temperatures were more than 2°C higher than usually and this situation started early June and lasted up to 20 August.

The comparison of phyisical data obtained in the same area in July and September 1983 and 2003 reflects the same oceanographyc patterns but surface layer temperature was higher in July 2003 as expected. The higher salinity values found in 2003 can also be explained by the lower precipitation over the main river basins. In September however while surface salinities were clearly higher in 2003, the surface layer temperature and pattern of distribution were similar to 1983. This situation would be explained if a cold air intrusion came before the cruise in September 2003. If this were the case, heavy precipitation and deepening of surface mixed layer would occur, but this was not the case. What was then causing the loss of heath in the surface layer of coastal water in September 2003? Was this related to the notable decrease of fish larvae abundance, relative to the same period in 1983?

The surface layer above the pycnoline near the coast in September is occupied by an intrusion of open sea waters and coastal lower salinity waters, colder, sink to the pycnocline. This is due to the lack of continental runoff in summer. A very preliminary explanation for the apparent heat loss of surface layer with respect to 1983 could be due to the relatively higher salinities of coastal waters in 2003. They should sink faster and in a thicker layer. In any case further work has to be done with data to verify this possibility or find out other alternatives.

References

1 - Salat J., and Pascual J. 2002. The oceanographic and meteorological station at L'Estartit (NWMediterranean) In: Tracking long-term hydrological change in the Mediterranean sea. *CIESM Workshop Series*, 16: 29-32.

2 - Bethoux J.P., Gentili B., Raunet J., and Tailliez D., 1990. Warming trend in the western Mediterranean deep water. *Nature*, 347: 660-662.

3 - Francour P., Boudouresque C. F., Harmelin J.G., Harmelin-Vivien M., and Quignard J.P., 1994. Are the Mediterranean waters becoming warmer ? Information from biological indicators. *Mar. Poll. Bull.*, 28: 523-626.

4 - Astraldi M., Bianchi C. N., Gasparini G.P., and Morri C., 1995. Climatic fluctuations, current variability and marine species distribution : a case study in the Ligurian Sea (north-west Mediterranean). *Oceanologica Acta*, 18: 139-149

5 - Bianchi, C.N., and Morri C., 2000. Marine biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. *Mar. Poll. Bull.*, 40: 367-376

6 - Quignard, J. P., and Raibaut, A., 1993. Ichthyofaune de la côte languedocienne (Golfe du Lion). Modifications faunistiques et démographiques. *Vie et Milieu*, 43: 191-195.

IMPLICATIONS OF A WINTER CIRCULATION ANOMALY IN THE CATALANO-BALEARIC SEA FOR DEEP MIXING AND PHYTOPLANKTON DISTRIBUTIONS.

M. Estrada, J. Salat *, M. Emelianov, L. Arín, D. Blasco, A. Morales
ICM-CSIC. P. Marítim, 37. 08003 Barcelona. Spain - marta@icm.csic.es

Abstract
The reduction of deep mixing extent and changes in phytoplankton distributions due to an anomaly in the circulation during winter are presented and compared with a typical winter.

Keywords: Deep mixing, phytoplankton, NW Mediterranean, marine circulation

Introduction

Deep mixing is a well known feature occurring at open sea in the Northwestern Mediterranean during winter. After the strong mixing pulses once the ocean is stratifying again there is an important spring phytoplankton bloom which is using the nutrient enrichment at the photic level. The extent and distribution of strong mixing is controlled both by northerly winds and the current pattern. Usually the circulation describes a cyclonic path with maximum current speeds near the continental slopes. In the centre a typical doming of isopycnals (1) which, under the typical winter conditions, is preconditioning the surface waters for deep mixing that will be triggered by strong northerlies. Only during very mild winters (2), mixing might not get the deepest layers.

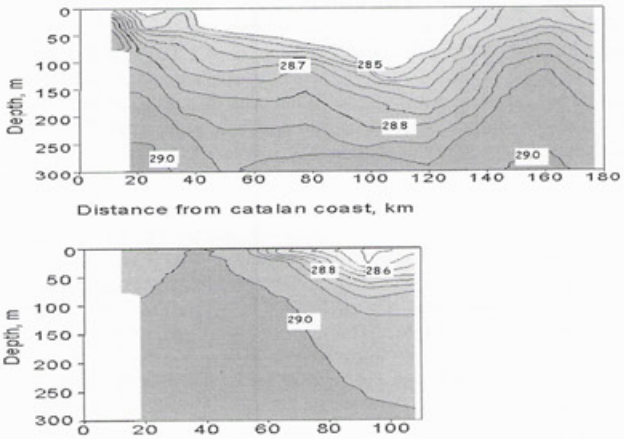


Fig. 1. Vertical sections of density across the Catalano-Balearic sea. Up: winter 1999, Down: winter 2000

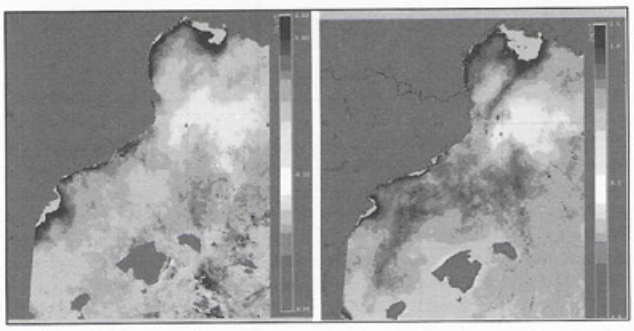


Fig. 2. Seawifs images of chlorophyll. Left: winter 1999, Right: winter 2000.

It has been agreed that the variability in the extent of the deep mixing process is directly related to the "severity" of the winter and the intensity and persistence of northerlies. This assumption however impliclty includes that the variability of the circulation pattern in the northern half of Western Mediterranean is relatively small or, at least, it maintains its cyclonic tendency over all the northern basin.

Results and discussion

In winter 1999 a persistent anticyclonic eddy was detected in the centre of the Catalano-Balearic sea (3). The classical doming of isopycnals was then limited preventing the southern extent of deep mixing process, even when the atmospheric conditions were suitable. The water mass involved in this anticyclonic eddy was a relatively new AW, with low surface salinity, instead of the classical old one with higher salinity. Consequently the surface of the central part of the Catalano-Balearic basin remained stratified during this winter. In other words, it was impossible to reach the surface density values high enough so that they become available for deep mixing. This anomaly imposed a severe restriction to the deep mixing extent south of 42°N and created a W-E frontal situation across the basin around this parallel. As a result, the northern current was deflected towards the east and did not reach the southern half of the Catalan slope. It was there replaced by a current from the south.

The biological distributions obtained from two oceanographic winter cruises in the Catalano-Balearic sea (Winter 1999 and 2000), carried out respectively under the anomalous and typical winter conditions, reveal the effects of the anomaly both near the coast and in open sea.

In 1999, high chlorophyll concentrations (chl_*a*), associated with diatoms, developed in the northern part of the study area and very close to the Catalan coast, while the anticyclonic eddy remained dominated by haptophytes (including *Phaeocystis* and coccolithophorids) and other flagellates, and presented relatively low chl_a concentrations. In winter 2000, elevated phytoplankton biomass values could be also found in the central zone, including diatoms.

The subsequent development of the winter phytoplankton bloom, as seen through SEAWIFS images, also presented marked differences between the winters of 1999 and 2000. From January to March, chl_*a* in the whole Catalano-Balearic Sea appeared to be lower in 1999 than in 2000. However in the northern part of the Western basin, chl_*a* in 1999 were much higher than in 2000 but the opposite happened in the area to the West of the Balearic Islands. These chl_*a* patterns appear to be linked to the presence of the anticyclonic eddy and its role blocking the typical circulation pattern.

Both the changes in total phytoplankton biomass and the dominance of different phytoplankton assemblages have ecological consequences. Diatom dominance favours the so-called classical food web (phytoplankton-mesozooplankton-fish), while small flagellates tend to enter the microbial food web. The reported observations suggest that the presence of anticyclonic eddies like that registered in 1999 may have important biogeochemical implications in addition to limiting the extent of deep mixing processes.

References

1 - Font, J., Salat, J., Tintoré, J., 1988. permanent features of the circulation in the Catalan sea. *Oceanol. Acta*, 11: 51-57.
2 - Estrada, M., Varela, R. A., Salat, J., Cruzado, A., Arias, E., 1999. Spatio-temporal variability of the winter phytoplankton distribution across the Catalan and North Balearic fronts (NW Mediterranean). *Journal of Plankton Research*, 21: 1-20.
3 - Pascual, A., Nardelli, B. B., Larnicol, G., Emelianov, M., Gomis, D., 2002. A case of an intense anticyclonic eddy in the Balearic Sea (western Mediterranean). *Journal of Geophysical Research*, vol. 197, No. C11, doi: 10.1029/2001JCC000913.

COMPARISON OF SEA LEVEL CHANGES IN THE LAST DECADE IN THE MEDITERRANEAN SEA USING SATELLITE ALTIMETRY VS TIDE GAUGE DATA

Luciana Fenoglio-Marc [1*], Dov S. Rosen [2]

[1] Institute of Physical Geodesy, Darmstadt University of Technology, Petersenstrasse 13, D-64287 Darmstadt, Germany
* de1m@hrzpub.tu-darmstadt.de,

[2] Israel Oceanographic and Limnological Research, Tel Shikmona, POB 31080, Haifa 31080, Israel - rosen@ocean.org.il,

Abstract

Sea level change has been measured over the last ten years using both tide gauge and altimetry. Only decadal and higher frequency sea level changes are studied using altimetry, due to its shorter time interval of data availability, while the lower frequency variations are investigated using tide gauge data. Altimetry from the Topex Poseidon mission and tide gauge time-series are compared in the time and frequency domains at a number of stations in the Mediterranean Sea. A good agreement is found between the decadal, the interannual and the seasonal components of the variability and three regions with different characteristics are identified in the Mediterranean. Linear trend of the sea level height differences of monthly and instantaneous sea level heights are interpreted as potential vertical land movements.

Keywords: sea level change, tide gauge, altimetry

Introduction

Global coverage and sea level measurements in a given reference frame are characteristics that distinguish altimetry from tide gauge measurements. For altimetry the sampling is denser in space but less dense in time at a given location and the available data span is shorter than for tide gauges. Topex-Poseidon (T/P) data are available since September 1992 with a 10-day time sampling rate, and 300 km spacing at the equator. Long-term sea level changes have been mainly investigated using T/P data [1] and ERS data [2]. The multi-mission altimetry requires a careful cross-calibration of the missions and homogenization of the corrections [3]. At present T/P provides the longest and uninterrupted dataset. Interannual to decadal sea level variations are estimated in the Mediterranean Sea over the interval from September 1992 to July 2002 from T/P altimetry data and from tide gauge monthly averaged data. At a few locations where hourly data are available, sea level heights at the times of the closest approach with the tide gauge sites are also compared and a linear trend in the differences is estimated.

Annual to decadal variations

The sea level anomalies are averaged in monthly grids with spacing of 1 x 1 degree using a Gaussian weighted average method with the half-weight parameter equal to 1 and the earth radius equal to 3 degrees. The inverse barometric correction is not applied to the altimetry data, while ocean, load and earth tide are applied. For each time-series in the grid nodes, the linear-term (decadal variability), the average variability over each month (seasonal variability) and the interannual components of the variability contained in the power-spectrum of the residuals are estimated. The decadal term is small in the western Mediterranean (a few mm/yr) and higher with positive values in the eastern Mediterranean (up to 8 mm/yr) and with negative values in the Ionian Sea (up to –12 mm/yr). The decadal component of sea level variability has a high correlation with decadal components of sea surface temperature and steric height change. The dominant frequency of the interannual part of the variability is different in the eastern and in the western Mediterranean. The comparison between the altimetry and the tide gauge results shows a good agreement between the decadal component of the sea level variability, while the cross-spectrum of the interannual variability shows a better agreement in the eastern than in the western Mediterranean.

Linear variability of altimetry *versus* tide gauge data

By differencing records from altimetry and tide gauge data, most of the coherent sea level variability is removed and the residual time series represents the Vertical Land Motion (VLM) at the tide gauge site together with any instrumental errors, such as datum shifts and data spikes in the tide gauge data and bias and drift in the altimeter data. By differencing records from adjacent stations, the differential VLM of the stations and the differential sea level variability is obtained. Differences between tide gauge sea level heights and altimetry derived sea level heights are computed separately using monthly averaged values and interpolated hourly averaged tide gauge data versus instantaneous altimeter sea level data at the time of the closest altimeter approach. In this last case, the ocean tide correction was not applied to the altimetry data, therefore the differential sea level variability due to currents and tides remains in the difference. The results are represented in Figure 1 for the stations of Toulon (SIMN) in the western Mediterranean and of Hadera (MedGLOSS) in the eastern Mediterranean. The linear-term of the sea level height differences is here of main interest. The small standard deviation of the differences and the high correlation coefficient show a good agreement of the data. The sea level height differences are used to assess the data quality and to estimate relative biases and drifts between the altimeter instruments as well as vertical land movements. A bias estimation of each altimeter mission relative to the geocenter requires collocated GPS measurements at the tide gauge station.

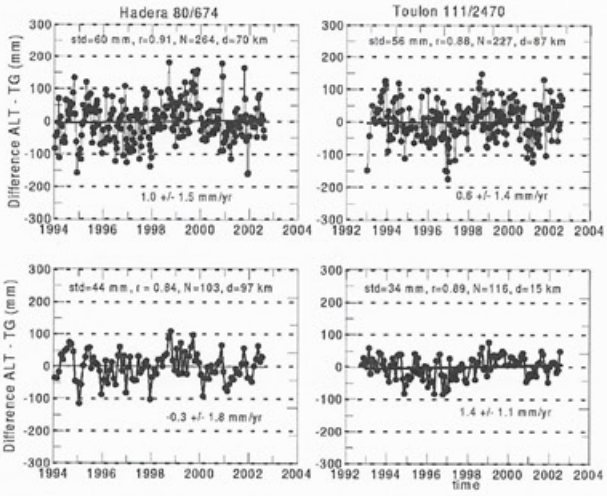


Fig. 1. Sea level height differences of hourly (above) and monthly (below) sea level heights at the tide gauge stations of Hadera and Toulon.

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References

1 - Nerem S., Mitchum G., 2001. Sea level change, in Satellite Altimetry and Earth Sciences, International Geophysics Series, Vol. 69, Academic Press, San Diego, pp. 329-349.

2 - Fenoglio-Marc L. 2002. Long-term sea level change in the Mediterranean Sea from multi-satellite altimetry and tide gauges, Physics and Chemistry of the Earth, pp. 1419-1431.

3 - Fenoglio-Marc L., Groten E. 2003. Cross calibration of the Envisat range using multi-mission altimetry and tide gauges in the Mediterranean Sea, in Proceedings of the Envisat calibration, ESA.

SURFACE SALINITY MEASURED BY AN AIRBORNE MICROWAVE RADIOMETER IN THE NW MEDITERRANEAN

C. Gabarró [1] *, J. Font [1], J. Miller [1, 2]

[1] Institut de Ciències del Mar. CSIC. Passeig Marítim 37-49, 08003 Barcelona, Spain - * cgabarro@icm.csic.es, jfont@icm.csic.es
[2] U.S. Office of Naval Research, London, UK. jmiller@onrifo.navy.mil

Abstract

SMOS (Soil Moisture and Ocean Salinity) is a satellite mission of the European Space Agency (ESA) to be launched in 2007. One of its goals is the generation of global Sea Surface Salinity (SSS) maps. SMOS will carry an L-band (1.4 GHz) interferometric radiometer with full polarimetric capability. The airborne EuroSTARRS campaign was sponsored by ESA in 2001 to provide land and ocean data for the scientific studies supporting the SMOS mission, in particular to acquire 'SMOS like' data to advance in the knowledge of passive microwave multi-incidence observations for various surfaces. Some results of the campaign in the NW Mediterranean are presented and discussed here.

Keywords: Microwave radiometry, SMOS, Surface salinity

The EuroSTARRS campaign took place in November 2001 over land and ocean sites in France and Spain (1). The STARRS (Salinity Temperature and Roughness Remote Sensing) instrument (2) from the US Naval Research Laboratory was flown onboard a DLR (Germany) plane. It is a pushbroom L-band (1400-1426 MHz) V-polarisation radiometer that measures simultaneously brightness temperature (Tb) in six crosstrack beams at different angles and builds a 2-D image as the aircraft moves along track.

On November 21st the plane overflown the Casablanca oil platform, near the shelf break 40 km off the Ebro river delta, in the NW Mediterranean. Simultaneously the R.V. García del Cid was measuring surface salinity and temperature following the flight line, plus some vertical T and S profiles in the area (3). At the same time another ESA campaign (WISE 2001) was taking place from that platform, with a fully polarimetric L-band radiometer measuring Tb at different incidence angles during one month, and several meteorological and oceanographic moored buoys recording surface data around the platform (4).

The objective of this work is to demonstrate that it is possible to retrieve salinity from the radiometer measurements in the Mediterranean, and to validate empirical and theoretical sea surface emissivity models needed for the inversion of Tb into salinity. In the past years, improved methods have been developed to model the polarimetric emission of the sea surface for different SSS, SST and surface roughness. However, these models have been developed or tuned at higher frequencies than L-band, typically 19 and 37 GHz. Using data acquired during WISE a new semi-empirical model was derived by fitting the sensitivity of Tb to wind speed at different angles. In (5) some of these models are presented and used to retrieve SSS from data acquired during WISE.

The algorithm used to obtain salinity from Tb is the Levenberg-Marquardt recurrent least square fit. It has been chosen for its easy implementation and computational efficiency. Tb is computed setting an initial guess for SSS into the direct emissivity model, and the resulting value is compared with the Tb measured by the radiometer. Then an increment (DSSS) is added to the initial salinity, the new Tb is computed and compared again to measurement. This recursive process is stopped when the difference between measured and computed Tb is smaller than a specified threshold.

In situ SSS measured during EuroSTARRS was quite constant, its variability being below the sensitivity of the radiometer. The wind speed was very low during the flight and an average value of 3.67 m/s has been used in the computation. SST was measured by additional infrared channels in STARRS. As the radiometric data were significantly noisy, an average of the 800 Tb measurements recorded during a straight flight in very similar atmospheric conditions have been used in the retrieval.

Six different emissivity models have been tested, and retrieval results compared with Casablanca in situ measurements. Semi-empirical models provide better results than theoretical models, and the best performances are obtained when using models derived from WISE data. It has to be stressed that the latter correspond to similar environmental and hydrographic conditions than during EuroSTARRS, but were acquired by a radiometer of different technology and situated much closer to the sea surface (4).

Table 1 presents the errors on the retrieved salinity using 3 different semi-empirical models, all of them derived from WISE campaign data: the first one is dependent on wind speed (WS), the second dependent on significant wave height (SWH), and the third dependent on both parameters. Results show that the best option is the joint dependence on WS and SWH, since this model, in opposition to the others, includes the effect on surface roughness of swell and not fully developed wind seas.

Table 1. Comparison of different semi-empirical models. ΔSSS = |SSS_measured - SSS_retrieved|

MODEL	ΔSSS
Wind speed dependence	0.086 psu
Wave height dependence	0.346 psu
Wind and wave height dependence	0.022 psu

An open question for the SMOS mission, is how these auxiliary parameters (WS and SWH), necessary for the SSS retrieval, will be obtained all over the world oceans. Table 2 shows the errors on the retrieved salinity in the EuroSTARRS case produced by errors on the wind speed measurements using the semi-empirical model dependent only on WS. Additionally to *in situ* data two different sources for wind speed information have been analysed: QuikSCAT satellite scatterometer and ARPEGE (MétéoFrance) atmospheric model. Both have similar spatial resolutions, but the temporal resolution is much higher for the model (6h) than for the satellite (3 days).

Table 2. Errors in retrieved salinity when using different sources for wind speed.

WS SOURCE	ΔSSS
Wind speed in situ measurement	0.086 psu
Wind speed QuikSCAT	0.655 psu
Wind speed from ARPEGE model	0.332 psu

It appears that small errors on WS (nominal error for the model is 2m/s) produce large errors on the retrieved salinity. The better results with ARPEGE output than with QuikSCAT measurements is probably related to the different temporal resolution.

References

1 - Berger M., Camps A., Font J., Kerr Y., Miller J.L., Johannessen J., Boutin J., Drinkwater M.R., Skou N., Floury N., Rast M., Rebhan H., Attema E., 2002. Measuring ocean salinity with ESA's SMOS mission – Advancing the science. *ESA Bull-Eur Space*, 111: 113-121

2 - Miller J.L., and Goodberlet M., 2003. Development and application of STARRS – a next generation airborne salinity imager. *Intl. J. Remote Sensing*, accepted.

3 - Emelianov M., Font J., Julià A., Gabarró C., LLoret M. and Solé J., 2003. Sea surface fiels at Casablanca site (NW Mediterranean) during the EuroSTARRS campaign. Proceedings of the WISE/LOSAC/EuroSTARRS Campaigns Workshop, ESA SP-525: 73-80

4 - Camps A. , Font J., Vall-llossera M., Gabarró C., Villarino R., Enrique L., Miranda J., Corbella I., Duffo N., Torres F., Blanch S., Arenas J., Julià A., Etcheto J., Caselles V., Weill A., Boutin J., Contardo S., Niclòs R., Rivas R., Reising S.C., Wursteisen P., Berger M. and Martín-Neira M., 2003. The WISE 2000 and 2001 campaigns in support of the SMOS mission: Sea surface L-band brightness temperature observations and their application to multi-angular salinity retrieval. *IEEE Trans. Geosci. Remote Sensing*, in press

5 - Gabarró C., Vall-llossera M., Font, J. and Camps, A., 2003. Determination of sea surface salinity and wind speed by L-band microwave radiometry from a fixed platform. *Intl. J. Remote Sensing*, 24, in press.

IMPROVING THE PREDICTION OF AN OCEAN MODEL USING NOVEL REMOTE SENSING DATA

Charles Galdies
International Ocean Institute, University of Malta, Msida, Malta

Abstract
Novel satellite SST is assimilated into a high-resolution primitive-equation ocean model to improve the simulation of surface ocean processes linked to the air-sea interactions at sub-mesoscale level. A high-resolution ocean model over the Ionian basin is used to provide short-range forecasts of the ocean state. The model is initialised using high-resolution air-sea fluxes generated by a high-resolution atmospheric model. An assimilation scheme using SST derived from the Tropical Microwave Imager is optimised to improve the ocean forecasting skill. Validation is performed over a 15-day model integration window.

Keywords : Tropical Microwave Imager, Newtonian nudging, Sea surface temperature, Princeton Ocean Model

Introduction

Free surface, sigma coordinate ocean models are being used for a variety of applications, ranging from small-scale process studies and coastal and estuarine modelling and prediction to basin-scale ocean circulation and climate change modelling. It is important to evaluate the sensitivity of the model and enhance its predictive capability as to help users choose the best parameters for their particular applications. This study uses independent information collected from satellite platforms to improve and spatially verify the forecasting accuracy of small-scale predicted oceanic fields.

Method

The ocean model is the Princeton Ocean Model (POM) with a domain starting from 15.8°E and 33.24°N with 82 grid points in the east-west direction, and 61 grid points in the north-south direction. The grid spacing in degrees is 0.042° with 24 sigma levels. The model bathymetry used is the US Navy Digital Bathymetric Base. The lateral boundary conditions were from MODB MED4. Sets of daily, 3-hourly surface fields were generated from a high-resolution atmospheric model working over the same domain and horizontal resolution and used to force the ocean model at the surface. SST was derived from the Tropical Microwave Imager at a nominal resolution of 0.25° and re-interpolated over the model's domain grid.

A hind-cast forecasting sequence was started with zero velocity on 1st July 1999 and continued in forecasting mode for an additional 20 days. No forcing of the surface boundary conditions was performed. The 3-D oceanic fields were dynamically adjusted to a constant SST field derived by the TMI on the 22nd of July 1999 at approximately 00UT. The actual model forecasts started on July 22nd at 1200 hrs with daily atmospheric forcing and consecutively every integration day until the 5th of August. The model was initialised using remotely-sensed SST. This information was propagated down to the vertical model prognostic fields. Two data assimilation (DA) experiments were performed to assess the effectiveness on the accuracy of the forecasted SST:

1. varying the nudging period during which the model fields are dynamically nudged towards the SST observations. Three scales were tested: 06, 12 and 24 hours.

2. including a second forcing, nudging coefficient, to nudge the model fields towards the SST observations. Four coefficients were tested $5x10^{-3}$, $5x10^{-4}$, $5x10^{-5}$ and $5x10^{-6}$ for each of three nudging periods.

Results and discussion

The first data assimilation scheme leads to the most accurate predictions of the SST. The best nudging period is 24 hours, giving a mean bias over the entire 15-day model integration of only –0.05°C against remotely sensed data. It is interesting to note that Horton *et. al.*, applied a similar DA scheme for their ocean forecasting system that assimilated AVHRR MCSST [1]. The new SST values were assimilated by the model using a nudging period of only 4 hrs.

The inclusion of an additional coefficient in the equation leads to strong nudging towards the initial observations. The optimal nudging coefficient is found to be $5x10^{-4}$ for 06 hours, giving a mean bias of –0.08°C.

Despite the small period of evaluation, some general remarks can be made. What is evident from this study is that an active data assimilation scheme tends to dampen the fluctuating bias tendency. The temporal fluctuation in the bias trend is caused by the model's attempt to equilibrate the model dynamics towards the prognostic SST values. However, its resilience or degree of damping is seen to be dependent on the two factors that regulate the extent of this fluctuation: the relaxation time $\frac{\partial q^{mod\ el}}{\partial t}$ and nudging coefficient K^q.

This treatment leads the model to show a better performance than other ocean forecasting systems used in the region. Nittis *et. al.*, for example, obtained a bias of 0.1 to 0.8°C when their 24-hour POM-forecasted SST was compared to collocated *in situ* buoy measurements [2].

High-resolution sea surface thermal signature observed by AVHRR confirmed the ability of the improved ocean model to predict sub-basin surface circulation. The small-scale SST pattern is shown to be set by a balance of atmospheric (provided by the high resolution, atmospheric model) and oceanic processes (provided by the high resolution POM), including wind-driven mixing, atmospheric heating and cooling, and horizontal and vertical advection in the ocean. Predicted ocean fronts are found to be collocated with atmospheric convergences as predicted by the atmospheric momentum stress over the geographical area. The AVHRR sensor reveals filaments and jets near these fronts.

The use of one-way atmosphere-ocean coupling offers distinct advantages over current basin-wide forecasting systems. Recent studies in the Mediterranean utilise bulk formulae to compute the surface boundary conditions of the ocean models [3]. Atmospheric variables, such as wind field, air temperature and relative humidity are derived from coarse, monthly averages of 12-hour NCEP analyses for the period 1980-1988.

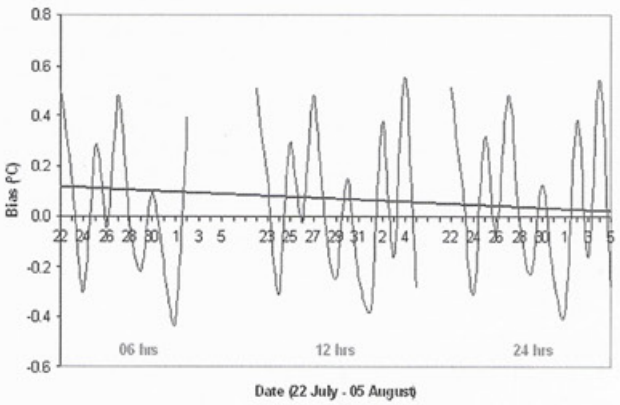


Fig. 1. Bias trends of 24-hr predicted SST using a varying nudging period (lower text in graph).

References

1 - Horton, C., M. Clifford, J. Schmitz, and L. Kantha, 1997. A real-time oceanographic nowcast/forecast system for the Mediterranean Sea. *J. Geophys. Res.*, 102, 25: 123-25,156.

2 - Nittis K., Zervakis V., Perivoliotis L., Papadopoulos A. and Chronis G., 2001. Operational Monitoring and Forecasting in the Agean Sea: System Limitations and Forecasting Skill Evaluation. *Marine Pollution Bulletin*, Vol. 43, Nos 7-12: 154-163.

3 - Lascaratos, A. and K. Nittis, 1998. A high-resolution three-dimensional numerical study of intermediate water formation in the Levantine Sea. *J. Geophys. Res.*, 103 (C9): 18497-18511.

CANONICAL CORRELATION ANALYSIS TO EXTRACT EXTERNAL INFLUENCES IN SEA LEVEL AROUND SPAIN

J. García Lafuente [1], J. Del Río [1] *, Enrique Alvarez [2], Begoña Perez [2], J.M. Vargas [1], F. Criado [1]

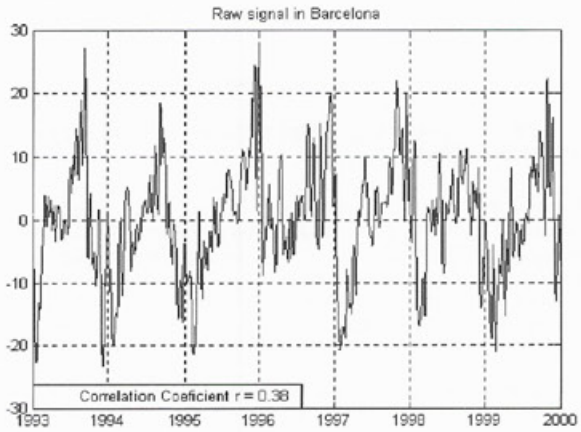
[1] Departamento de FISICA APLICADA II, Universidad de Málaga.
[2] Área del MEDIO FÍSICO, Puertos del Estado, Spain.

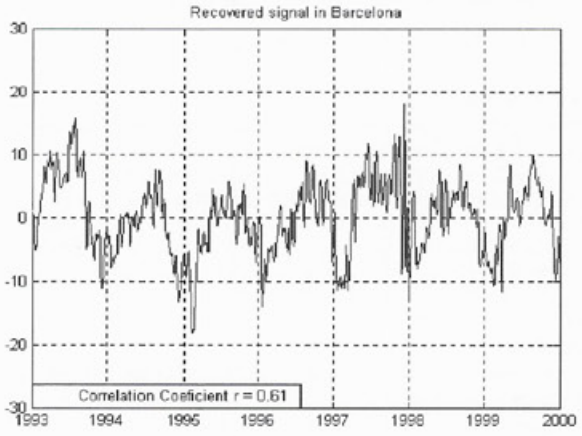
Keywords: CCA, Sea Level, Temperature, Pressure.

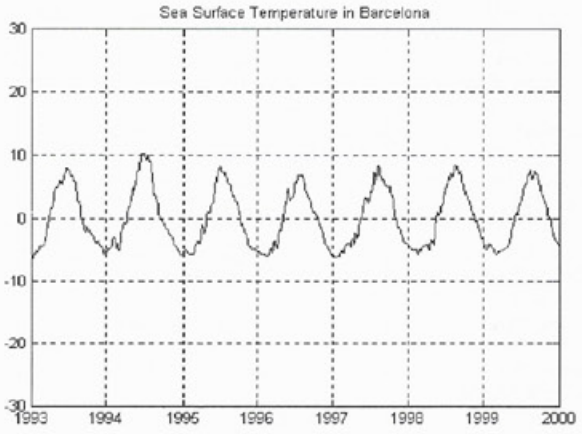
Canonical Correlation Analysis (CCA) is a mathematic technique [1,2] that uses two datasets, each one consisting of a given number of time series, in order to look for the canonical functions (or canonical series) that optimize the relationship between a linear combination of variables from the first data set and a linear combination of variables from the second data set. The technique provides ensembles of canonical series, each one accounting for decreasing amount of co-variation between both data sets, in a manner that recalls the decomposition done by Principal Component Analysis (PCA). In other words, the first canonical function will describe what both datasets are sharing most, then the next one will be computed over the residual variance, and so on.

This work uses CCA to extract the variability of sea level in locations around Spain collected by Puertos del Estado, Spain (http://www.puertos.es) induced by external forcing such as atmospheric pressure and sea surface temperature (SST). Atmospheric data have been collected from National Centers for Enviromental prediction (http://wwwt.ncep.noaa.gov/) and SST have been downloaded from Deutsches Zentrum für Luft un Raumfarht (http://www.dlr.de/). The number of canonical series used to reconstruct the signal in each location may be computed through the correlation coefficient between the canonical series of both data sets. If this value is higher than 0.5 we consider that the canonical series contains enough information to be considered as significant. The canonical functions may be used to reconstruct the original signals. If all canonical functions are used, then the original series is recovered (all contributions to the signal are present) but if only a selected and suitable set of canonical functions are chosen (the most significant ones) then the recovered signals mostly contain the effects of the external forcing (parameter) we are considering (pressure or SST for instance) and influences due to other physical variables are rejected.

The recovered signal is better related to the parameter (pressure, SST) than the original series, as a measure of that relationship we use the correlation coefficient. An example of the performance of this technique is shown in the figures, where sea level signal in Barcelona, Sea level recovered in the same location using two canonical functions (the ones that mostly take into account the thermosteric effect) and their respective correlation coefficient with SST are presented, Sea Surface Temperature nearby Barcelona is also shown. Note that correlation coefficient in Barcelona (see figures) between raw sea level signal and SST is 0.38 and the correlation between the recovered signal and SST is 0.61.







References

1 - Barnett T.P., Preisendorfer R., 1987. Origins and levels of monthly and seasonal forecast skill for United States Surface air temperatures determined by canonical correlation analysis. *Monthly Weather Review*, 115: 1825-1850.

2 - Kirby, M. and Anderson, C.W., 2003. Geometric Analysis for the Characterization of Nonstationary Time-Series. *In:* Springer Applied Mathematical Sciences Series Celebratory Volume for the Occasion of the 70th Birthday of Larry Sirovich, ed. by Kaplan, E., Marsden, J., and Sreenivasan, K.R., Springer-Verlag, Chapter 8, pp. 263-292.

THE PROPAGATION OF THE EASTERN MEDITERRANEAN TRANSIENT FROM THE EASTERN TO THE WESTERN MEDITERRANEAN BASIN

G.P. Gasparini [1] *, A. Ortona [2], G. Budillon [2], M. Astraldi [1] and E. Sansone [2]

[1] CNR – ISMAR, Sezione della Spezia, Forte Santa Teresa, 19036 Pozzuolo di Lerici, Italia - * gasparini@sp.ismar.cnr.it
[2] Istituto di Meteorologia e Oceanografia, Università di Napoli "Parthenope", via De Gasperi 5, 80133 Napoli, Italia

Abstract

Recent studies have evidenced the highly sensitivity of the Mediterranean to the effects produced by the large-scale atmospheric systems. During the 1985-2003 period the hydrographic monitoring in the Strait of Sicily and Tyrrhenian sea evidenced significant changes of the hydrographic characteristics, related to the Eastern Mediterranean Transient. It was possible to follow the evolution of the water mass characteristics under the influence of the climatic transient occurred in the eastern Mediterranean before its beginning to the present phase of relaxation. The impact on the Tyrrhenian Sea has been evidenced, while possible effects on the western Mediterranean basin have been discussed.

Keywords: Eastern Mediterranean Transient; Strait of Sicily; hydrographic characteristics.

A hydrographic data set covering both the Strait of Sicily and the Tyrrhenian Sea and ranging from the second half of 80's until 2003 was able to describe the Eastern Mediterranean Transient (EMT) influence on the Strait and also to evidence changes induced in the Tyrrhenian water column. At their beginning the available data showed the hydrographic characteristics before the EMT influence. It was only after 1988 that a clear change was observed in the central region of the Strait: the LIW salinity increased progressively until 1992, followed by a sudden drop which lasted until 1997. During that period the EMT had the maximum influence on the Strait. Successively, the restoring phase begun, and continued during the following years. The available observations permitted also to establish that the EMT reached the Tyrrhenian entrance between April and May 1992 by an impulsive huge amount of salt and cold water mass. A significant agreement with the different phases observed in the EMT and with changes observed in Eastern Basin is found (1). More specifically, results confirm that the EMT begun well before the winter 1991-92 and that 1989 appears to be a more suitable period.

Comparing the Strait evolution with the evolution observed in the Levantine basin we can infer a very fast propagation of the EMT from the region of origin. The hydrographic situation in the Eastern Basin during October 1991 (2) can supply backing on this aspect. The distribution of salinity gives evidence that a significant volume of saltier water of Aegean origin is now present over most of the sea and explain the progressive salinity increase in the strait (Fig. 1). Conversely what seems to be related to the severe winters 1991-92 and 1992-93 (3) is the sudden inversion both in temperature and salinity, which can be associated to the sinking phase of the EMT. Due to its abnormally density increase, the new Sicily outflow sunk at very high depth, probably reaching the deepest layers of the Tyrrhenian basin. The consequence was that a remarkable amount of heat and salt spread along the deep water column. This behaviour suggests that the deep trends (θ and S) found in the southern Tyrrhenian (4; 5), can be explained in terms of EMT. The salinity increase in a layer comprehensive of intermediate and deep water (approximately from 250m to the bottom) suggests a greater salt export through the Strait during the EMT period, which is equivalent to net evaporation of 0.04 m/yr in the eastern basin.

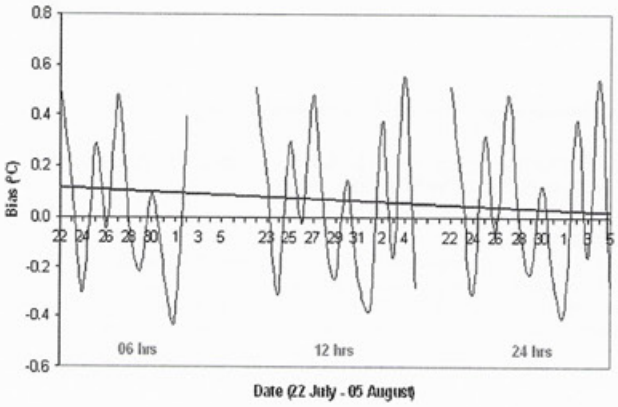


Fig. 1: Time evolution of S_{max} characteristics in the central part of the Strait of Sicily. (a) Potential temperature of S_{max}; (b) S_{max}; (c) Potential density of S_{max}.

Consequences related to the EMT can also be observed in the surface layer evolution. The salt conservation observed in the Strait evidenced that a salt decrease in the Atlantic Water (AW) corresponds to the LIW salt increase. As consequence, during the higher EMT phase, the eastern basin was reached by surface fresher water, hindering the production of new deep water. The AW behaviour suggests that the EMT, especially during its major activity, induced an enhancement of the Atlantic water through the Gibraltar Strait.

References

1 - Lascaratos A., W. Roether, K. Nittis and B. Klein, 1999. Recent changes in deep water formation and spreading in the eastern Mediterranean Sea: a review. *Progr. Oceanogr.*, 44: 5-36.

2 - Malanotte-Rizzoli, P., Manca, B.B., Ribera d'Alcalà, M., Theocharis, A., Brenner, S., Budillon, G, Ozsoy, E., 1999. The Eastern Mediterranean in the 80s and in the 90s: the big transition in the intermediate and deep circulations. *Dyn. Atm. Oceans*, 29: 365-395.

3 - Josey S.A., 2003. Changes in the heat and freshwater forcing of the eastern Mediterranean and their influence on deep water formation. *J. Geophys. Res.*, 108, C7: 3237.

4 - Astraldi M, G.P. Gasparini, A. Vetrano and S. Vignudelli, 2002. Hydrographic characteristics and interannual variability of water masses in the central Mediterranean: a sensitivity test for long-term changes in the Mediterranean Sea. *Deep-Sea Res.* I, 49: 661-680.

5 - Fuda J.L., Etiope G., Millot C., Favali P., Calcara M., Smriglio G. and Boschi E., 2001. Warming, salting and origin of the Tyrrhenian Deep Water. *Geophys. Res. Let.*, 29, 1886-1889.

6 - Klein, B., Roether, W., Manca, B., Bregant, D., Beitzel, V., Kovacevic, V., Luchetta, A., 1999. The large deep water transient in the Eastern Mediterranean. *Deep-Sea Res.*, I46: 371-414.

SHELF/SLOPE EXCHANGES AND SUBMARINE CANYONS: LABORATORY MODELLING

B. Gomez [1], S. Kremenetskiy [2], J. Martín [1], O. Stroganov [2], E. García-Ladona [1 *], A. Zatsepin [2], A. Palanques [1], M. Emelianov [1], P. Puig [1], J. Guillen and J. L. Pelegrí [1]

[1] Institut de Ciències del Mar, (CMIMA-CSIC), Barcelona, Spain - * emilio@icm.cs
[2] Shirshov Institute of Okeanolokyia, RAS, Moscou, Russia

Abstract

Preliminary laboratory experiments on the interaction of a coastal current and a submarine canyon using a rotating platform are presented. The influence of canyon on the behaviour of frontal current and the associated exchange processes between the shallow and deep parts of the basin are analyzed under quasi barotropic conditions. A strong influence of the canyon on the dynamics of the frontal current is clearly observed, mainly due to a downslope flow through the near bottom viscous layer. Comparison with recent field observations are presented.

Keywords: Submarine canyons, shelf/slope exchanges, laboratory experiments.

The continental slope is characterized by a very specific dynamics of the water flows and could be considered as a frontal zone of potential vorticity due to the rapid change of the depth with off-shore distance. The variability and structure of the circulation within the canyons themselves depend on various forcing factors bringing alterations in planktonic communities and in matter transfers between the shelf open ocean zones.

An experimental device to analyze the interaction of a coastal current with a submarine canyon incinsing the bottom slope has been designed [1]. The device was composed of tank of water over a rotating platform containning a cone to simulate the sloping bottom and including a canyon. A coastal current was obtained releasing lighter colored fluid trhough a source in the cone vertex axisymmetrically positioned. Two sets of experimental runs with similars basic parameters but with and without the presence of a submarine canyo were provided. In both cases an axisymmetric anticyclonic frontal current was initially forme. After a while, its width increased and then a near bottom viscous layer downslope flow was formed at the front of the anticyclonic current while the position of the front remained stationary. When the canyon is present a considerable part of the downslope flow as well as the frontal current were trapped by the canyon at its downstream wall (Fig. 2 a,b). Both up and down canyon currents have been also observed and the downward flow at the downstream wall was responsible for the major fluid exchange from the quasi-axisymmetric frontal current (Fig. 2b). This fluid was transported much below of the outer edge of the frontal current until a depth level where it continued to flow along the slope downstrean the canyon.

An interesting consequence of the above results is the strong downslope flow near the bottom boundary layer inside the canyon and their implications on shelf/slope mass transfer. These results could explain the internal structure of particulate fluxes observed in a field experiment carried out in the Palamós canyon (Northwest Mediterranean), in which nera-bottom particulate were higher at the head of the canyon and in the downstream wall than in the upstream wall (Fig. 3).

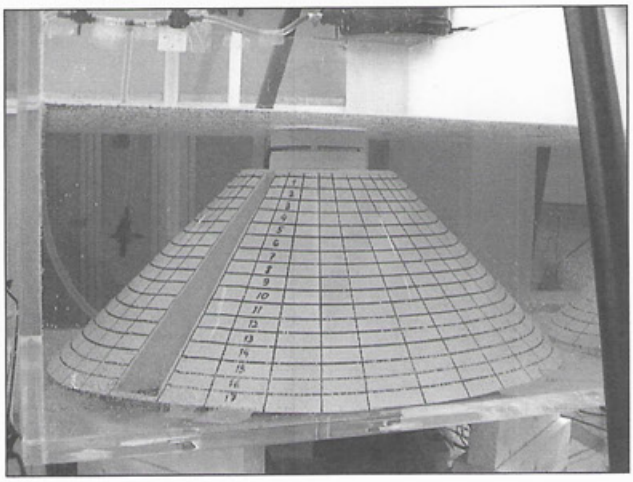


Fig. 1. Laboratory set up to study the interaction of a coastal current and a submarine canyon.

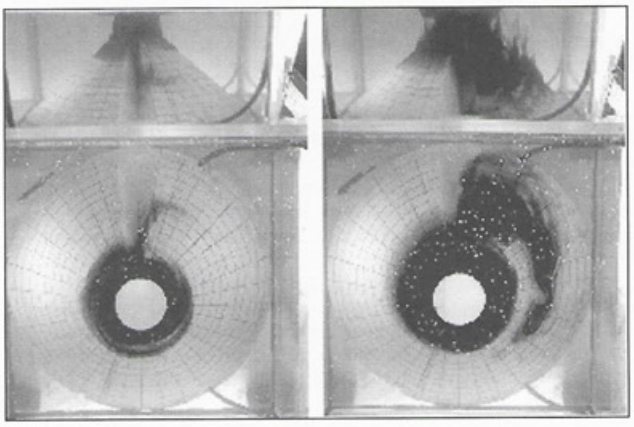


Fig. 2. Experiments for the quasi barotropic case including tha canyon at two different times.

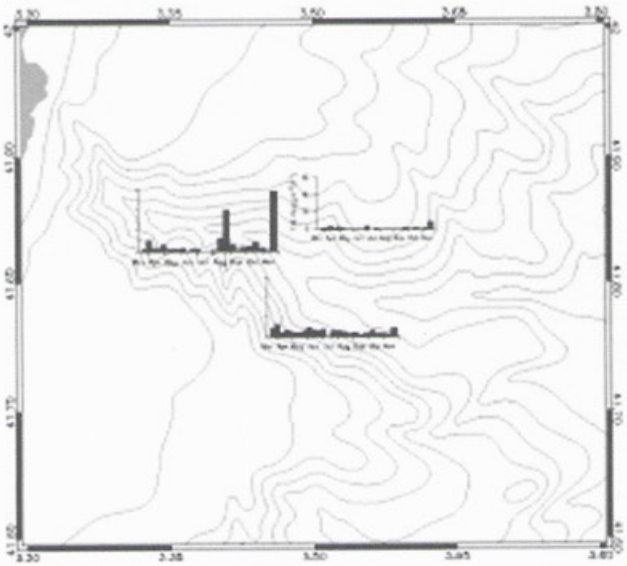


Fig. 3. Particulate fluxes near the bottom at three locations in the Palamós canyon during the field experiments.

References

1 - Didkovskii, V., A. Semenov, A. Zatsepin (2000). Mesoscale currents upon the smooth sloping bottom and in the presence of ridges and canyons. In: Oceanic Fronts and Related Phenomena Konstantin Fedorov International Memorial Symposium, IOC, Workshop Rep., 159: 89-94.

PROGRESSIVE WARMING OF THE WESTERN MEDITERRANEAN DEEP WATER AT THE BALEARIC AREA SINCE MID NINETIES.

González-Pola C. [1]*, López-Jurado J. [2], Vélez-Belchi P. [3]

[1] Instituto Español de Oceanografía, C.O. de Gijón, Avda. Príncipe de Asturias 70 bis, 33212 Gijón, Spain - * cesar.pola@gi.ieo.es
[2] Instituto Español de Oceanografía, C.O. de Baleares, Muelle de Poniente s/n, 07080 Palma de Mallorca, Spain - lopez.jurado@ba.ieo.es
[3] Instituto Español de Oceanografía, C.O. de Canarias, Crta. de San Andrés 45 s/n, Tenerife, Spain - pedro.velez@ca.ieo.es

Abstract

The interanual variability of the heat stored on intermediate and deep water at the Balearic Sea is analyzed from two deep hydrographic stations repeated frequently from year 1996. A statistically significant warming trend, equivalent to approximately 0.015 ºC per year, has been found below the 700 db in both stations. Thickness of DW (Deep Water) layer as classically defined at the area has been dramatically reduced whereas the LIW (Levantine Intermediate Waters) layer has increased.

Keywords: heat content, warming, Balearic Sea

The accumulation of evidences in favour of an anthropogenic induced climate change scenario have increased in the last decades the interest on the behaviour of long term properties of intermediate and deep water around the oceans of the world. All data available for the whole ocean shows a warming of 0.03 ºC for the 300 m depth upper layer during the previous century [1]. Some studies regarding the Mediterranean Sea have also found warming and salinity increase for deep and intermediate waters [2], [3].

In this paper we will explore the recent changes on heat content of the central and deep waters at the Balearic Sea from a series of hydrographic cruises repeated almost once a year in the period between 1996 and 2003. The base of this work is the data set from the "Canales" and "Cirbal" projects (Instituto Español de Oceanografía) [4]. Under those projects several transects were reoccupied in different seasons (Fig. 1). Deep hydrographic stations 25 and 33, located on the northern entrance of both the Ibiza and Majorca channels have been sampled more than 10 times for the whole water column, their respective depths are 1250 and 1360 m.

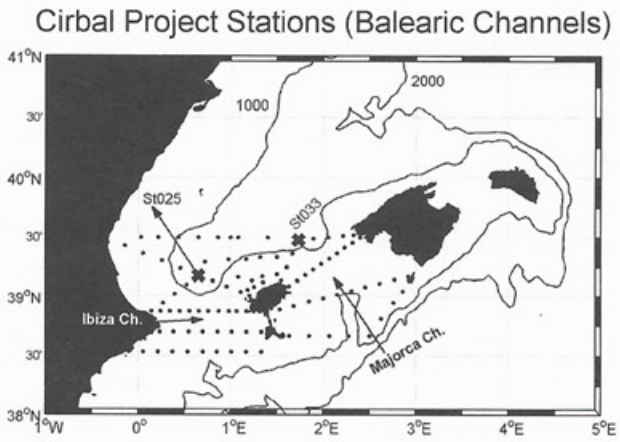


Fig. 1. Stations for the "Canales" and "Cirbales" Projects (1996-2003) at the Balearic Channels. The two chosen for this work are marked.

Water masses at the Mediterranean Sea are characterized by the no existence of permanent thermocline which maintains a stratified situation controlled by density. This particular feature makes impossible to use isopycnal levels to define water masses so $\Delta\theta/\Delta s$ bounded regions are used instead. Below the upper mixing layer at the studying area we find the seasonal Winter Intermediate Water (WIW, [12.5-13.0 37.9-38.3])[4], Levantine Intermediate Water (LIW, [13.0-13.5 38.4-38.55]) and Deep Water (DW, [12.70-12.90 38.4-38.50]). The mean depth of the core of LIW, from an averaged profile for the whole data set, is located around 500 db and the top level of DW waters as previously defined is around 1100 db.

A noticeable warming of the water column is observed from the data. Levantine Intermediate Water (LIW) shows yearly dependence on the climatic atmospheric forcing and higher values of temperature and salinity appeared on year 1998 coinciding within the warmest year ever recorded on the north Atlantic. Both DW and the transition branch from the LIW have experimented a progressive warming which resulted in a reduction of the thickness of DW, as previously defined, from more than 300 db (years 96 and 97) to around 100 db (year 2003). A linear fit of the evolution of heat content stored by 100 db thickness layers gives positive trend at 95% confidence intervals for all depths below 700 db (station 33 on Figure 2 and similar result for station 25). The mean value from 700 db to the bottom is 58 ± 25 kJ/m^{3}year heat increase (which would result on 0.014 ± 0.006 ºC/year if applied on standard (s=35,θ=10,p=0) seawater). Confidence intervals reduces with depth showing a lesser noisy warming signal (better linear fitting) as we approach to the bottom layer.

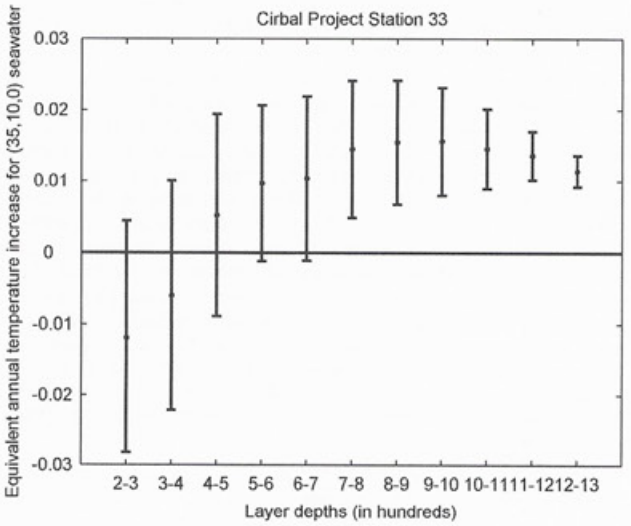


Fig. 2. Trend found for a linear fitting of the evolution of the heat stored between isobaric layers, showed as a temperature equivalent if applied on (s=35,θ=10,p=0) seawater, for the time series at station 33. Confidence interval 95%.

References

1 - Levitus S., Antonov J.I., Boyer T.P., and Stephens C., 2000. Warming of the world ocean. *Science*, 287: 2225-2229.

2 - Bethoux J.P., Gentili B., Raunet J. and Tailliez D., 1990. Warming trend in the western Mediterranean deep water. *Nature*, 347: 660-662.

3 - Rohling E.J. and Bryden H.L., 1992. Man-induced salinity and temperature increases in Western Mediterranean Deep Water. *Journal of Geophysical Research. C. Oceans*, 97: 11191-11198.

4 - Pinot J.M., Lopez-Jurado J.L. and Riera M., 2002. The CANALES experiment (1996-1998). Interannual, seasonal, and mesoscale variability of the circulation in the Balearic Channels. *Progress in Oceanography*, 55: 335-370.

HARBOUR WAVE CONDITIONS IN THE NW MEDITERRANEAN COAST. NESTING AND FORECASTING.

Daniel González Marco [1]*, Agustín Sánchez-Arcilla [1], Rodolfo Bolaños [1], Joan Pau Sierra [1], Sergi Paricio [2] and Eliseu Vilaclara [2].

[1] Laboratori d'Enginyeria Marítima, LIM-CIIRC DEHMA. ETSECCPB Universitat Politécnica de Catalunya. c/ Jordi Girona 1-3, Módul D-1, Campus Nord, C.P. 08034, Barcelona, Spain.
*daniel.gonzalez-marco@upc.es, agustin.arcilla@upc.es, rodolfo.bolanos@upc.es, joan.pau.sierra@upc.es
[2] Servei Meteorològic de Catalunya, c/ Berlín nº 38-46 C.P. 08029, Barcelona, Spain. sparicio@meteocat.com, evilaclara@meteocat.com

Abstract

This paper addresses the performance envelope of wave forecasting under fetch and duration limited conditions such as those found in the NW Mediterranean. The main aim is to develop an operational tool, which helps harbour and coastal authorities on taking decisions. The emphasis is thus on: 1) Accuracy, 2) Resolution, 3) Forecasting horizon, 4) Robustness of the obtained predictions. The sequence of nested wave models will be validated for this purpose with the meteorological and oceanographic data recorded by the XIOM network (Oceanographic and Meteorological Instruments Network) of the SMC (Catalan Meteorological Service).

Keywords: wave generation, wave propagation, nesting

Harbour and coastal issues in a coast such as the Spanish Mediterranean are extremely significant for the economic activities of the zone and for the safety of the numerous populations there concentrated. The forecasting of wave conditions is within this framework important for the management of harbour activities and also for the management of beach touristical activities (under operational conditions). Likewise the forecasting of wave conditions is essential for the design of harbour infrastructures and for the mitigation of erosion and flooding damages and even loss of life (survival or extreme conditions).

For this purpose a suite of nested models has been adapted to the fetch and duration limited conditions found in the NW Mediterranean. This sequence (schematised in Fig. 1) starts with the WAM model for wave generation (1). This third generation model feeds a phase averaged wave model (LIMWAVE, 2) which propagates the spectral density function from the closest WAM grid point to the harbour entrance area. This result is used to feed a third model (LIMPORT) which can be, depending on the objectives, either a Boussinesq based model (3) or an elliptic wave model (based on the Mild-Slope equation, 4). This nesting introduces a number of hard to quantify uncertainties through closure submodels (e.g. bottom friction, e.g. wind shear stress) and trough the "internal" boundary conditions. These uncertainties are then checked with the available Meteo and Oceanographic data recorded by the XIOM network (Oceanographic and Meteorological Instruments Network) managed by the SMC (Catalan Meteorological Service).

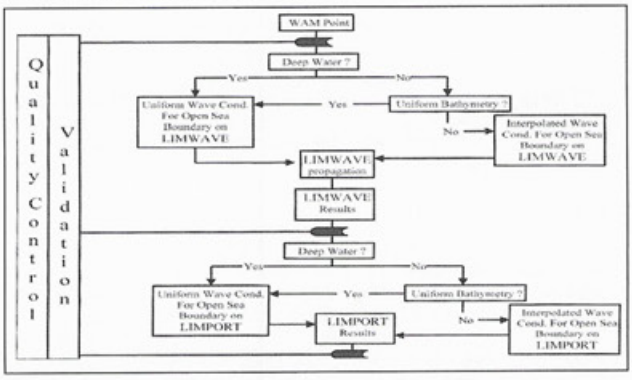


Fig. 1. Schematisation of model nesting for wave predictions near and inside harbour domains.

The combination of nested simulations and observations has allowed a robust prediction of wave conditions with a time horizon of up to 36 hours. The accuracy and resolution also allow a system of warnings for harbour and beach operation, which includes the following variables:

1. Wave agitation
2. Wave overtopping
3. Long waves
4. Wind strength

This allows a safer and better operation of harbour infrastructures and beach areas. As a sample of the obtained results, Figure 2 shows the wave agitation corresponding to the recent recorded storm during October 2003 for a Spanish Mediterranean Harbour. The sequence of models nested is been continuously validated and updated with the meteo-oceanographic database available.

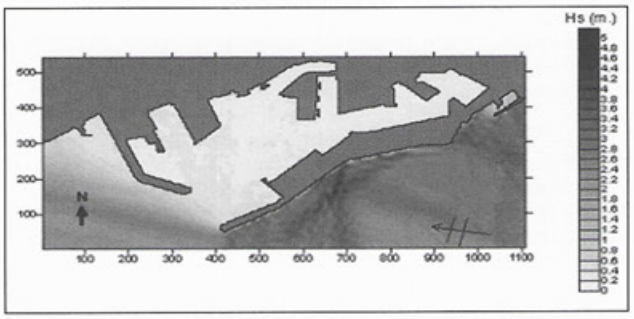


Fig. 2. Sample illustration of simulated wave conditions inside a Spanish Mediterranean harbour.

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References

1 - Wamdi Group, 1988. The WAM model – A tirad generation ocean waves prediction model. *J. Phys. Oceanogr.,* 18: 1775-1810.
2 - Cáceres, I., González Marco, D., Alsina, J.M., Sierra, J.P., Sánchez-Arcilla, A., 2002. Hydro-Morphodynamics for a LCS. A firs approach for a Mediterranean case. Delos 1st Year Meeting, Barcelona 01/2002.
3 - Sierra, J.P., Sánchez-Arcilla, A., Egozcue, J.J., Monsó, J.L., 1988. Effect of Boussinesq-type equations on wave spectra propagation. XXI Int. Conf. On Coastal Engineering, Torremolinos, pp. 350-362.
4 - Liu, P.L.-F., 1990. Wave transformation. Pp. 27-63.In: The sea, Wiley-Interscience Publication. v. 9.

UNUSUAL THERMOHALINE SEASONALITY IN THE MIDDLE ADRIATIC COASTAL WATERS (OCTOBER 2002-SEPTEMBER 2003)

Grbec Branka*, Dadić Vlado, Beg Paklar Gordana, Morović Mira and Matić Frano
Institute of Oceanography and Fisheries, Setaliste Ivana Mestrovića 63, 21000 Split, Croatia - * grbec@izor.hr

Abstract
Intensive experiment with weekly CTD measurements in the middle Adriatic coastal area was carried out from October 2002 until September 2003. The first outlook of temperature and salinity space and time variability, together with departures from typical climatology of the area is presented.

Keywords: thermohaline, coastal water, Adriatic Sea

Introduction

The middle Adriatic area has strong temporal variability of thermohaline structure caused mainly by air-sea interaction, river discharges, mixing and seasonally dependent circulation (1). In the middle Adriatic coastal zone fresh water provides a strong buoyancy source, while in the wider shelf-sea freshwater influence is dispersed. The ADRICOSM (2) research area is pointed as a region where fresh water input from the eastern Adriatic coast is observed, especially from the Cetina and Neretva rivers, whereas in the offshore waters, influence of the northern Adriatic rivers during the stratified period might be significant. Spring and summer 2003 were warmer and drier than usual, causing high temperatures and salinities with strong departures from the local climatology.

Research area

Intensive be-weekly and weekly CTD profiling was carried out in the period between October 2002 and September 2003 at 14 stations in the channel area of the eastern middle Adriatic (Fig. 1, stations denoted by circle). Collected data set had good space and time coverage for comparison with general thermohaline climatology of the region.

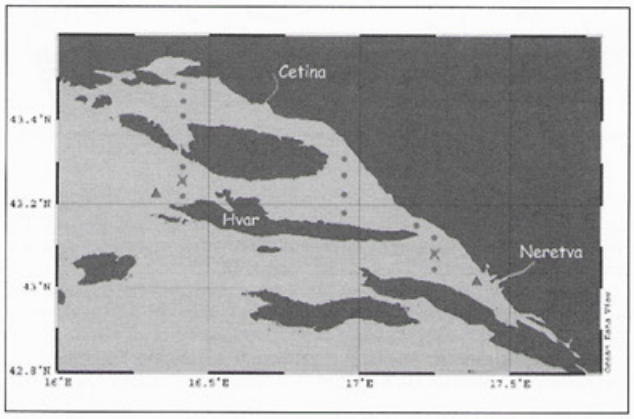


Fig. 1. Location of CTD stations in ADRICOSM research area (denoted by circles) and climatological stations (denoted by triangles).

Climatology of the research area was obtained from temperature and salinity data collected between January 1961 and December 2000 in the offshore area in front of the west coast of Hvar Island and in the vicinity of Neretva estuary (stations denoted by triangles). Uniform salinity annual course has been found at depths up to 18 m at the near-coastal stations. Spring salinity minimum coincide with Neretva discharge maximum, whereas the second minimum in November is caused by extensive precipitation. At the offshore stations, beside the spring minimum, an additional summer minimum is observed in the surface layer (Fig. 2), probably caused by the spreading of low-salinity water from the north.

Preliminary results

Project goals were to reveal the mechanisms responsible for typical thermohaline variability and to determine the contribution of horizontal and vertical processes to the total heat and salt exchange. Spring and summer 2003 were warmer and drier than usually with strong evaporation and minimum precipitation, which resulted in exceptionally high salinity values at almost all stations. Temporal salinity changes obtained during the experiment show strong departures from typical annual cycle in which salinity follows E-P variability. Throughout the whole experiment strong positive trend in the salinity was observed (Fig. 2). As a consequence of intensive heating, sea surface temperatures became greater than long-term means. High temperature gradient was observed between shallow surface layer and layer bellow thermocline, which disappeared after an episode of bura wind in the mid-September.

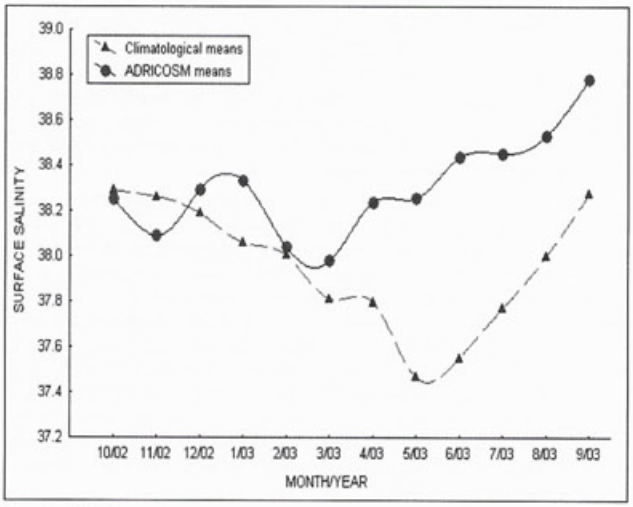


Fig. 2. Salinity monthly means for the station near the Hvar Island over the 1961-2000 period compared to the monthly mean salinities obtained in the Hvar channel during the ADRICOSM experiment from October 2002 to September 2003.

Acknowledgements. The contents of this article were developed under a financial support from the Istituto Nazionale di Geofisica e Vulcanologia, Italy, and funded under Italian Ministry for the Environment contract ADRICOSM

References

1 - Zore-Armanda, M., Grbec, B. and Morović, M., 1999. Oceanographic properties of the Adriatic Sea - a point of view. *Acta Adriat.*, 40: 39-54.
2 - ADRICOSM. The first year scientific report (unpublished paper). INGV, Bologna.

THE SURFACE CIRCULATION IN THE EASTERN BASIN OF THE MEDITERRANEAN SEA

N. Hamad, C. Millot * and I. Taupier-Letage

Antenne LOB-COM-CNRS, BP 330, F-83507 La Seyne-sur-Mer, France - * cmillot@ifremer.fr

Abstract

The Atlantic Water (AW) circulation schemata widely referred to nowadays (1, 2, 3) represent a cross-basin meandering jet, thus disagreeing with a pioneering work (4) and a former analysis of IR images (5, 6). A roughly similar controversy was elucidated in the western basin where this imagery was proven reliable. This has motivated the visual analysis of daily/weekly (~1000, 1996-2000) and monthly (since 1985) composites. In our schema, the mean flow is anticlockwise along the upper part of the continental slope and it generates mesoscale eddies that tend to follow the deeper isobaths. Other eddies are induced by the Etesians every year. All eddies can have several-year lifetimes, propagate and merge.

Key-words: Mediterranean Sea, eastern basin, IR imagery, surface circulation, mesoscale eddies

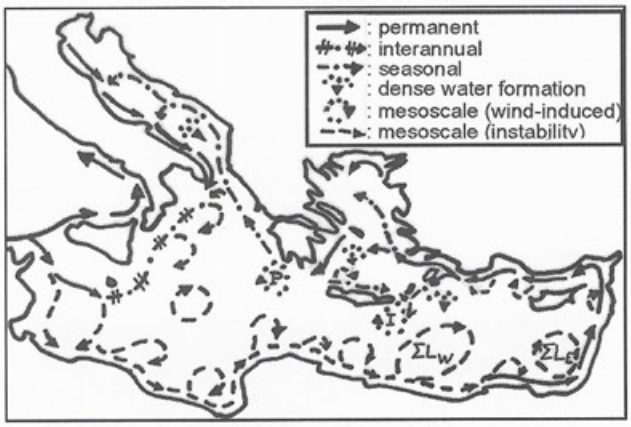
Overall, the AW circulation (100-200 m thick) is alongslope and anticlockwise. It is permanent from Tunisia to Turkey and seasonally variable in the Aegean, the Ionian around Greece and the Adriatic. A branch, having spread for years (up to early 1998) from the Sicily channel towards the northern Ionian before vanishing, represents interannual (not seasonal) variability. Mesoscale eddies, generated by the instability of the AW flow or by orographic effects on the Etesians, were not correctly described before. Although they have characteristics almost specific to each subbasin and/or to their generation mechanism, the largest are anticyclonic, reach diameters of a few 100s km and can be tracked for months/years propagating at up to a few km/d . They represent a relatively large amount of AW and play a fundamental role in spreading it seaward.

In the southern Ionian, large eddies generated by the AW flow as soon as the depth exceeds a few 100s m seemingly drift along intermediate to deeper isobaths, probably depending on their vertical extent. An eddy, initially found east of Sicily, drifted southwards as far as Libya where it disturbed the AW alongslope flow more than two years later. All eddies originated either in the north (including Pelops) or in the south can drift in the central Ionian and create there a complex eddy-field that, being only partially investigated, was incorrectly associated with the alleged "Atlantic Ionian Stream" and "Mid-Ionian Jet". On average, AW does not cross the Ionian in its central and/or northern parts but ultimately concentrates in the south as an alongslope anticlockwise flow that is unstable and generates anticyclonic (Libyan) eddies.

These eddies then propagate downstream along the eastern Libyan slope and eventually interact with Ierapetra, thus increasing the interannual variability of the latter. In addition, Ierapetra can remain stationary more than one year and thus be intensified the year after, it can drift over 100s km, merge with a former Ierapetra and / or reach the Libyan and Egyptian slopes; hence, successive Ierapetra's can be found simultaneously. At the entrance of the Levantine, the largest Libyan eddies tend to follow the deeper isobaths and thus detach from their parent current. Then, together with Ierapetra, they generally remain trapped by the Herodotus trough before finally decaying. Contrary to what has been believed hitherto, the "Mersa-Matruh" area (named ΣL_W) is occupied not by a recurrent / permanent feature but by slowly propagating and merging anticyclonic eddies originated elsewhere. The northwestern edges of such mesoscale eddies must have been confused with a northeastward "Mid-Mediterranean-Jet". The specificity of that area is thus due to processes never foreseen before.

The Shikmona area (named ΣL_E) is occupied by an offshore anticyclonic structure fed by various kinds of small-scale eddies originated alongslope. Both the "Cilician Current" and the "Asia Minor Current" are the continuity of the overall alongslope flow that meanders and generates medium-size eddies. The flow continues either into the Aegean, especially in winter, or southwestwards, up to feeding Ierapetra. North of Crete, most eddies propagate eastwards. In the northern Ionian, the flow towards the Adriatic displays a marked seasonal variability, intensifying in winter. In the Adriatic, it clearly surrounds the dense water formation zone in winter.

The monthly-composite analysis confirms that an alongslope and anticlockwise schema also applies to the late eighties - early nineties at least. In addition, all features evidenced with all available *in situ* data sets (in particular the POEM ones) can be seen with the IR imagery. It is thus concluded that i) all available data sets are reliable and ii) the POEM schemata (1, 2, 3) result from a misinterpretation of the observed features. Although mainly descriptive, our visual analysis of IR images allows proposing an alternative realistic schema of the AW circulation. The mean flow is anticlockwise alongslope and unstable. Mesoscale (100-200 km) anticyclonic eddies, propagate for months/years at up to a few km/d and tend to follow the deeper isobaths. An extended version of this paper is presently submitted to Progress in Oceanography.



References

1 - Robinson A.R., Golnaraghi M., Leslie W.G., Artegiani A., Hecht A., Lazzoni E., Michelato A., Sansone E., Theocharis A., and Ünlüata Ü., 1991. The Eastern Mediterranean general circulation : features, structure and variability. *Dyn. Atm. Oceans*, 15 : 215-240.

2 - Robinson A.R., and Golnaraghi M., 1993. Circulation and dynamics of the Eastern Mediterranean Sea; Quasi-Synoptic data-driven simulations. *Deep Sea Res.*, 40 : 1207-1246.

3 - Malanotte-Rizzoli P., Manca B.B., Ribera d'Alcala M., Theocharis A., Bergamasco A., Bregant D., Budillon G., Civitarese G., Georgopoulos D., Michelato A., Sansone E., Scarazzato P., and Souvermezoglou E., 1997. A synthesis of the Ionian Sea hydrography, circulation and water mass pathways during POEM-Phase I. *Prog. Oceanogr.*, 39 :153 -204.

4 - Nielsen J.N., 1912. Hydrography of the Mediterranean and adjacent waters. Rep. Dan. Oceanogr. Exp. Medit., 1 : 77-192.

5 - Le Vourch J., Millot C., Castagné N., Le Borgne P., and Olry J.P., 1992. Atlas of thermal fronts of the Mediterranean Sea derived from satellite imagery. *Mém. Inst. Océanogr. Monaco,* 16.

6 - Millot C., 1992. Are there major differences between the largest Mediterranean Seas? *Bull. Inst. Oceanogr. Monaco*, 11 : 3-25.

STATISTICS OF MEDITERRANEAN COHERENT VORTICES: ANALYSIS OF THE SEA SURFACE HEIGHT

Jordi Isern-Fontanet *, Jordi Font and Emilio García-Ladona
Institut de Ciències del Mar CSIC, Passeig Marítim de la Barceloneta, E-08003 Barcelona, Spain - * jisern@icm.csic.es

Abstract
Basic statistics of coherent vortices in the Mediterranean sea are investigated from the analysis of Sea Level Anomalies. The study includes the analysis of their energy, amplitude size and spatial distribution. Their effect on velocity Probability Densitiy Function (PDF) is also analyzed.

Keywords: Mesoscale eddies, velocity PDF, altimetry

Mesoscale variability is characterized by the presence of coherent vortices. This makes mesoscale observations of ocean resemble two-dimensional turbulence. This similarity suggests that vortex identification techniques common in turbulence studies can be used for ocean studies [1]. The Okubo-Weiss parameter (W) is defined as the squared strain minus squared vorticity [2,3]. A coherent vortex is defined as the simply connected region with values of the Okubo-Weiss parameter $W<-0.2\sigma$ where σ is the spatial standard deviation of W. When vortices areidentified their properties can be estimated. In this study, this definition is applied to altimetric Sea Level Anomaly (SLA) maps between October 1992 and October 1999 constructed by CLS [4] combining TOPEX/Poseidon and ERS-1/2 data onto a regular grid [5].

Results show that the Mediterranean sea is characterized by an approximately homogeneous distribution of vortices. However, some of their properties such energy or amplitude are irregularly distributed showing higher values in regions where the presence of mesoscale eddies is well known. This suggests that a classification based on the amplitude could allow to separate these eddies from other structures. The analysis of the dependence of the mean size of vortices with amplitude shows an asymptotic behavior that tends to radius of the order of 40 km. These results suggest the heuristic classification of coherent structures into intense vortices (characterized by values of the amplitude smaller than -2σ) that have the size of mesoscale vortices, and weak vortices (characterized by amplitudes greater or equal than -2σ) that correspond to noisy structures and low energy stages of mesoscale vortices. This separation of structures allows to easily track vortices from map to map and for the first time construct a complete picture of the preferential paths followed by them.

Furthermore, the Probability Density Functions (PDF) of the velocity field derived from SLA maps have also been analyzed. The Mediterranean sea has been divided into 7 regions depending on the geometry and the distribution of intense vortices. For each region PDF of the geostrophic velocities have been calculated. Observed shapes of velocity PDF are characterized by a Gaussian core with exponential tails as observed in the Atlantic and numerical simulations of 2D turbulence [6,7]. However, the size of the core and the tails change from one region to the other depending on the distribution of intense vortices. A decomposition of the velocity field into: a background induced field, a weak vortices-induced field and a intense-vortices field shows that the first two are characterized by distributions close to a Gaussian, while the third one has a distribution close to an exponential distribution.

Acknowledgements : This is a contribution to GRAC project funded by the Spanish R+D Plan and the European Union (2FD97-0588) and the IMAGEN project funded by the Spanish R+D Plan (REN2001-0802-C02-02). Jordi Isern-Fontanet has been partially supported by contracts from GRAC and IMAGEN projects. Altimetric maps for the period analyzed were elaborated and provided by CLS (Toulouse, France) under contract of the MATER project funded by the European Commission (MAS3-CT96-0051).

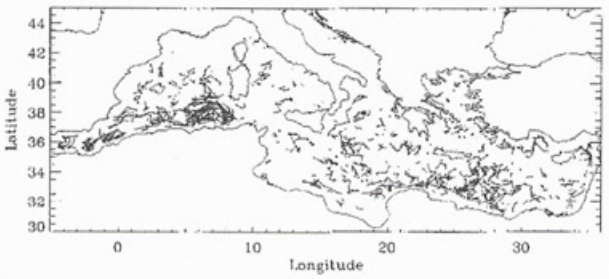


Fig. 1. Observed trajectories of anticyclonic intense eddies.

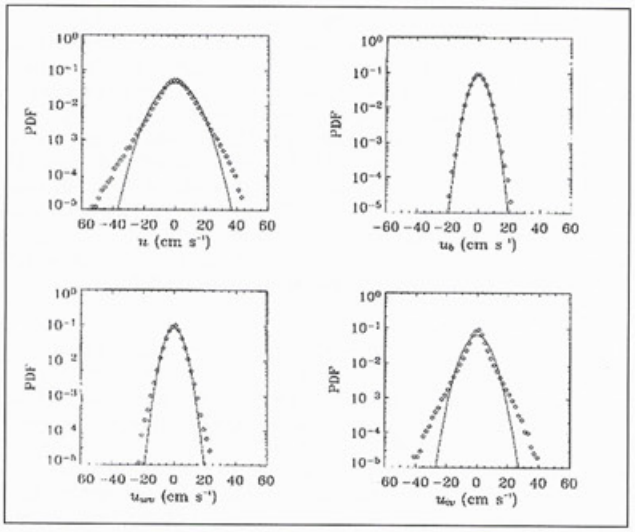


Fig. 2. Example of the velocity PDF of the decomposition of the velocity field (U) into a background-induced field (Ub), a weak eddy-induced field (Uwv) and an intense eddy induced field (Uiv) for the Algerian basin.

References

1 - Isern-Fontanet J., Gacría-Ladona E. and Font J., 2003. Identification of marine eddies from altimetry. *J. Atmos. Oceanic Technol.*, 20:772-778.
2 - Okubo A., 1970. Horizontal dispersion of floatable particles in the vicinity of velocity singularities such as convergences. *Deep-sea Res.*, 17: 445-454.
3 - Weiss J., 1991. The dynamics of enstrophy transfer in two-dimensional hydrodynamics. *Physica D*, 48: 273-294.
4 - Le Traon P.Y., Nadal F. and Ducet N., 1998. An improved mapping method of multi-satellite altimeter data. *J. Atmos. Oceanic. Technol.*, 15: 522-534.
5 - Larnicol G., Ayoub N. Le Traon P.Y., 2002. Major changes in the Mediterranean sea level variability from 7 years of TOPEX/Poseidon and ERS-1/2 data. *J. Mar. Syst.*, 33-34: 63-69.
6 - Bracco A., LaCasce J., Pasquero C. and Provenzale A., 2000. The velocity distribution of barotropic turbulence. *Phys. Fluids*, 12: 2478-2488.
7 - Bracco A., LaCasce J. and Provenzale A., 2000. Velocity density functions for oceanic floats. *J. Phys. Ocean*, 30: 461-474.

TIDAL DYNAMICS OF THE ADRIATIC SEA USING HIGH RESOLUTION 3D FINITE ELEMENT MODEL AND IN SITU OBSERVATIONS

Ivica Janekovic* and Milivoj Kuzmic

Center for Marine and Environmental Research, Rudjer, Boskovic Institute, Bijenicka c 54, 10002 Zagreb, Croatia - * ivica@irb.hr

Abstract

In the present work we explore the impact of assimilating local tide gauge on the quality of predicting seven major Adriatic tidal harmonics. To that end we compute optimal tidal open boundary conditions for a 3D high-resolution finite element model using inverse modeling technique. Derived harmonic constants from original time series from 10 tide gauges are assimilated and the results are analyzed with literature available values. RMSE for observed and modeled amplitudes are less than 1cm. The model output is also successfully validated with current data, not used in the assimilation.

Keywords: Tides, numerical model, data assimilation, Adriatic Sea

Introduction

The need for accurate tidal correction of altimetric signal has revived interest in tidal modelling of marginal seas. In case of the Adriatic, estimation of tidal dynamics is primarily dependent to determination of boundary conditions along one open boundary. Complexity of flows in the basin resulting from the elaborate coastline and bottom topography makes the problem interesting and challenging. In a recent modelling study [1] the Adriatic tides were addressed as a part of the larger, Mediterranean solution. Similar 3D model was used [2] to simulate co-oscillation of four Adriatic harmonics while data assimilation technique, for the first time, was used in [3] to study major Adriatic harmonics (M2 and K1). The goal of the present study is to explore further dynamics for seven major tidal harmonics by assimilating data from 10 local tidal gauges.

Data

One type of used data are original tide gauge time series for 10 stations (squares on Figure 1). The data were collected simultaneous with record length of approx. two months (28/2/1982 – 30/4/1982). Tidal analyses were done for 38 harmonics and only seven of the most energetic ones (M2, S2, K2, N2, O1, P1 and K1) were used in the study. The other data source is harmonic constants compiled and verified from available literature (dots on Figure 1). The current data used in verification were obtained with 6 Aanderaa RCM-4 current meters deployed at 2 mooring stations in the Northern Adriatic (stars in Figure 1). Useful deployment period was about one month, from December 2nd 1986 till January 4th 1987.

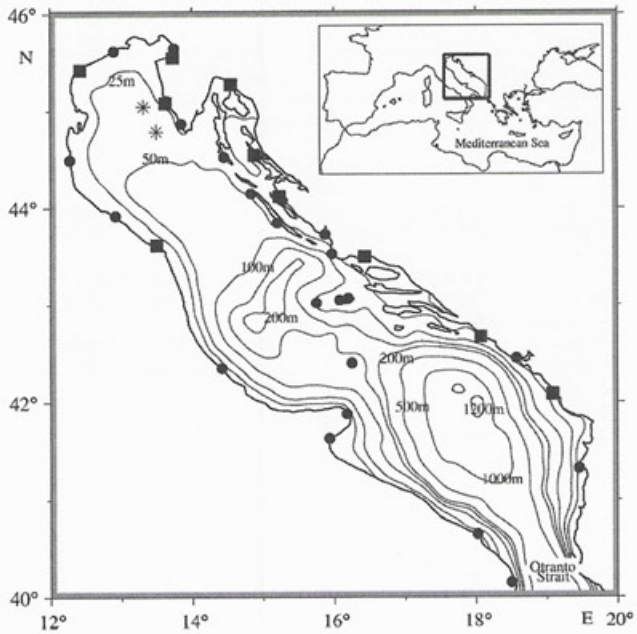


Fig. 1. Adriatic Sea bathymetry map with stations used in the study.

Method and models

Although the Adriatic Sea has only one short open boundary along the Straits of Otranto this appears to be a difficult one as there has been no published data on the bottom pressure covering the boundary. We used 3D finite element linear model and its inverse in order to obtain open boundary conditions for each tidal harmonic separately. Inversion is based on the best fit of the model to the observations, in the least squares sense. Three-dimensional forward model [4] is a finite element model based on the 3D non-linear shallow water equations. The finite element grid consists of 23055 nodes and 37200 elements with the nodal distances varying from about 500m in coastal areas up to 44 km in the largest triangle (deep parts of domain). With this mesh we have been able to include in our simulations 77 major islands and recognise realistic topography and lateral geometry better than in any previous Adriatic tidal model. The model is forced only by time varying sea level boundary conditions along 40°N resulting from the output of data assimilative models.

Results and conclusions

Using the mentioned method we were able to obtain open boundary values for seven major harmonics in dynamically consistent way. The two most energetic harmonics M2 and K1 obtained in previous study [3] showed good agreement with values in this study (although a different inverse models and technique were used). Obtained open boundary amplitude structure shows small values (<2 cm) for harmonics other than 3 major ones (M2, S2 and K1). By assimilating higher amplitude values at the northern part of domain (where tidal signal is stronger) we succeeded to reproduce small values at the open boundary. The phase structure is characterised by 2 groups: diurnal with values between 40° and 55°, and semidiurnal with phases ranging between 90° and 110°. For semi-diurnal harmonics basin-wide solutions show well known cyclonically rotating amphidromic system; diurnal solutions exhibit narrow phase sweep (20° to 25°) in cross-basin direction (northeast to southwest) with amplitude rise along the central axis (southeast to northwest). Comparison of modelled amplitudes with those obtained via harmonic analyses generated small RMSE (M2 ~0.8cm, S2 ~0.2cm, K2 ~0.4cm, N2 ~0.3cm, K1 ~0.5cm, P1 ~0.2cm, O1 ~0.3cm).

Verification of model with measured currents produced rather agreeable result. At two locations and at three depths the model was able to reproduce both the major and minor semi-axes in close agreement with measured data (not used in data assimilation procedure). RMSE for major (M2 ~1.4cm/s, S2 ~1.2cm/s, K1 ~0.9cm/s) and minor semi-axis (M2 ~0.9cm/s, S2 ~0.5cm/s, K1 ~0.3cm/s) are close to observed RMSE (1.8cm/s and 1.5cm/s for major and minor semi-axis).

References

1 - Tsimplis M. N., Proctor R. and Flather R. A., 1995. A two-dimensional tidal model for the Mediterranean Sea. *J. Geophys. Res.*, 100C: 16223-16239.

2 - Cushman-Roisin B. and Naimie C. E., 2002. A 3D finite-element model of the Adriatic tides. *J. Marine Sys.*, 37: 279-297.

3 - Janekovic I., Kuzmic M and Bobanovic J., 2003. The Adriatic Sea M2 and K1 tides by 3D model and data assimilation. *Estuar. Coast. Shelf Sci.*, 57: 873-885.

4 - Lynch D. R., Justin T. C. IP., Naimie C. E. & Werner F. E., 1996. Comprehensive coastal circulation model with application to the Gulf of Maine. *Cont. Shelf Res.*, 16: 875-906.

LIGHT GPS BUOYS FOR THE ENVISAT SATELLITE ALTIMETER CALIBRATION IN THE NW MEDITERRANEAN

Agustí Julià [1] *, Josep Torrobella [2] and the GRAC IEEC-ICM Team

[1] ICM. Institut de Ciències del Mar C.S.I.C. Passeig Marítim 37-49, 08003 Barcelona, Spain - * ajulia@icm.csic.es
[2] IEEC. Institut d'Estudis Espacials de Catalunya. C/ Gran Capità, 2-4. Ed. Nexus, 204. 08034 Barcelona, Spain - badia@ieec.fcr.es

Abstract

A new system is described for the precise measurement of absolute sea level at open sea. It was designed to compare with observations by satellite radar altimeters, and has been used in the ENVISAT absolute range calibration. The system consists on two attached light buoys containing GPS antennas connected by coaxial cables to their receivers in a nearby small boat. Form April to October of 2002, 45 short cruises were performed along 400 km of the NW Mediterranean coast in simultaneity with ENVISAT overpasses.

Keywords: ENVISAT, Satellite altimetry, sea level, GPS, drifting buoys

We describe a newly designed system employed in the calibration of the ENVISAT radar altimeter, using a double GPS receiving system floating freely on the sea surface under the track of the satellite at the moment of the overpass. The sea level is measured at very high precision with reference to the WGS84 ellipsoid, and later compared with the satellite altimetry data. This was part of the joint participation of Institut d'Estudis Espacials de Catalunya and Institut de Ciències del Mar (Barcelona) in the activities coordinated by the European Space Agency during the ENVISAT calibration phase, under ESA contract No. 15349/01/NL/SF.

We designed a two-buoy rigid system with one GPS choke ring antenna each, attached to their corresponding receivers using impermeable low loss coaxial cable and a sustaining rope. The distance to the boat was around 40 meters to avoid possible reflections of the incoming signal on the boat structure, but not longer to avoid excessive signal loss along the cable.

The system was left to freely drift during 3 hours within 1 nautical mile of the nominal point, centred in the ENVISAT overpass, and acquiring two-frequency GPS data at 1 Hz. The boat was also drifting but keeping the possibility of a manoeuvre to avoid tension on the cable that could prevent the two-buoy system to exactly follow the free surface motion. The system oriented spontaneously parallel to the wave front, and its size allowed the antenna centres (the point exactly positioned by GPS) to be always at the same distance from the free sea surface. Careful measurements under controlled conditions (small pond and harbour) were used to precisely determine this distance (some 3.75 cm). Simultaneously to the open sea measurements, on land and near the shore, another fixed system equipped with one antenna and receiver, recorded reference GPS data in order to estimate the tropospheric delay. To avoid the error introduced on the reflected signal due to the differences between the scattering coefficients of the land and the sea surface, that could be both present in the foot print (1), the measuring points at sea were chosen at a 10 miles distance from the coast, under the satellite track.

The strategy was to cover 10 ENVISAT tracks (6 ascending night passes and 4 descending day passes) along 400 km of the NW Mediterranen Catalan coast, between 40° and 42° N. We selected 6 harbours and 10 ground sites for the land station, and hired small boats (between 7 and 12 meter long) to reach the measuring points. All were equipped with good navigation facilities and a cabin, where the receivers were safely installed and campaign notes could be taken.

During the six months calibration phase, from April to October 2002 starting one month after ENVISAT launch, 53 satellite overpasses took place in the study area, and 45 simultaneous GPS data acquisitions were achieved (85% success). The failures were due to equipment malfunctioning, logistic problems and mainly to bad weather conditions. 18 different people were involved in the operations, usually three on the boat and one operating the ground station.

The tight activity schedule, with one operation at sea every 3-4 days without interruption during 6 months, required a constant and careful maintenance at ICM. Work at sea, assembling and disassembling, and transportation by road can produce important stress to the different elements of the two-buoy system, the ground station and the GPS receivers. During all the experiment, we have maintained the system under two main scopes: a general and complete check before each mission, including the buoy water tightness, batteries charge, cables inspection and connectors condition. The second one included repair of the defective components or elements. It was necessary to do 18 repairing interventions, 6 of them on the buoy water tightness and 8 on the cable connections, meaning that 78 % of the maintenance had to be done on the elements of the system subject to the physical effort on the sea. In few occasions the GPS receivers had to be substituted due to malfunctioning.

All the data acquired in the 45 cruises were processed at IEEC, including the Precise Point Positioning technique (2), GIPSY/OASIS software and JPL products, and delivered to ESA that used them for the ENVISAT RA-2 range calibration within the so called regional approach in the whole NW Mediterranean, including different kinds of coastal and open sea measurements and modelling techniques (3).

References

1 - Chelton D. B, Ries J., Haines B., Fu L-L. and Callahan P. 2001. Satellite Altimetry. Pp. 4-7. *In:* Lee-Lueng Fu and Anny Cazenave (ed.), Satellite Altimetry and Earth Sciences. International Geophysics Series. vol. 4, chap. 1. Academic Press. San Diego

2 - Zumberge J.F., Heflin M.B., Jefferson D.C. and Watkins M. M 1997. Precise point positioning for the efficient and robust analyses of GPS data from large networks. *J. of Geophysical Research.,* 102: 5005-5017.

3 - Francis R. and Roca M., 1997. RA-2 in-orbit calibration plan: Range, ESA-ESTEC Internal Document, PO-PL-ESA-RA-00xx, 48 p.

SEASONAL DYNAMICS OF PARTICULATE MATTER IN THE NE MEDITERRANEAN SEA: ANALYSIS OF A HISTORICAL (1991-2001) DATA SET OF LIGHT TRANSMISSION MEASUREMENTS

Karageorgis A.P. [1] *, Gardner W.D. [2], Mishonov A.V. [2], Krasakopoulou E. [1], Anagnostou Ch. [1]

[1] Hellenic Centre for Marine Research, P.O. Box 712, 19013 Anavyssos, Greece - * ak@ncmr.gr, ekras@ncmr.gr, chanag@ncmr.gr
[2] Department of Oceanography, Texas A&M University, College Station, TX 77843, USA. wgardner@ocean.tamu.edu, avm@ocean.tamu.edu

Abstract

Light transmission measurements in the NE Mediterranean, during the period 1991-2001 are homogenized and interpreted. The period of high precipitation and river freshwater discharge (winter-spring) is characterized by high beam cp values in the Northern Aegean Sea and coastal areas of Greece at the surface (0-50 m) waters. The Rhodes cyclonic gyre is related to relatively higher beam cp due to an increase in productivity. Summer-autumn conditions exhibit more relaxed features and generally less turbid waters. Beam cp is markedly correlated with particulate matter concentration and particulate organic carbon, enabling the definition of empirical equations to be used in future projects, budget estimates and modeling.

Keywords : light transmission, particulate matter concentration, particulate organic carbon, NE Mediterranean Sea

Introduction

Light attenuation is an important parameter providing information on the quantity and dispersal patterns of particulate matter (PM) throughout the water column. PM dynamics studies have attracted the scientific community's interest in large multidisciplinary projects, i.e. the JGOFS North Atlantic Bloom Experiment [1, 2]. However, within the NE Mediterranean Sea, similar investigations have focused only in specific geographical regions, i.e. the NW Aegean Sea [3], and the NE Aegean Sea [4]. A major objective of the present communication is to study, for the first time, particulate matter dynamics over the entire NE Mediterranean Sea. For this purpose, the historical data set of light transmission measurements, obtained by the Hellenic Centre for Marine Research (HCMR) during 1991-2001, was analyzed and interpreted.

Methods

The initial data set comprised light transmission measurements conducted in parallel with routine CTD casts in 3136 stations (Fig. 1). Data have been obtained from 40 cruises of 14 research projects on board the *R/V Aegaeo*. Metadata, light transmission readings, and beam c_p (attenuation due to particles, m^{-1}) were stored in the 'Ocean Data View' format [5] for archiving and visualization.

Particulate matter concentration (PMC, 1689 samples) and particulate organic carbon (POC, 638 samples) data obtained over the period 1997-2001 were utilized to calibrate optical measurements against those parameters.

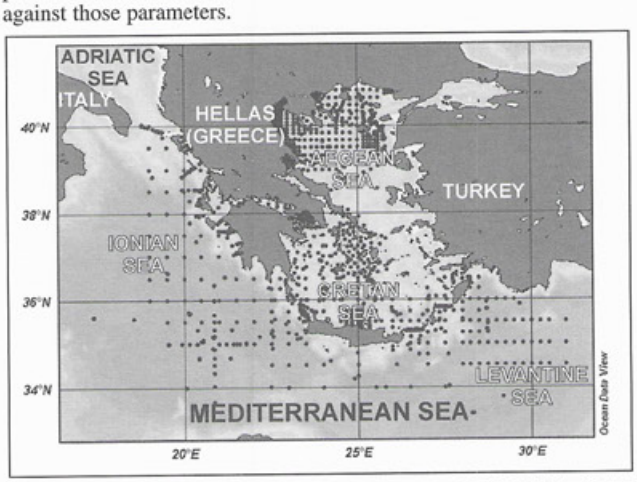


Fig. 1. Light transmission stations obtained during 1991-2001 by HCMR in the NE Mediterranean.

Results and discussion

Transmissometry

A preliminary assessment of beam c_p distribution in the NE Mediterranean Sea shows the following:

1. The surface nepheloid layer (at 5-m depth, SNL) exhibits the highest signal in c_p during the winter-spring (wet) period. The continental shelf of the Northern Aegean Sea appears to be the most turbid water area. This feature is attributed to the particulates introduced from a number of rivers (Axios, Aliakmon, Pineios, Strymon, Nestos, and Evros), which discharge into the area.
2. Relatively high c_p values appear in other coastal areas, such as the gulfs of Patras, Corinth, Kyparissiakos, and Saronikos.
3. Low c_p values generally characterize the deep sector of the N. Aegean Sea, the central Aegean Sea, the Cretan Sea and the Ionian Sea, indicating minimal terrigenous supply and oligotrophic conditions.
4. The Rhodes gyre (cyclone) is an area of elevated beam c_p signal, attributed to increased productivity due to the presence of nutrient-rich upwelling waters [6].
5. The aforementioned features can be observed at 20 m and 50 m depths. From 100 m depth up to 500 m depth beam c_p distribution is more homogeneous all over the NE Mediterranean Sea and reaches minimum values.
6. The dry period (summer-autumn) of low precipitation and low river discharge is characterized by more relaxed c_p signal. Relatively high beam c_p values appear only at the surface waters of the Northern Aegean Sea, whilst deeper waters maintain decreased c_p values.

Beam c_p vs. PMC and POC

Linear regression between c_p and PMC revealed a marked correlation (r=0.829, n=1689). Likewise, c_p was strongly correlated to POC (r=0.819, n=638). The overall positive and marked correlation of the aforementioned parameters may enable the definition of empirical functions relating optical measurements to PMC and POC. This could be useful for the estimate of PM and POC budgets and/or their use in models.

Conclusions

The analysis of historical light transmission measurements from the NE Mediterranean Sea was successful. Overall, we were able to differentiate distribution patterns between wet and dry seasons, in order to estimate the seasonal variability of PM in the NE Mediterranean. Elevated and/or relaxed features of beam c_p were identified and directly related to physical processes affecting PM distribution in the water column.

The correlation of optical measurements vs. PMC and POC is noticeable and may result to the definition of global (for the NE Mediterranean) equations, to be used in future research projects, estimations of budgets and in modeling exercises.

References

1 - Gardner, W.D., Walsh, I.D., Richardson, M.J., 1993. Biophysical forcing of particle production and distribution during a spring bloom in the North Atlantic. *Deep-Sea Research II,* 40(1-2): 171-195.

2 - Gardner, W.D., Chung, S.P., Richardson, M.J., Walsh, I.D., 1995. The oceanic mixed-layer pump. *Deep-Sea Research II,* 42(2-3): 757-775.

Karageorgis, A.P., Anagnostou, Ch.L., 2001. Particulate matter spatial-temporal distribution and associated surface sediment properties: Thermaikos Gulf and Sporades Basin, NW Aegean Sea. *Continental Shelf Research,* 21: 2141-2153.

3 - Karageorgis, A.P., Kaberi, H.G., Tengberg, A., Zervakis, V., Anagnostou, Ch.L., Hall, P., 2003. Comparison of the particulate matter distribution between a mesotrophic and an oligotrophic marine area: The

4 - Skagerrak Sea and the northeastern Aegean Sea. *Continental Shelf Research*, in press.

5 - Schlitzer, R., 2003. Ocean Data View, http://www.awi-bremerhaven.de/GEO/ODV.

6 - Souvermezoglou, E., Krasakopoulou, E., 1999. The effect of physical processes on the distribution of nutrients and oxygen in the NW Levantine Sea. In: P. Malanotte-Rizzoli and V.N. Eremeev (eds.), The Eastern Mediterranean as a laboratory basin for the assessment of contrasting ecosystems. Kluwer Academic Publishers, Dordrecht, Boston, London, *NATO Science Series* 2, Vol. 51: 225-240.

THE EVOLUTION OF THE INTERMEDIATE WATER MASSES OF THE EASTERN MEDITERRANEAN

Birgit Klein [1] *, Beniamino Bruno Manca [2] and Wolfgang Roether [2]

[1] University of Bremen, Inst.of Environmental Physics, Bremen, Germany,
* bklein@physik.uni-bremen.de and wroether@physik.uni-bremen.de

[2] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico (Trieste), Italy
bmanca@ogs.trieste.it

Abstract

Hydrographic observations in 1999 and 2001 are used to highlight the evolution in the intermediate water masses. During the current stage of the Eastern Mediterranean Transient the Aegean is an active source of a warm and highly saline intermediate water mass. The distributions of the tracer CFC-12 show that the Cretan Intermediate Water (CIW) is strongly ventilated and is now spreading along the main pathways of Levantine Intermediate Water towards the Strait of Sicily.

Keywords: Intermediate waters, ventilation, tracer

Introduction

The Eastern Mediterranean Transient (EMT) is a major disturbance of the thermohaline circulation of the Eastern Mediterranean. It started in the early 1990s, when the Aegean took over the leading role in deep water production from the Adriatic. One of the most prominent features during the early stages of the EMT had been the massive ventilation of the deep water masses. This could be seen very clearly in the strongly increased concentrations of the tracer CFC-12. As a side effect of the massive outflow of dense water from the Aegean ‚old' Eastern Mediterranean Deep Water (EMDW) was pushed upward and diluted the Levantine Intermediate Water (LIW) layer, causing salinities to decrease. The evolution of the intermediate waters is of great interest because the salt they are transporting is an important prerequisite to achieve high densities during convection. The initial decrease of salinity in the LIW had been linked to the lack of convective activity in the Adriatic during the 1990s and it had been postulated that the resumed salt advection into the Adriatic by the Cretan Intermediate Water (CIW) would help the Adriatic to regain its leading role in deep water production [1, 2].

Materials and Methods

The data presented in this study have been obtained during two cruises of RV *METEOR* in April/May 1999 and October/ November 2001 in the Eastern Mediterranean. The data comprise hydrographic profiles, nutrient and oxygen profiles, as well as profiles of transient tracers (CFCs, helium isotopes, and tritium). Atmospheric concentrations of CFCs display a time-dependant behaviour. CFCs are introduced into the ocean by air/sea gas exchange and carry the time-varying signal into the ocean. They are therefore excellent tools to identify ventilation and spreading pathways of water masses.

Results and Discussion

Figure 1 shows the change in concentration of CFC-12 between 1999 and 2001 along an east/west transect in the Eastern Mediterranean. The evolution of CFC-12 between 1999 and 2001 shows only moderate increases in the deep water (H>1500m). One area of increase is observed close to the Italian continental break and the other is seen in the Levantine Basin, where spreading of the dense water from the Aegean is still continuing. Whereas a very strong signal of ventilation is observed in 200-400 m depth range. This signal is persistent from the eastern Straits of the Cretan Arc toward the Strait of Sicily but is absent in the Levantine Basin. A closer examination of the T/S properties shows that the CFC-12 increase is associated with the Cretan Intermediate Water. CIW is warmer and saltier than LIW and therefore is found on top of the LIW in the water column. In the salinity profiles CIW and LIW overlap into large subsurface salinity maximum, but the CFC-12 distributions clearly mark CIW as the more ventilated water mass and allow the separation of the two intermediate water masses. In 1999 CIW had not been found in the Cretan Passage, but was exchanged through Antikythera Strait into the Ionian and advected into the Adriatic. The salt advected into the Adriatic by the CIW and previously the LIW is a prerequisite for deep convection in the southern Adriatic. The 2001 observations indicate that CIW is now following one of the main spreading pathways of LIW, flowing westward towards the Strait of Sicily and is thus included into the exchange of water masses between the Eastern and Western Mediterranean. In the Levantine Basin the CFC-12 differences between 1999 and 2001 indicate decreasing concentrations. This results from the absence of CIW and from the still ongoing upward movement of ‚old' EMDW into the LIW horizon.

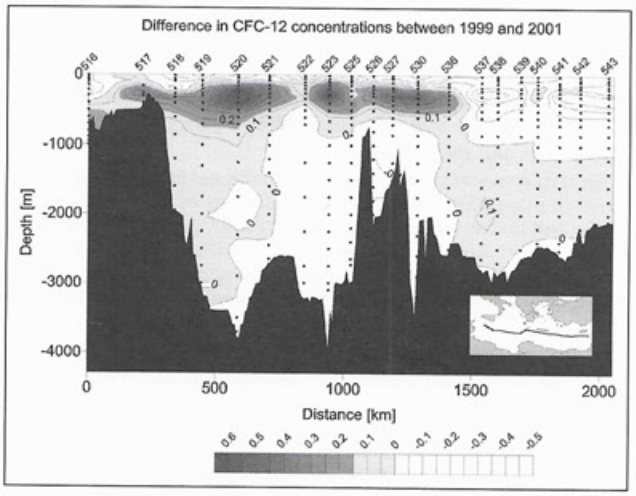


Fig. 1. Difference in CFC-12 concentrations [pmol/kg] between 2001 and 1999 along a section between Sicily and Cyprus. Positive values correspond to an increase in CFC-12 from 1999 to 2001, negative values denote a decrease.

References

1 - Klein, B., W. Roether, G. Civitarese, M. Gacic, B. Manca, M. Ribera d'Alcala, 2000. Is the Adriatic returning to dominate the production of Eastern Mediterranean deep water?, *Geophys. Res. Letters*, Vol. 27 (20): 3377-3380.

2 - Manca B.B., Budillon G., Scarazzato P., Ursella L., 2003. Evolution of dynamics in the eastern Mediterranean affecting water masses structures and properties in the Ionian and Adriatic Seas, *J. Geophys. Res.*, 108(C9),8102, doi:10.1029/2002JC001664.

THE STATUS OF DENSE WATER FORMATION IN THE SOUTHERN ADRIATIC SEA IN MAY 2003

Birgit Klein [1] *, Vanessa Cardin [2] and Miro Gačić [2]

[1] University of Bremen, Inst.of Environmental Physics, Bremen, Germany - * bklein@physik.uni-bremen.de
[2] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico (Trieste), Italy
vcardin@ogs.trieste.it and mgacic@ogs.trieste.it

Abstract

Hydrographic observations conducted in May 2003 assess the present status of deep water formation in the southern Adriatic. The observations highlight the importance of the intermediate waters. The highly saline Cretan Intermediate Water is dominating the upper water column, while the Levantine Intermediate Water is displaced to greater depth. Concurrent velocity measurements with an lADCP depict the synoptic flow field and confirm the well-known cyclonic circulation in the Adriatic. The East Adriatic Current is seen as a surface intensified jet, strong currents are also found over the Italian shelf associated with the dense waters from the Northern Adriatic.

Keywords: Adriatic Sea, deep convection, current field

Introduction

Since the start of the Eastern Mediterranean Transient (EMT) the Adriatic has been under scrutiny regarding to her performance as a deep water source. A prime ingredient to maintain deep convection is the presence of highly saline intermediate waters. During most of 1990s the ventilation of the Adriatic Deep water did not occur and only recently in 2002 could the restart of an active renewal be observed [1].

Next to the open ocean convection in the centre of the Southern Adriatic, dense waters formed on the shelves have also been found to be important for the ventilation of the deep layers [2].

Materials and methods

The data presented in this study were collected in early spring 2003 as part of a co-operation between the University of Bremen, Germany and the Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Italy. The field programme in May 2003 comprised hydrographic measurements, current measurements with an lADCP and the recovery of a mooring which had been deployed the previous fall.

Results and discussion

The salinity section across the southern Adriatic (Fig. 1) gives evidence of the still ongoing changes in the Adriatic caused by the EMT [1]. Near the Croatian coast we observed a shallow core of very saline water (S>38.8), which marked the presence of the highly saline Cretan Intermediate Water (CIW). As part of the changes induced by the EMT CIW has been replacing the Levantine Intermediate Water (LIW) in the upper part of the water column. Centred around 400 m depth one observes another salinity maximum in the centre of the gyre (S>38.78) accompanied by enhanced small scale variability in this layer. Compared to the situation in 2002 [1] the salinities and temperatures in this depth horizon (400-600 m) show large increases, which is caused by displacement of the LIW to increasing depth.

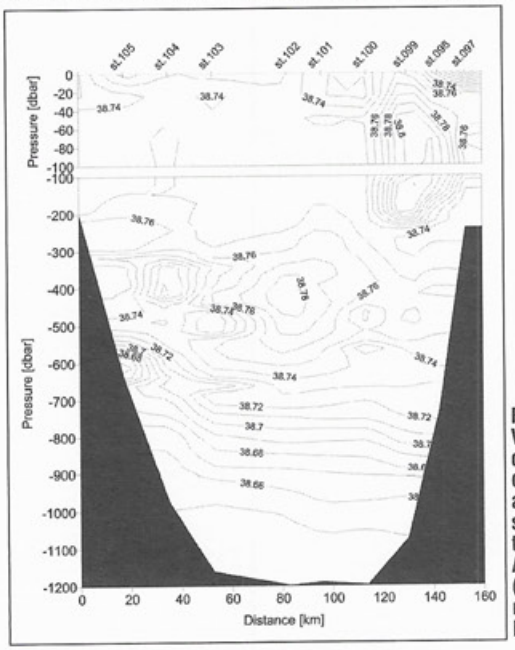


Fig. 1. Vertical distribution of salinity along a section in the southern Adriatic Sea (see inset maps) in May 2003.

An increase of salinity and temperature compared to 2002 is also found in the bottom layer. The 2002 data had indicated an important contribution of dense Northern Adriatic waters to the ventilation of the bottom layers [1]. We did encounter the vein of the dense Northern Adriatic waters on the Italian shelf on all sections with an especially strong signal on the southernmost section. Its density however was not high enough to allow it to sink to the bottom of the Southern Adriatic Pit.

Simultaneous to the hydrographic observations current measurements were performed at each station with an lADCP. This is the first time that a synoptic top to bottom flow field was obtained in the Adriatic. Figure 2 shows the cross section velocity component for the central Adriatic section. In the northern part of the section the north-westward flowing East Adriatic Current is found, which is surface intensified and shows maximum velocities of 16cm/s in the core of the jet. In the southern part of the section the flow seems to be less energetic. The veins of the dense Northern Adriatic waters stand out as cores of higher velocities at the shelf break.

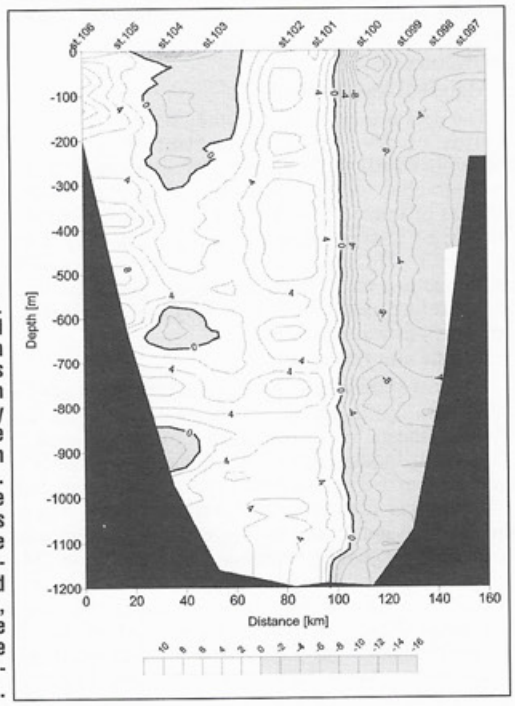


Fig. 2. Vertical distribution of cross section velocity along the same section as in Fig. 1. Positive velocities indicate south-eastward flow, negative velocities are north-westward.

References

1 - Manca B. B., Civitarese G, Klein B., and Ribera d'Alcalà M., 2004. Dense water formation in the Southern Adriatic Sea associated with variations of the thermohaline circulation in the Ionian Sea during 2001-2002, this issue.

2 - Gačić M., Lascaratos A., Manca B.B., and Mantziafou A., 2001.Adriatic deep water and interaction with the Eastern Mediterranean Sea. Pp. 111-142. In: Physical Oceanography of the Adriatic Sea, B. Cushman-Roisin *et al.* (eds.), Kluwer Academic Publishers.

3 - Cardin, C., Gačić M., and Klein B., 2004, Mesoscale activity in the Southern Adriatic as evidenced from a deep-sea mooring, this issue.

ON A POTENTIAL VORTICITY IDENTIFICATION OF THE NO-MOTION LEVEL USING ONLY HYDROLOGIC DATA, WITH APPLICATIONS TO THE MEDITERRANEAN SEA

M. Kurgansky [1, 2], and E. Salusti [3*]

[1] Department of Atmospheric and Oceanic Physics, Faculty of Physics and Mathematics, University of Concepcion, Casilla 160-C, Concepcion, Chile - kurgansk@udec.cl

[2] A.M. Obukhov Institute of Atmospheric Physics, Academy of Sciences, Russia.

[3] INFN, Phys. Dept., "La Sapienza" Rome University Piazzale A. Moro, 2 Rome, Italy, * ettore.salusti@roma1.infn.it

Abstract

The theory of potential vorticity for stratified fluids in a rotating system is applied to potential temperature θ and salinity S. These 'tracer potential vorticities' are used to obtain an absolute fluid velocity that generalizes earlier formulations. Here we use not the steady absolute velocity but only a vector $\nabla\theta\times\nabla S$ proportional to it. In this way, insight is gained into a purely hydrological identification of the no-motion level. This is then applied to historical data of the Mediterranean Sea with interesting results.

Keywords: potential vorticity, no motion level

A classical problem

It is well known how from the measurements of marine temperature and salinity one can obtain vertical gradients of the current velocity $\mathbf{u}$ [1], [2]. Recently, oceanographers using the β-spiral theories have greatly improved our theoretical understanding of these problems by noting how in reality hydrologic data allow the identification of the no-motion level [see 3 for a review]. A somewhat simpler relation for steady currents was obtained in [4] that in addition utilizes only potential temperature θ and salinity S data set.

Here we restrict ourselves to a simpler results that gives not $\mathbf{u}$ but only a vector $\nabla\theta\times\nabla S$ proportional to it, to search for surfaces of no absolute motion (NAM in the following) for steady or quasi-steady, inviscid or viscous marine currents. This is then applied to historical data of the Mediterranean Sea with good agreement between our theory and other information.

The absolute velocity field

In a steady adiabatic case, assuming $\nabla\cdot(\rho\mathbf{u})=0$, $\mathbf{u}\cdot\nabla\theta=0$, $\mathbf{u}\cdot\nabla S=0$, calling ρ the water density, the most general representation is

$$\rho\mathbf{u} = \varphi(\theta, S)\,\nabla\theta\times\nabla S, \tag{1}$$

where $\varphi(\theta, S)$ is an arbitrary function. We now consider potential vorticities $\Pi_\theta=(\omega_a\cdot\nabla\theta)/\rho$ and $\Pi_S=(\omega_a\cdot\nabla S)/\rho$ with ω_a as the absolute vorticity. Application of the general Ertel's vorticity theorem and also the method [4] gives two formulas

$$\mathbf{u}=\frac{g\rho^{-2}(\partial\rho/\partial\theta)\mathbf{k}\cdot\nabla\theta\times\nabla S}{\nabla\left(\dfrac{\omega_a\cdot\nabla S}{\rho}\right)\cdot\nabla\theta\times\nabla S}(\nabla\theta\times\nabla S)\equiv\frac{g}{\rho^2}\frac{w(\partial\rho/\partial\theta)}{\mathbf{u}\cdot\nabla\Pi_S}(\nabla\theta\times\nabla S) \tag{2}$$

$$\mathbf{u}=-\frac{g\rho^{-2}(\partial\rho/\partial S)\mathbf{k}\cdot\nabla\theta\times\nabla S}{\nabla\left(\dfrac{\omega_a\cdot\nabla\theta}{\rho}\right)\cdot\nabla\theta\times\nabla S}(\nabla\theta\times\nabla S)\equiv-\frac{g}{\rho^2}\frac{w(\partial\rho/\partial S)}{\mathbf{u}\cdot\nabla\Pi_\theta}(\nabla\theta\times\nabla S) \tag{3}$$

where $\mathbf{k}$ is the unit vertical vector, g the gravity and w the vertical velocity. According to (1-3) we focus our attention on the vector $\nabla\theta\times\nabla S$. In [4] it is shown that $\nabla\theta\times\nabla S$ is proportional to $\mathbf{u}$ if the streamlines do not change their shape with time, even if $|\mathbf{u}|$ can be (slightly) time-dependent. This single vector can moreover give sufficient information about the NAM surfaces Σ.

The condition $\nabla\theta\times\nabla S=0$ is satisfied when $\theta=\Psi(S)$ or more generally $\nabla\theta=\Phi(\mathbf{x})\nabla S$ where Ψ and Φ are arbitrary functions. When Σ is essentially inclined to the horizon, as it is typical in the southern Mediterranean Sea, then we may take $\Phi=\Phi(z)$ or better $\Phi=\Phi_1(z)\Phi_2$, as a first guess in order to arrive at $\nabla\theta\times\nabla S=0$ from the above conditions.

No-motion surfaces in the Mediterranean Sea

The Mediterranean Sea has been studied for a particularly long time, since the Phoenician and Greek civilizations. However only in 1961 G. Wüst [5] was able to present a realistic scheme of its general circulation. The data set of θ and S we analyze is taken from the Atlas Hydrologique de la Mediterranée [6], prepared by P. Guibout.

We start with transect 69-70 between the Libyan coast and Sicily (Cape Passero), along 15°40′ E for the winter season. Under the MAW, the LIW core is rather superficial, at 350-400 m depth. There is a sharp zone of strong shears of the current velocity in the upper 200 m, spreading from the Libyan coast till ~35°N. So a reasonable Σ surface can be identified with the S=38.60 surface, that is ~250 m deep in the main part of transect between 32°30′-35°00′ N, and then rapidly shoals near the Malta Island.

Transect 65-66 from Cape Dimas, Tunisia, to Malta Island is rather similar to the previous transect: a reasonable Σ surface is at 400-300 m depths, corresponding to an S = 38.30 - 38.60 layer while the LIW core is at ~1000 m depth.

The transect 15-16 from Algeria to Toulon, along 6° E, is also interesting. The core of LIW, with S = 38.50, is at ~400 m depth. At south one can easily recognize the superficial core of MAW. A reasonable Σ surface is evident only between Algeria, where it is ~170 m deep, and the region at 39°30′-40°00′ N, along the surfaces S = 37.70 - 37.90. Near the French coast there is a very strong coastal jet, flowing westward, which doesn't seem to have any no-motion level.

All this look in agreement with the scheme of an eastward superficial MAW surface current at south, flowing opposite to the underlying LIW, and of rather parallel flows of LIW and MAW at the north. However, these are actually debatable points as discussed by C. Millot and other authors in various articles (see [7], for a review).

It is obvious that there are still some serious difficulties regarding the direct implementation of our theoretical results in the study of real data, both from the observational and the computational standpoints. So far, only the Mediterranean Sea, seen as a natural laboratory with its sharp contrasts between different water masses and relatively dense observational network, including historical data sets, can be used to test our ideas, albeit in a preliminary way.

References

1 - Fomin, I.M., 1964. The Dynamic Method in Oceanography. Elsevier Oceanography Series. Elsevier Publ. Comp., Amsterdam-London-NY, 212 p.

2 - Wunsch, C., 1978. The North Atlantic general circulation west of 50∞ West determined by inverse methods. *Rev. Geophys. Space Phys*, 16: 583-620.

3 - McDougall, T., 1995. The influence of ocean mixing on the absolute velocity vector. *J. Phys. Oceanogr.*, 25: 705-725.

4 - Kurgansky, M.V., Budillon G. and Salusti E., 2002. Tracers and potential vorticities in ocean dynamics. *J. Phys. Oceanogr.*, 32: 3562-3577.

5 - Guibout, P., 1987. Atlas Hydrologique de la Mediterranée. SHOM ed., Ifremer, Paris, 150 p.

6 - Wüst, G., 1961. On the vertical circulation of the Mediterranean Sea. *J. Geophys. Res.*, 66(10): 3261-3271.

7 - Fuda J.L., Millot C., Taupier-Letage I., Send U. and Bocognano J.M., 2000. XBT monitoring of a meridian section across the western Mediterranean Sea. *Deep Sea Res.* I, 47: 2191-2218.

THE ADRIATIC SEA SURFACE TEMPERATURE VARIABILITY VIA EOF/WAVELET ANALYSIS OF THE AVHRR DATA

Milivoj Kuzmic [1] * and Zoran Pasaric [2]

[1] Center for Marine and Environmental Research, Rudjer Boskovic Institute, P.O. Box 180, 10002 Zagreb, Croatia
* kuzmic@rudjer.irb.hr

[2] Geophysical Department, Faculty of Science, Horvatovac bb, 10000 Zagreb, Croatia

Abstract

Fourteen years of five-day averaged medium-resolution (9.3km) Adriatic remotely sensed SST fields is analysed with a view to better discern their spatial and temporal variability. The EOF analysis is employed to derive orthogonal spatial patterns, and continuous wavelet transform (CWT) applied to EOF-derived principal component time series. The first EOF mode revealed dominant spatial patterns, carrying prominent part of the total variance in both time- and space-demeaned cases (98.5% and 66% respectively). The time series of band-integrated principal components has provided revealing insights into intra- and inter-annual variability.

Keywords: Adriatic Sea, surface temperature, wavelet analysis

Introduction

The sea surface temperature dominates the exchange of heat with atmosphere, and exerts influence on the transfer of momentum and moisture affecting a wide range of sea motions. Discerning its spatial and temporal variability using in situ data alone is rarely easy, so spaceborne sensors are welcome to provide much needed repeatability and coverage. LeVourch *et al.* [1], for example, used AVHRR imagery to compile an atlas of the Mediterranean Sea fronts. More recently, Gacic *et al.* [2] used low resolution (18km) weekly averaged time series of AVHRR scenes to study seasonal and inter-annual variability of the Adriatic Sea surface temperature. Their analysis showed an absence of permanent surface thermal features, and revealed basin-scale four-seasonal variability. We report deliberations of an ongoing study better resolving both spatial and temporal variability in a longer (14 years) Adriatic AVHRR SST dataset. Improvement in resolving temporal change is sought by employing the wavelet analysis offering localisation in both time and frequency domains. The analysis is performed on EOF-derived time series of principal components of the surface temperature fields.

Data

The remotely sensed SST data set used in this study is an Adriatic subset of the NASA Seasonal to Interannual Prediction Project AVHRR global pentad SST set (kindly provided by Dr. Kenneth Casey). It was created by extracting the area spanning 12° to 20° East longitude, and 40° to 46° North latitude. The extracted subset comprised 1022 SST fields (14 years [1985-1998] x 73 pentads /year) each consisting of 1556 pixels. Not a single time-series had less than 70 gaps and only 28 series had more than 400 gaps. In order to fill in the gaps simple linear interpolation was performed on residuals after which the removed annual and semi-annual cycles were added back. To validate the subset we looked at 2 northern Adriatic in situ SST series spanning the same period.

Two-variant EOF analysis was applied, one with temporal and the other with spatial mean removed prior to further calculations. The EOF analysis allowed identification of orthogonal spatial patterns. It is tempting although not necessary to interpret the patterns as natural modes of variability of the studied fields. Projected onto those functions, the Adriatic SST fields yielded time series amenable to spectral analysis. For the wavelet analysis we have chosen the Morlet wavelet, well suited to capture the frequency content of a time series. It provides both the modulus measuring the energy density, and the real part commensurate with the intensity and phase of the signal varying in the time-frequency domain.

Results

Removal of the temporal and spatial mean from the original set has allowed pattern ranking by respective residual variance. In both cases the first EOF mode provided dimensionless and timeless dominant spatial patterns carrying respectively 98.5% and 66% of the total residual variance. Related time series of principal components provided temporal variability with two contributions standing out clearly: the annual and semi-annual harmonic, not surprising considering the influence of the annual solar cycle. An example CWT spectrum is presented in Figure 1, for the time-demeaned signal. The absolute value of the real part of the CWT spectrum is plotted. Also plotted is the cone of influence, which maps out the extent of the edge effects. The palette scale is logarithmic. The annual signal dominates the spectrum, but the figure also presents plenitude of other periodicities whose intensity changes with time. For example, removal of the annual and semi-annual harmonics prior to the CWT allows bi-annual component to surface, but also the irregularities near the six-month scale to present themselves. The CWT analysis performed on the space-demeaned series has also yielded spectrum with prominent annual signal.

Other revealing pieces of information can by gained by looking at the time series of band-integrated principal components. In both time-demeaned and space-demeaned cases intra-annual anomalies have been observed in 0-1.5 month band, with pronounced inter-annual variability in some years, e.g. 1989 vs. 1993 in case of time-demeaned series, or the year 1995 vs. 1996, in case of the space demeaned data. The intensity of the integrated signals in this shortest-period band generally reflected relation observed in the original residual series: about five times stronger signal remained after time demeaning than after prior removal of the spatial mean. Consistent amplitude difference was also observed in other bands, the 4 – 18 months in particular. Here the size of the time-demeaned amplitude was about an order of magnitude larger than the one for the space demeaned signal. The time-demeaned signal in this band exhibited more regular oscillation throughout the observed period, whereas the space-demeaned counterpart has shown more provocative irregularities in the second half of the observed period.

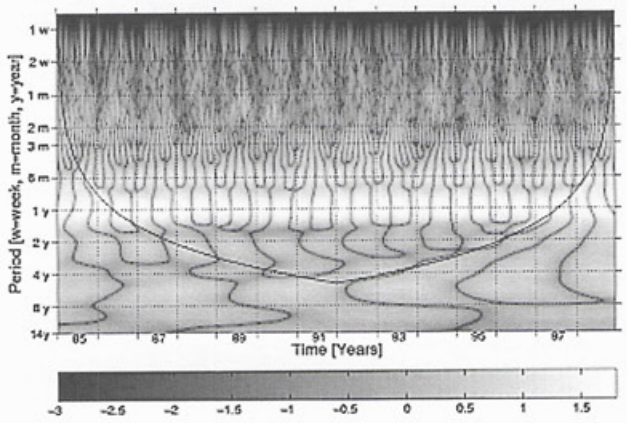


Fig. 1. CWT spectrum of the time demeaned series of principal components.

References

1 - LeVourch J., Millot C., Castagne N., LeBorgne P., and Olry J.P., 1992. Atlas of thermal fronts of the Mediterranean Sea derived from satellite imagery. Mem. Instit. Oceanogr. Monaco, No 16, 146 p.

2 - Gacic M., Marullo S., Santoleri R., and Bergamasco A., 1997. Analysis of the seasonal and interannual variability of the sea surface temperature field in the Adriatic Sea from AVHRR data (1984-1992). *J. Geophys. Res.*, 102C: 22937-22946.

DEEP WATER MASS VARIABILITY IN THE EASTERN MEDITERRANEAN

A. Lascaratos * and S. Sofianos

Ocean Physics and Modelling Group, University of Athens, University Campus, 15784 Athens, Greece

Abstract

The study of the hydrological properties of water masses in the Eastern Mediterranean revealed abrupt changes in temperature and salinity characteristics of the deep waters. Two events approximately twenty year apart "detach" from the general trends. They present different characteristics that may be due to the different location where the two events were originated. During the mid 60s and early 70s big changes occurred in the Levantine and spread to other basins of the Eastern Mediterranean (Levantine Transient), while during the late 80s and early 90s the Aegean Sea played a key role in the climatic event (Eastern Mediterranean Transient).

Key-words: Eastern Mediterranean Sea, Climatic Changes, Water-mass Characteristics

Introduction

Because of its small dimensions and the complicated topography which divides the basin in several sub-basins, the Mediterranean Sea response to atmospheric forcing is very rapid and on much smaller time scales than those of the global ocean. The recent Eastern Mediterranean Transient (EMT) which occurred in the late 80's and early 90's (1,2), is such an example of a rapid response of the eastern basin's thermohaline circulation and deep-water formation to changes in atmospheric forcing. A careful study of the deep water characteristics shows that this was not a unique case of abrupt changes in the Eastern Mediterranean Sea deep water masses. In order to identify climatic variability features and understand critical processes responsible for the observed variability, oceanographic datasets were analyzed and compared with meteorological data and process oriented model experiments.

Data

Temperature, salinity and density time series over the second half of the last century for the Levantine, Ionian and Cretan Seas were constructed using the MEDATLAS data base, which combines pre-existing databases such as the MODB data set, with more recent data. In this study we focus mainly on the deep water masses and the depth of 2000 *m* is selected as a reference level for deep water monitoring in the Levantine and Ionian basins while the depth of 1000 *m* for the Cretan Sea, which is not far from its mean depth and sill depths. The choice of depths reflects also the availability of data. Figure 1 presents the time series for the three basins.

Discussion

In the deep layers in all regions we can observe positive trends for all three parameters. But the most important feature is the saw-tooth jagged form of the time series revealing two major events, one centered in the mid-70s and the second one approximately 20 years later. The most recent is the well known EMT. The second one is detected in the 70s and concerns a considerable increase of salinity and density. It seems to be only salinity induced (the pulses in salinity are of the same order of magnitude in both cases, while the temperature does not show any signal as it does in the EMT), hence different from the EMT episode and is called Levantine Transient (LT).

The differences between the two events can be attributed to the different origin of the transient deep water masses. During the EMT dense waters of Cretan Sea origin are spreading to the adjacent basins altering the temperature-salinity characteristics of the deep layers (1,2). On the other hand, during the LT, the data indicate that the source lies in the Levantine basin. The formation of very dense waters in the Levantine basin may caused the uplifting of the deep water horizon The new state favored the intrusion of deep waters in the Cretan Sea, producing a decreasing trend in the temperature of the deep waters. With a few years delay the signal is observed in the Ionian basin. The signal resembles that of the Levantine but with weaker amplitude. Although data is not enough to describe the whole cycle of this event, the temperature-salinity anomalies fade rapidly (approximately 10 years).

Changes of the atmospheric forcing (3) and the water budget due to the Nile River dam construction (4), during the late 50s and early 60s the Eastern Mediterranean, are being investigated using meteorological data and process oriented modelling experiments. Such conditions may trigger changes in the thermohaline circulation and water mass formation processes resulting in formation of deep waters with unusual temperature-salinity characteristics. Model experiments showed that the Nile damming combined with cooling events can lead to formation of deep waters with higher salinity in the Levantine basin, compared with the characteristics of the Eastern Mediterranean Deep Water (5). Concluding, it is very interesting to notice the different forms of response of Eastern Mediterranean sub-basins to variability in the atmospheric forcing, underlining the sensitivity of the basin to natural and anthropogenic changes.

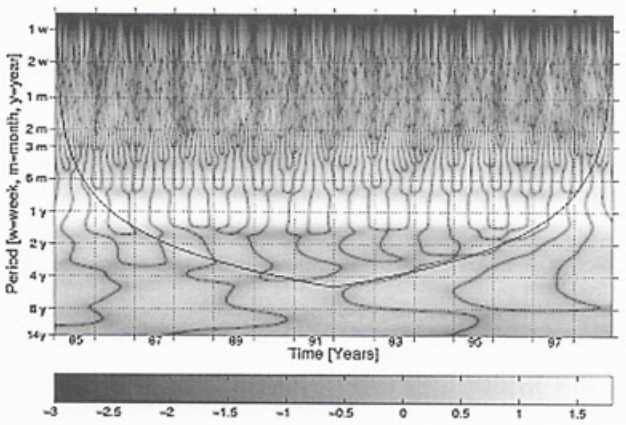


Fig. 1. Potential temperature, salinity and sigma-theta in (a) the Levantine basin (2000 m), (b) the Cretan Sea (1000 m), and (c) the Ionian Sea (2000 m).

References

1 - Roether, W., B. B. Manca, B. Klein, D. Bregant, D. Georgopoulos, V. Beitzel, V. Kovacevic, and A. Luchetta, 1996. Rceent changes in Eastern Mediterranean deep waters. *Science*, 271: 333-335.

2 - Lascaratos, A., W. Roether, K. Nittis, and B. Klein, 1999. Recent changes in deep water formation and spreading in the eastern Mediterranean Sea. *Prog. Oceanogr.*, 44: 5-36.

3 - Lascaratos, A., S. Sofianos, and G. Korres, 2002. Interannual variability of atmospheric parameters over the Mediterranean basin from 1945 to 1994. *CIESM Workshop Series,* nº 16: 21-23.

4 - Skliris, N., and A. Lascaratos, 2003. Impacts of the Nile River damming on the thermohaline circulation and water mass characteristics of the Mediterranean Sea. *J. Mar. Sys.*, under review.

SHALLOW WATER FRONTS, RIVER PLUMES AND STRONG FORCING- PRELIMINARY RESULTS FROM INTENSIVE SURVEYS OF THE NORTHERN ADRIATIC

Craig M. Lee [1]*, Burton H. Jones [3], Robert Arnone [2], Jason Gobat [1], Mauro Marini [4], Mirko Orlic [5], Zoran Pasaric [5], Hartmut Peters [6], Pierre Poulain [7], Dietmar Thaler [8], Damir Vilicic [5]

[1] Applied Physics Laboratory, University of Washingto, USA - * craig@apl.washington..edu
[2] Naval Research Laboratory, Stennis Space Center, USA
[3] Department of Biology, University of Southern California, USA
[5] University of Zagreb, Croatia
[6] Rosenstiel School of Marine and Atmospheric Science, University of Miami, USA
[7] L'Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy
[4] Consiglio Nazionale delle Ricerche, Istituto di Scienze Marine-Sezione Pesca Marittima, Ancona, Italy
[8] Austrian Military Weather Service, Austria

Abstract

Quasi-synoptic, three-dimensional surveys of physical and optical variability characterize the mesoscale features that dominate the Northern and Central Adriatic, following their response to strong forcing events. During winter (February), sampling emphasized the response to episodic Bora wind events. Although springtime (May) measurement program was designed to sample during the Po River spring freshette, freshwater discharge rates were more than a standard deviation below the 12-year mean and winds remained weak throughout the survey period, leading to a study of weakly forced dynamics in a strongly stratified, shallow water regime. Wintertime sampling included surveys of a strong shallow-water front and a prominent extension of the Po River plume. The surveys captured the evolution of a nearly vertical, compensated front that tilts as the strong Bora winds weaken. A broad survey of the northern basin characterized the structure of a Bora-driven Po plume extension and reveals cyclonic (anticyclonic) circulation to the north (south) of the plume, consistent with the response found in previous numerical experiments.

Key Words: Adriatic Sea, fronts, mesoscale, optics, watermass formation

Introduction

Winter and spring surveys executed as part of the U.S. Office of Naval Research sponsored DOLCE VITA (Dynamics Of Localized Currents and Eddy Variability In The Adriatic) Experiment focused on the response of mesoscale fronts and filaments to strong atmospheric forcing by Bora events and riverine buoyancy input. Wintertime sampling extended from 31 January to 24 February and included three strong Bora events. The spring field program took place between 26 May and 15 June, during a period of weak wind forcing. Although the springtime surveys were timed to coincide with the climatological Po River spring freshette, May 2003 discharge rates were over one standard deviation below the 12-year mean. In the absence of strong forcing, small-scale internal variability dominated the northern and central Adriatic.

Methods

Directed by real-time satellite remote sensing (sea surface temperature and ocean color) and dedicated synoptic meteorological forecasts, we employed an adaptive sampling strategy to characterize the evolution of selected mesoscale features through periods of strong wind and buoyancy forcing (Fig. 1). Repeated, quasi-synoptic surveys using a hybrid SeaSoar (TriSoarus) towed profiling vehicle provided full-depth, three-dimensional measurements of physical and bio-optical variability. Along-track resolutions ranged between 200 – 1500 m (depending on profile depth), with typical cross-track separations of 3 km. Additional measurements included velocity and turbulence profiles from a 5-beam, bottom moored ADCP, hydrographic stations (nutrient, pigment and phytoplankton analysis), optical profiles, microstructure profiles and short-term surface drifter deployments.

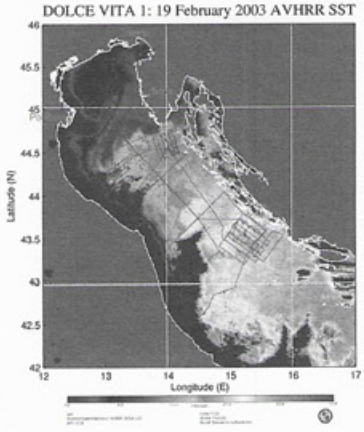


Fig. 1. Remotely sensed AVHRR sea surface temperature (23 February) with a black line marking the wintertime survey track.

Preliminary results

Prominent features present during the wintertime measurement period included a strong front extending westward from the tip of the Istrian peninsula (visible primarily in sea surface temperature, Fig. 1) and an extension of the Po River plume that stretched northeastward from the river delta to the Istrian coast (visible in both ocean color and sea surface temperature imagers). During one strong Bora wind event, sampling focused on the strong shallow water (50 m) 'Istrian front'. Frontal temperature and salinity contrasts were largely compensating and occurred over extremely small scales (1 °C over 100 m). The interface remained nearly vertical during the period of strong wind forcing, but began to tilt as the winds subsided. This could be driven by slumping, distortion by shear in the upper layer flow or distortion by the deep offshore-moving return flow that balances wind-driven downwelling off the tip of Istria. A narrow band of anomalously dense water occupied the frontal interface. Elevated levels of chlorophyll fluorescence and beam attenuation were also associated with the dense-water regions. Although cabelling can produce density anomalies across sharp temperature-salinity interfaces, the observed density contrasts are too large to be explained by this mechanism alone. The associated optical signal and strong westward flow along the front hint that advection may play a role in establishing the observed density structure.

Another set of intensive surveys sampled the double gyre pattern and eastward (upwind) extension of Po River water generated by windstress shear between the two Bora jets that extend from Trieste and Senj [1]. A filament of Po River water reaches across the basin to the Istrian coast, beginning as a narrow, buoyant plume that broadens and weakens with distance from the Po delta. A broadscale survey revealed cyclonic circulation in the northern basin, with an anticyclonic gyre occupying the region south of the Po extension, consistent with expectations derived from numerical results. In contrast to our expectations that barotropic, basin-scale features would dominate wintertime variability, towed profiling surveys revealed energetic small- and meso-scale features that evolved rapidly in response to atmospheric forcing..

Acknowledgements

We thank Captain Colburn, Captain Silva, and the crew of the R/V Knorr for their skilled, enthusiastic assistance. Dr. Vlasta Tutis and colleagues at the Croatian Meteorological Service provided custom forecasts and access to their data. Tim McGinnis, Eric Boget and Marlene Jeffries kept TriSoarus running under difficult conditions. Lindsay Pender and colleagues at CSIRO generously shared their knowledge and engineering expertise to assist with SeaSoar modifications. This research has been supported by the Office of Naval Research.

References

1 - Orlic, M., M. Kuzmic, and Z. Pasaric, 1994: Response of the Adriatic Sea to the bora and sirocco forcing. *Continental Shelf Research*, **14:** 91-116.

ASTRONOMICAL AND METEOROLOGICAL TIDE DESCRIPTION IN THE CATALAN COAST.

López J. [1] *, Espino M. [1], Martínez-Benjamín J.J. [2], Sánchez-Arcilla A. [1]

[1] Laboratori d'Enginyeria Marítima, Universitat Politècnica de Catalunya, Campus Nord, Mòdul D1, c/ Jordi Girona 1-3, 08034 Barcelona, Spain - * jaime.lopez-marco@upc.es

[2] Departamento de Física Aplicada. , Universitat Politècnica de Catalunya, Campus Nord, Mòdul D1, c/ Jordi Girona 1-3, 08034 Barcelona, Spain

Abstract

Due to small tidal induced sea level variations [1], the Mediterranean Sea is an attractive site to calibrate and validate altimeter data from the TOPEX/POSEIDON and JASON satellites. Hence, the need to determine accurate sea level variations and to better estimate different components that contribute to sea level variability. The objectives of this study are therefore, to associate sea level variations with astronomical tide, to determine and to quantify the atmospheric forcing that cause these sea level variations.

Keywords: sea-level, Mediterranean, tides.

Introduction

Time series of sea level in the Catalan Sea, provided by the l'Estartit harbour tide-gauge, operational since 1990, and the XIOM net tide-gauges set in la Ampolla and San Carles de la Ràpita harbours both operational since 1997, was used. From these time series the study of sea level variation was divided in several phases.

The first phase consists in following the evolution of the mean daily, monthly and annual sea level values. Second phase includes the harmonic analysis of the tide-gauges data to determine the harmonic components of the astronomical tide. After obtaining a tide prediction and a meteorological residual, an analysis to compare residual with the atmospheric pressure effect, known as inverted barometer effect, was made. In the dates that, the previous effect, did not adjust to the residual, a wind analysis will take place, in order to determine the cause of this non-pressure residual.

Mean daily, monthly and annual value analysis

From these analyses, there are two interesting conclusions to comment. An annual cycle of sea level with maximum mean sea level values in autumn (October and November) and the minimum mean values in winter (February and March). This annual cycle can be explained by the steric component, ocean dynamics and upper layer heat variability as commented in [2].

Moreover, we can also observe a small ascent of the annual mean sea level in the Catalan Coast through the years, although we can find two abnormally high mean sea levels for the years 1996 and 1997.

Tidal harmonic components analysis

From a least-squares fit between the time series and the frequencies associated to the astronomical movements, done with the Foreman method [3] and with the T_TIDE program [4], the amplitudes and phases of the harmonic tidal constants have been found and quantified. The same has been done with 95% confidence interval for both amplitude and phases of the harmonic tidal components. The most important harmonic components found for the Catalan Coast are, in decreasing importance order: M2, K1, O1, P1, S2 and N2 (Table 1). The amplitudes associated to each one of the previous components are smaller than 5 cm. We can also find large period components with similar amplitude order than M2 component.

Component		Estartit	Ampolla	San Carles
M2	Amplitude (cm)	5.37	3.68	3.12
	Phase	307.33	237.78	237.67
K1	Amplitude (cm)	2.96	3.07	3.10
	Phase	190.56	172.65	166.85
O1	Amplitude (cm)	1.72	1.92	1.89
	Phase	172.08	123.62	123.90
P1	Amplitude (cm)	1.08	1.24	1.21
	Phase	180.86	166.90	155.41
S2	Amplitude (cm)	1.78	1.00	0.80
	Phase	270.44	242.04	244.10
N2	Amplitude (cm)	1.11	0.88	0.73
	Phase	272.65	222.88	215.89

The components with semidiurnal frequencies have an interesting behaviour. The amplitudes associated to these components increase their values from South to North along the Catalan Coast. However the diurnal components do not present a clear behaviour and remain near constant values along the Catalan Coast. This behaviour is also observed in other tide-gauges [5]. This change in the amplitudes of the semidiurnal harmonic components produces a change in the Form Factor (F) value,

$$F = \frac{A(K1) + A(O1)}{A(M2) + A(S2)}$$

which increases its value southward.

Once we have the amplitudes and phases of the harmonic components, we can predict the tide. This prediction fits quite well to the real measured sea level time series. But there is a difference between them, this difference is known as meteorological tide, and can be caused by atmospheric forcing like atmospheric pressure or wind stress.

Inverted Barometer Effect and wind stress analysis

With the atmospheric pressure data obtained from the meteorological stations placed very close to the tide-gauges, the inverted barometer effect [6] has been calculated to obtain the relation with the meteorological residual. There is a clear relation and a good fit between both, meteorological residual and inverted barometer effect, nevertheless there are still some periods in which the difference between the two parameters are still important.

To determine the cause of these differences, it is necessary to analyse the wind systems of those periods to obtain the main direction, mean velocity and hence, the wind stress in each period. The goal of this study is to calculate the relation between the wind stress and the remaining meteorological residual. All this work will allow us to know the effect of the distinct storms in the Catalan Coast and to be able to forecast with great accuracy sea level changes in this part of the Mediterranean Sea.

References

[1] Tsimplis, N.T., Proctor, R. and Flather, R.A., 1995. A two-dimensional tidal model for the Mediterranean Sea. *J. Geophys. Res.,* 100(C8) 16: 223-16,239.

[2] Bouzinac, C. J. Font, and J. Johannessen, 2003. Annual cycles of sea level and sea surface temperature in the western Mediterranean Sea. *J. Geophys. Res.,* 108(C3): 3059.

[3] Foreman M. G.G., 1979. Manual for tidal heights analysis and prediction, Pacific Marine science report 77-10, Institute of Ocean Sciencies, Patricia Bay, Victoria, B.C.

[4] Pawlowicz, R., B. Beardsley, and S. Lentz, 2002. "Classical Tidal "Harmonic Analysis Including Error Estimates in MATLAB using T_TIDE", Computers and Geosciences, 28: 929-937.

[5] Annual Reports of the Spanish tides from Ente Público Puertos del Estado. www.puertos.es.

[6] Le Traon, P-Y. and Gauzelin, P., 1997. Response of the Mediterranean mean sea level to atmospheric pressure forcing. *J. Geophys. Res.,* 102(C1): 973-984.

IS THE ALTERNATIVE LIW PATH BECOMING MORE IMPORTANT?

López-Jurado J.L. [1], Vélez-Belchí P. [2 *], González-Pola C. [3], Vargas-Yáñez M. [4]

[1] Instituto Español de Oceanografía, C.O. de Baleares, Muelle de Poniente s/n, 07080 Palma de Mallorca, Spain - lopez.jurado@ba.ieo.es
[2] Instituto Español de Oceanografía, C.O. de Canarias, crta de San Andrés N°45, 38180 , S/C Tenerife, Spain - * pedro.velez@ca.ieo.es
[3] Instituto Español de Oceanografía, C.O. de Gijón, Avda. Príncipe de Asturias 70 bis, 33212 Gijón, Spain - cesar.pola@gi.ieo.es
[4] Instituto Español de Oceanografía, C.O. de Malaga, Puerto Pesquero de Fuengirola s/n, 29640 Fuengirola (Málaga), Spain - manolo.vargas@ma.ieo.es

Abstract

During July 2003, intense (38.60) signal of LIW was found south of the Balearic archipelago. Comparison with historical data shows as this high LIW values in the Algerian basin have not been found before. This new data rise up the question about the importance of this alternative path for the LIW transport into the western Mediterranean sea.

Keywords: LIW, Algerian Basin, circulation

The principal path of the LIW in the western Mediterranean sea is following a cyclonic loop that begin in the strait of Sicily, surround western Italy, Corcega Sardinia, the French coastline and the Spanish one until they arrive to the Alborán Sea. Completing the loop some waters also flow back eastward along the Algerian coastline. In spite the many studies done in the Algerian Basin, a direct path of LIW from the channel of Sardinia to the Alborán Sea have not been found, neither Leddies due to the LIW vein becoming unstable near the southwestern corner of Sardinia [1,2]. On the other hand, some data corroborates the second route for the transport of LIW westward through the Algerian basin. As hypothesized by [3], eddies from the Algerian current could catch LIW near the Strait of Sardinia and drift it westward. This overall circulation at intermediate depths is clearly observed for the Algerian Basin in figure 1, where the distribution of the salinity maximum for the historical data (Medatlas, 2002), with the box delimitated by 0°W,8W and 38°N, is represented. The maximum salinity is found in the neighbourhood of the Strait of Sardinia (S>38.66), decreasing westward, with its axis along the centre of the basin. This structure is associated with the secondary route for the LIW [3],[4].

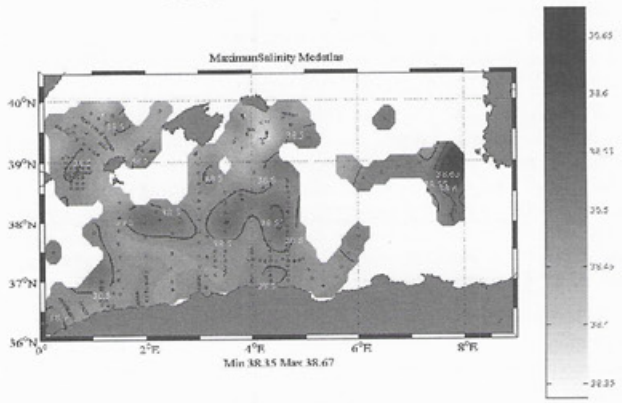


Fig. 1. Horizontal distributions of the salinity maximum for all CTD profiles from the Medatlas 2002 database found within the box delimited by 0°W-8W, 40°N and the northern African coast.

During July 2003 the Tunibal0703 survey was carried out, by the Instituto Español de Oceanografía, on the waters surrounding the Balearic Archipelago. CTD data during this survey was obtained with a SBE-911+, and post-cruise calibration was carried out with salinity bottles an a AutoSal-Guideline salinometer, yielding standard WOCE accuracy for salinity. For redundancy two stations were carried out with a SBE-25 attached to the SBE-911+, yielding differences within the technical specifications of the sensors.

The intermediate circulation in the northern Algerian Basin during Tunibal0703 shows a pattern of LIW with maximum salinity values up to 38.60 and temperatures up to 13.6°C, as can be observed in figure 2, where the distribution of the salinity maximum during that survey is represented. The depth of this maximum is generally between 300 and 600 Dbar. Southern than Mallorca the high salinity values appear. The data in the upper layer (not shown), denote strong anticyclonic circulation and waters of atlantic origin, therefore indicating a possible source for these LIW: drifted from the strait of Sardinia by an anticyclonic Eddie formed in the Algerian current. The horizontal distribution of maximum salinity depth and dissolved oxygen at this surface denote a frontal zone for clearly different LIW. The importance of the data presented here resides in that this high values have not been found before in the western Algerian basin. Therefore, it could be that the role of this alternative LIW path were more important as thought before, as indicated by the data gathered during the similar surveys carried out in 2001 and 2002 summer, where LIW salinities of 38.53 and 38.55 were observed in the same area. Or even that the discussion of 'Leddies' could be open again.

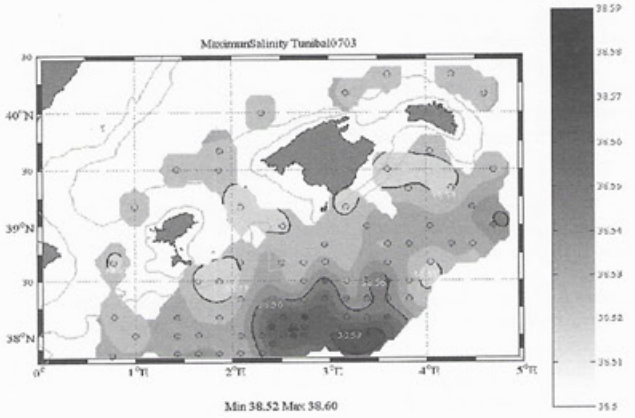


Fig. 2. Horizontal distributions of the salinity maximum found during Tunibal0703.

References

1 - Benzohra, M. and C. Millot, 1995. Characteristics and circulation of the surface and intermediate water masses off Algeria, *Deep-Sea Research (Part I)*, 42: 1803-1830

2 - Fuda, J. L., C. Millot, I. Taupier-Letage, U. Send, and J. M. Bocognano, 2000. XBT monitoring of a meridian section across the western Mediterranean Sea, *Deep-Sea Research (Part I)*, 47: 2191-2218.

3 - Millot, C., The circulation of the Levantine intermediate water in the Algerian Basin. *J. Geophys. Res.*, 92: 8265-8276.

4 - Perkins, H. and P. Pistek, 1990. Circulation in the Algerian Basin during June 1986. *J. Geophys. Res., C.Oceans*, 95: 1577-1585.

COASTAL GEOSTROPHIC FLOW IN THE NORTHEASTERN ADRIATIC: JUNE-SEPTEMBER 2003

Daniel M. Lyons *, Nastjenjka Supić, Nenad Smodlaka

Center for Marine Research, Rudjer Bošković Institute, G. Paliaga 5, 52210 Rovinj, Croatia - supic@cim.irb.hr

Abstract

High resolution CTD data collected during 18 cruises from June to September 2003 are used here to compute relative geostrophic currents in the northeastern Adriatic coastal belt. Results indicate a strong southerly outflow in the area throughout the whole period investigated, suggesting a current that flows counter to the accepted general cyclonic circulation of the Adriatic.

Keywords: CTD, geostrophic circulation, northern Adriatic

Introduction

General Adriatic circulation consists of a cyclonic meander with an inflow along the eastern and outflow along the western coast (1). However, results of recent investigations indicate a more complex system where a very strong outflow can occur in the northeastern coastal zone during the warm part of the year, near the Istrian peninsula. These previous studies are based on direct current measurements at several points in the area (2) or on analysis of geostrophic currents derived from low resolution hydrographic data collected monthly at several depths at two stations 24 km apart (3). However, in order to describe the circulation pattern near the northeastern coast of the Adriatic more precisely we report herein an analysis of geostrophic currents, known to be a good approximation of real currents in the area during the warm part of the year (4), computed on the basis of fine resolution hydrographic data as a means for determining the initial conditions before deep water formation processes begin in autumn and winter.

Data and methods

CTD (SeaBird SBE 25) data were collected over a 19 station grid during 18 cruises from June to September 2003 off the Istrian coast of Croatia (Fig. 1). Geostrophic currents, relative to the 20 m depth level, between each two neighboring stations were computed using standard mathematical methods (3) and elaborated graphically using the ODV software package.

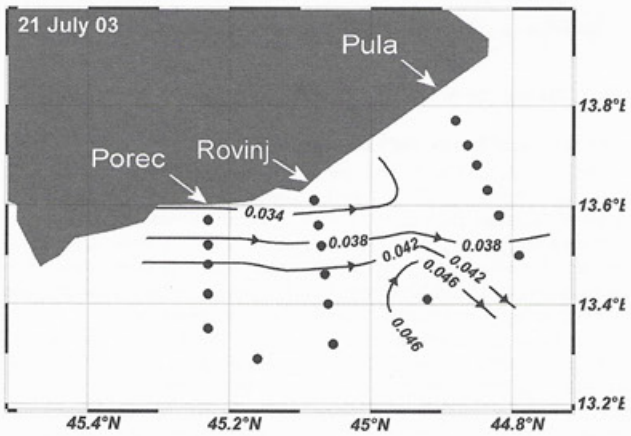


Fig. 1. Oceanographic stations and dynamic heights (dyn m) at 2 m depth relative to the 20 m level.

Results

Dynamic height variations, represented as iso-lines at 2 m depth, indicate a southerly outflow throughout the period concerned, with weekly variations in intensity and extent. On several occasions – as for example on 21 July 2003 - the outflow was strong along the whole western coast of the Istrian peninsula (Fig. 1). Generally, northward movement of water was observed in vertical profiles at all depths corresponding to the mesoscale cyclonic circulation of the Adriatic. However, a southerly outflow of water counter to the normal circulation, localized to a layer extending from the surface to 15 m depth and located close to the coast in a 10 km belt, prevailed at all sections. Relative geostrophic velocities for the Poreć and Rovinj (Fig. 2) profiles typically attained values of about 10 cm s^{-1} for outflow while inflow velocities were about 2 cm s^{-1}. Motions at the Pula section were stronger (typically from 2-5 cm s^{-1} for inflow, and 10-20 cm s^{-1} for outflow) compared to the other sections. This indicates the appearance of a current moving in a southerly direction in the coastal zone off Istria, previously named the Istrian Coastal Countercurrent (ICCC; 3). It is held that the ICCC is part of a closed anti-cyclonic circulation cell in the northern Adriatic in which waters of Po origin are restricted (4). Unusually, this lower salinity pool was also observed in northeastern Adriatic open waters in spring and summer of 2003 in spite of exceptionally low Po discharge rates (D. Degobbis, personal communication).

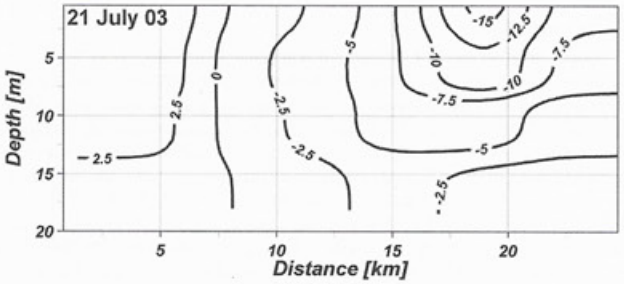


Fig. 2. Vertical profile of the Rovinj section showing relative geostrophic velocities (cm s^{-1}) with respect to the 20 m level. Negative sign denotes southward flow.

Conclusion

Using high resolution temperature and salinity data in the interval from June-September 2003 document in detail for the first time the location, extent and relative magnitude of counter currents to the normal circulation over a large area adjacent to the Istrian coast. Our results show that during the interval concerned there was an almost permanent, or highly prevailing, southerly anti-cyclonic alongshore flow in the region, becoming greater in magnitude towards the south, and may bound a low salinity pool in the middle northern Adriatic.

References

1 - Franco P., and Michelato A., 1992. Northern Adriatic Sea: Oceanography of the Basin Proper and of the Western Coastal Zone. *Sci. Total Environ.*, Suppl.: 35-62.

2 - Brana J.H., and Krajcar V., 1995. General Circulation of the Northern Adriatic Sea: Results of Long-term Measurements. *Estuar. Coast. Shelf Sci.*, 40: 421-434.

3 - Supić N., Orlić M., and Degobbis D., 2003. Istrian Coastal Countercurrent in the year 1997. *Nuovo Cim. C*, 26: 117-131.

4 - Krajcar V., Supić N., and Kuzmić M., 2003. Referencing geostrophic velocities at a northern Adriatic section. *Nuovo Cim. C.*, in press.

MEDATLAS 2002: DATABASE AND DATA MANAGEMENT SYSTEM FOR THE LONG TERM MONITORING OF MEDITERRANEAN AND BLACK SEAS

C. Maillard [1] *, E. Balopoulos [2], N. Mikhailov [3], M. Fichaut [1], G. Maudire [1], M-J. Garcia [4], B. Manca [5], A. Giorgetti [5], A. Iona [2], M. Rixen [6], and The Medar Group

[1] IFREMER, Centre de Brest, BP 70, 29280 Plouzané, France - * Catherine.Maillard@ifremer.fr.
[2] HCMR, P.O. Box 712, 190 13 Anavyssos, Greece - efstathios.balopoulos@hnodc.ncmr.gr.
[3] RIHMI-WDC, Kaluga Region, Obninsk 024020, Russia - nodc@meteo.ru.
[4] IEO, c. Corazon de Maria 8, Madrid, Spain - MJesus.garcia@md.ieo.es.
[5] OGS, Borgo Grotta Gigante, Trieste 34010, Italy - manca@ogs.trieste.it.
[6] GHER, Univ. de Liege, BE4000, Liege, Belgium - M.Rixen@ulg.ac.be.

Abstract

The EU concerted action MEDAR/MEDATLAS-II, was launched in 1998 with the overall objective to make available a comprehensive data product of multi-disciplinary in-situ data and information in the Mediterranean and Black Sea, through a wide co-operation of the bordering countries. The resulting integrated multidisciplinary database MEDATLAS 2002 includes observed data collected over more than one century and gridded climatological fields and maps. This database has been published on CDrom to facilitate its use. New actions are in preparation to improve the data services by offering an integrated and continuously updated data access on internet.

Key words: Mediterranean, Black Sea, Oceanography, Chemicals, Database

Introduction

Long time series of marine observations are required for many studies, especially to follow up changes in the seawaters, to manage living and non-living marine resources and to make predictions. Many scientific laboratories collect such data, but in most cases they remain dispersed in heterogeneous formats and systems. Their access is difficult, and due the lack of appropriate archiving, they are frequently in danger to be lost. The IOC "Global Ocean Data Archaeology and Rescue (GODAR)" programme has been launched to rescue and disseminate the dispersed data. Two pilot projects MODB and MEDATLAS (1994-1997) initiated the Mediterranean and Black Sea regional module of GODAR. These projects were followed by a wider EU concerted action MEDAR/MEDATLAS-II, launched in 1998 with the overall objective to make available a comprehensive data product of multi-disciplinary in-situ data and information in the Mediterranean and Black Sea, through a wide co-operation of the bordering countries. The data management was focused on basic parameters that influence the biodiversity and the primary production and for which sufficient preliminary knowledge of the distributions were available to allow quality checks to be performed. These selected parameters were: Temperature, Salinity, Oxygen, Phosphate, Silicate, PH, Nitrate, Nitrite, Ammonium, Chlorophyll, Alkalinity, Total Phosphorus, H_2S, Total Nitrogen. This paper present a brief overview of the resulting data and products and new actions in preparation to improve the Mediterranean data servicing.

Data processing

The 17 oceanographic data centres of the MEDAR consortium have compiled historical and recent data from 150 source laboratories of 33 countries. The integrated database has been prepared by using a common protocol (1) for formatting the data and checking them for quality in agreement with the international standards of ICES, IOC and EC/MAST. Accordingly automatic (objective) and visual (subjective) checks have been performed, which result in a quality flag added to each numerical value: location, date and data points, respectively. These checks have been performed at four Regional Data Centres, while the Global Assembling Centre finalized quality and duplicates checks. Several up and down transfers of subsets of data between the data centres have been necessary before getting a fully qualified integrated data set. The resulting volume of data has doubled compared to 1997 database. It includes now 161 877 vertical profiles of temperature form bathythermographs and thermistor chains and 124 002 multi-parameters profiles from CTD and bottle casts. However the number of profiles is very variable from a parameter to another, and besides temperature and salinity (118 009 profiles, Fig. 1), the highest numbers of available profiles are for oxygen and phosphate (44 928 and 20 761 respectively).

The qualified data were used to produce higher-level products providing a more complete and synthetic view of the bio-chemical systems. Climatological and gridded fields were computed by using the Variational Inverse Model (2), on finite elements and then re-interpolated on a regular grid (0.2 degrees in Latitude and Longitude), with smaller scales for local computations. The computations were made on a climatic, seasonal or monthly scale when the space and time data coverage were sufficient. The gridded fields have been mapped horizontally and vertically. On these maps the main features of the region, such as the Atlantic inflow and the Levantine meso-scale eddies appear very clearly at the resolution of the computation.

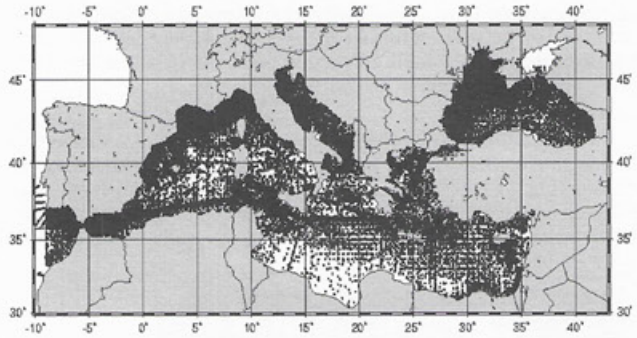


Fig. 1. Distribution of the 118 009 salinity profiles

Present and future data services

MEDATLAS 2002 (3) disseminated by the MEDAR network, is the resulting database published in the form of a set of four CDRoms in order to facilitate the access to data. It includes meta-data, observed and gridded data, maps, vertical sections, user friendly software to extract, visualise, plot, check for quality and process data. It is presently the best available integrated database for the Mediterranean and Black Seas, and a real scientific and educational tool.

Still there are needs for getting similar possibilities on line, for getting new data sets and products such as mean, decadal, seasonal, monthly statistics at basin, regional and shelf scales and for developing the quality assurance protocols for bio-chemicals and gridded products. Therefore new projects are in preparation (MEDBLACK-ODN and SEA-DATANET), intending to provide the needed integrated services through the networking of national data centers, enhanced capacity building activities and better public awareness on the data heritage.

MEDAR Group acknowledgement with thanks the laboratories, which contributed to the database, the organisations and EU (contract MAS3-CT98-0174/ERBIC20-CT98-0103), which provided the financial support for the project.

References

1 - MEDAR Group, 2001. Medar-Medatlas Protocol *(Version 3)* Part I: Exchange Format and Quality Checks for Observed Profiles; Rap. Int. IFREMER/TMSI/IDM/SIS002-006, 50 P.

2 - Rixen, M., Beckers, J.-M., Brankart, J.-M., and Brasseur, P., 2001. A numerically efficient data analysis method with error map generation. *Ocean Modelling*, 2(1-2): 45-60.

3 - MEDAR Group, 2002. MEDAR/MEDATLAS 2001 Database. Mediterreanean and Black Sea cuise Inventory, Observed Data, Analysed Data and Climatological Atlas, IFREMER Ed. (4 Cdroms).

RISE OF EFFLUENT FROM AN UNDERWATER SEWAGE DIFFUSER IN THE SOUTHERN PART OF THE GULF OF TRIESTE (NORTHERN ADRIATIC) DURING THE BORA EVENT

Vlado Malacic

National Institute of Biology, Marine Biology Station, Piran, Slovenia - malacic@mbss.org

Abstract

Initial dilution and rise of effluent from diffusers of a submarine sewage outfall for the town of Piran (15000 PE) is simulated with a numerical model. CTD vertical profiles conducted during the 'Bora' wind in autumn of 1997 were re-analysed by calculating the overturning length scale. The tail of the patch of the overturning length scale is roughly elongated in the direction of the inflow into the Gulf of Trieste, and the height of its peak coincides with the height of the peak of bacteria, as well as with the height of a plume predicted by the numerical model.

Keywords: overturning length scale, sewage dilution

The sewage outfall for the town of Piran accounts for only 7% of the sewage load that arrives in the Gulf of Trieste (1). The statistics of the analysis of eight dominant nutrient compounds during 1997-1999 showed that only ammonia followed the increase of bacteria (2) in a layer of neutral buoyancy, with a correlation factor of 0.58. There was no significant correlation between bacteria and the fluorescence signal, nor with dissolved oxygen, both being recorded with the multiparameter CTD probe. The initial rise and dilution was modeled numerically with a calibrated model (3), that was previously applied in the planning of future discharges (4).

Vertical CTD profiles conducted during the survey that took place on the autumn morning of 26 September 1997, during the 'Bora' wind, were re-analysed by calculating the overturning length scale. The Bora wind forced the convection, as well as the horizontal circulation. The overturning length scale was calculated from temperature, salinity and from density vertical profiles that were obtained with a fine-scale CTD probe that retrieves the data with a vertical resolution of 2.5 cm during the free-fall. Results of the numerical model for the initial rise of effluent were compared with the vertical distribution of faecal coliforms at the central position of the near-field, as well as with the distribution of the overturning length scale.

The distribution of the overturning length scale was affected by the forced convection that originated at the sea-surface. However, there are indications that there was a core of turbulent effluent at the pycnocline above the bottom boundary layer, where a local maximum of the overturning length scale was found. The depth of the subsurface local peak of the overturning length scale, that is calculated from the density profile in the center of the sewage near-field, matches with the depth of the peak of faecal coliforms, and with the height of the simulated plume rise. The 3D space distribution of the overturning length scale indicates a spread of a structure with enhanced overturning activity below the surface mixed layer over an area of 1 km^2, and could be attributed to an effluent that erupts turbulently from diffusers.

Wind and current-meter observations during winter 2002-2003 have shown that a wind driven circulation during the Bora has an outflow current in a thin surface layer in the direction of the wind. Below is an inflow of the water mass in the Gulf of Trieste, that governs the transport of the water mass through the water column. The distribution of the overturning length scale confirms that the effluent, which remains well below the surface spreads in this direction of the inflow.

References

1 - Olivotti, R., Faganeli J., and Malej A., 1986. Impact of 'organic' pollutants on coastal waters, Gulf of Trieste. *Water Sci. Technol.*, 18: 57-86.

2 - Mozetič, P., Malačič V., and Turk V., 1999. Ecological characteristics of seawater influenced by sewage outfall. *Annales*, 9: 177-190.

3 - Malačič, V. 2001. Numerical modelling of the initial spread of sewage from diffusers in the Bay of Piran (northern Adriatic). *Ecol. Model.*, 138: 173-191.

4 - Malačič, V., Petelin, B., Vukovič A., and Potočnik, B., 2000. Municipal discharges along the Slovenian littoral (the northern Adriatic Sea) - community planning and the environmental load. *Period. Biol.*, 102: 91-100.

DENSE WATER FORMATION IN THE SOUTHERN ADRIATIC SEA ASSOCIATED WITH VARIATIONS OF THE THERMOHALINE CIRCULATION IN THE IONIAN SEA DURING 2001-2002

Beniamino B. Manca [1 *], Giuseppe Civitarese [2], Birgit Klein [3], and Maurizio Ribera d'Alcalà [4]

[1] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico (Trieste), Italy
* bmanca@ogs.trieste.it

[2] Istituto Scienze del Mare, Sezione di Trieste, Trieste, Italy, g.civitarese@ts.ismar.cnr.it

[3] University of Bremen, Institute of Environmental Physics, Bremen, Germany, bklein@physik.uni-bremen.de

[4] Stazione Zoologica 'A. Dohrn', Napoli, Italy, maurizio@alpha.szn.it

Abstract

Hydrographic observations conducted in the southern Adriatic and Ionian Seas during 2001-2002 asses the role of the Adriatic in driving the deep/internal thermohaline circulation of the Eastern Mediterranean. The concurrent presence of key elements in the southern cyclonic gyre (i.e. strong atmospheric forcing and the exposure of highly saline waters at surface) and the arrival of dense waters from the northern shelf caused the deep ventilation of the bottom layer. The mixing between the pre-existent 'older' deep waters and the new discharged one has been estimated, along with the salt contents and some biochemical elements budgets, following the transient event.

Keywords: Adriatic Sea, deep convection, thermohaline circulation

Introduction

The factors controlling the dense water formation in the Adriatic Sea have been largely studied using field observations and modelling simulations [1]. Dense water formation events occur in the southern Adriatic Sea by open-ocean deep convection because of winter outbreaks of northerly cold air masses and of highly saline waters from the Eastern Mediterranean that regularly intrude into the Adriatic Sea at the intermediate layer. Dynamic topography maps based on individual hydrographic cruises have shown consistently a topographically controlled baroclinic cyclonic circulation and periodical exposures at surface of highly saline waters [1], often associated with vigorous air-sea interactions during the winter. However, the deep ventilation of the bottom layer has not been observed during the last two decades. The overall objective of this work is to assess the regained role of the Adriatic Sea as site of dense water formation for the Eastern Mediterranean, which was temporarily reduced during the ascendant and the mature phase of the Eastern Mediterranean Transient (EMT).

Results and Discussion

The data used for this study were collected during late winter in March-April 2002 in the Adriatic-Ionian region within the SINAPSI (Seasonal, INterannual and decAdal variability of the atmosPhere, oceanS and related marIne ecosystems) national programme. The field investigations have indicated a prevailing increase of the salinity in the Southern Adriatic Sea according to the spreading of the highly saline Cretan Intermediate Water [2], which intruded into the Adriatic Sea. In the Southern Adriatic gyre, the deep ventilation of the bottom layer (1200 m) have been observed along with a density-driven bottom current transporting less saline, cold and highly ventilated dense water into the deep Ionian basin.

Figure 1 shows the vertical water-mass structure in the Southern Adriatic gyre, exemplified by the salinity, oxygen and beam attenuation coefficients measured by means of transmissometer. These observations indicate: (i) the presence of highly saline water masses at surface (S>38.80), consistent with changes in the Eastern Mediterranean circulation; (ii) the deep convection in the centre of the cyclonic gyre exemplified by the deep ventilation down to 800-1000 m (O_2 > 5.35 ml/l); and (iii) the presence of a highly ventilated water mass (O_2 > 5.40 ml/l) in the bottom layer, presumably cascading from the shelf/slope. This interpretation is further confirmed by an increase of suspended material in the bottom layer because of the re-suspension of the sediment as the water mass is cascading along the shelf/slope.

In synthesis, in 2002 the dense waters that reside in the deep southern Adriatic reservoir were renewed. However, the deep convection did not reach the bottom layer, allowing us to conclude that the signal of the ventilation of the bottom waters is associated with a large contribution from the northern shelf region. As concluding remark we can say that it took almost one decade from the maximum manifestation of the EMT for the Adriatic Sea to resume the leading role for the dense waters production of the Eastern Mediterranean.

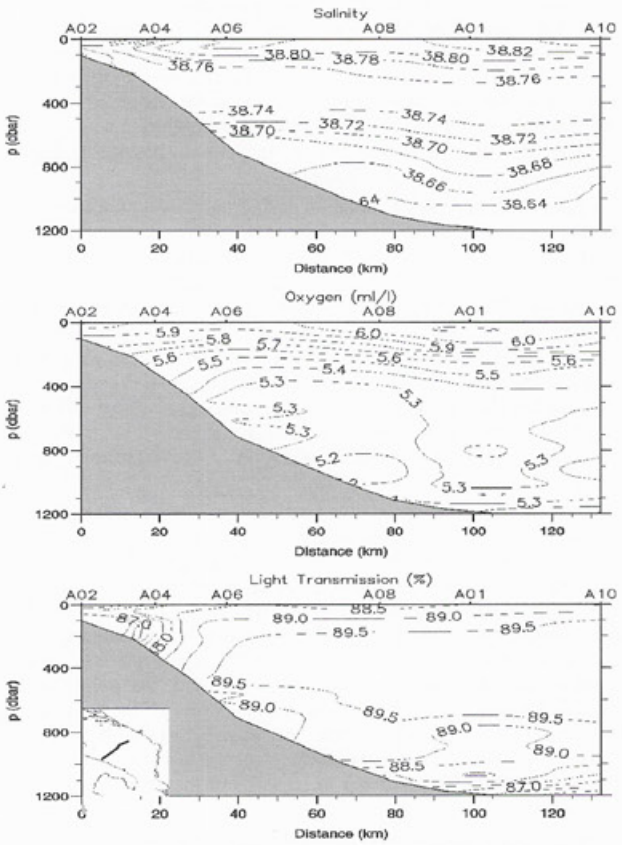


Fig. 1. Vertical distribution of Salinity, Dissolved Oxygen (ml/l) and Light Transmission (%) along the section in the southern Adriatic Sea (see inset map) in early April, 2002.

References

1 - Gačić M., Lascaratos A., Manca B.B., and Mantziafou A., 2001.Adriatic deep water and interaction with the Eastern Mediterranean Sea. Pp. 111-142. In: Physical Oceanography of the Adriatic Sea, B. Cushman-Roisin *et al.* (eds.), Kluwer Academic Publishers.

2 - Manca B.B., Budillon G., Scarazzato P., Ursella L., 2003. Evolution of dynamics in the eastern Mediterranean affecting water masses structures and properties in the Ionian and Adriatic Seas. *J. Geophys. Res.*, 108(C9), 8102, doi:10.1029/2002JC001664.

DEEP-WATER FORMATION PROCESSES IN THE ADRIATIC SEA: SIMULATIONS OF THE INTERANNUAL VARIABILITY

A. Mantziafou and A. Lascaratos *

Ocean Physics and Modelling, Group, University of Athens, Department of Physics, University Campus, Builds PHYS-V, 15784, Athens, Greece - amand@oc.phys.uoa.gr

Abstract

The sensitivity of the water mass formation processes in the Adriatic Sea to inter-annual atmospheric forcing is investigated using the POM model for a period of 21 years (1979-1999) and it is found to be important in agreement with observations. During severe winters deep convection occurs in the Southern Adriatic Pit (SAP) and DWF rates can be almost 3 times larger than climatology. The production of the deep water is mostly associated to events of enhanced buoyancy loss and not to the mean winter fields.

Keywords: Adriatic Sea, deep-water formation, inter-annual variability

Introduction

The Adriatic Sea is the area where the deep waters of the Eastern Mediterranean are formed. Climatological model simulations showed that the major portion of the Adriatic Deep Water (ADW) exiting through the Otranto Strait is formed in the Southern Adriatic Pit, while a smaller contribution originates in the Northern Adriatic (1) and the annual DWF rates of the basin is 0.34Sv (2). Observations (3,4) show that the intensity of vertical convection in the Southern Adriatic varies greatly on an inter-annual basis. The scope of this study is to simulate and estimate the inter-annual variability of the deep-water formation process in Adriatic in terms of deep-water formation sites, rates and characteristics and investigate the role of the atmospheric forcing.

Model set up

This study is performed using the Princeton Ocean Model (POM) with a 10km horizontal grid and 20 sigma levels in the vertical. The model is initialized with MODB data set and the atmospheric forcing is provided from 6h-ECMWF re-analysis and analysis data for a period of 21 years (1979-1999). All major rivers of the basin have been parameterized in it and the heat fluxes are computed with an air-sea interaction scheme that uses the model produced sea surface temperature (SST).

Results and discussion

The analysis of the atmospheric data of the period under examination revealed a stronger inter-annual variability during winter than in summer both in the heat and fresh water budget components which in turn induces a strong inter-annual signal in the deep-water formation process. The spatial pattern and the intensity of the buoyancy losses within the Adriatic basin vary from winter to winter. Thus there are different contributions of the Northern Adriatic Deep Water (NADW) and the Southern Adriatic Deep Water (SADW) in the overall production of ADW that exits through the Otranto Strait into the Ionian Sea from year to year. The inter-annual variability in the duration of the DWF process and the DWF sites and rates seem to be highly determined by the inter-annual variability of the prevailing atmospheric conditions. The simulations show that during the severe winters of the years 1986-87, 1991-92 and 1992-93 deep convection occurred in the Southern Adriatic, while during the mild winters of the years 1989-90, 1993-94, 1996-97 the mixed layer depth in the SAP was shallow. Moreover years with similar mean buoyancy winter losses have different mixed layer depths and different deep-water characteristics in the SAP. The mixed layer depth seems to be determined mostly by the high frequency events of cold and dry winds rather than the mean buoyancy loss of the specific year. Finally the amount of deep-water that outflows through the Otranto strait follows the intensity of the deep-water formation process inside the Adriatic basin.

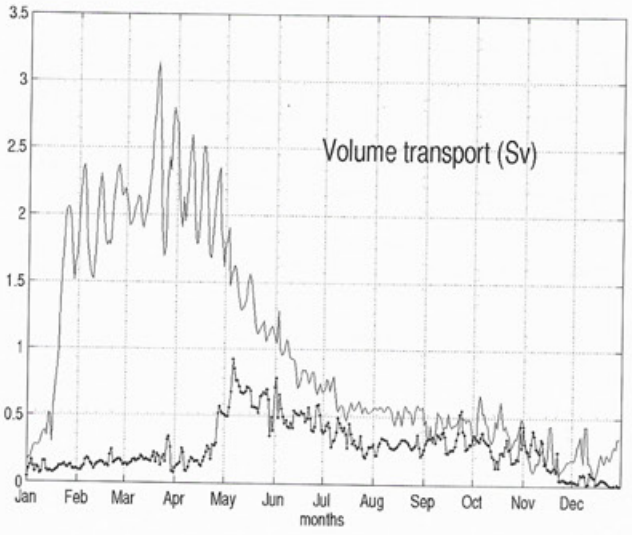


Fig. 1. Time series of the Adriatic Deep-Water outflow (sigma theta greater than 29.15) for the years 1992 (solid line) and 1997 (dotted line) with mean annual ADW rates of 0.99Sv for the year 1992 and 0.27Sv for the year 1997.

References

1 - Mantziafou A., Lascaratos A., 2003. An eddy resolving numerical study of the general circulation and deep-water formation in the Adriatic Sea. *Deep Sea Research*, under review

2 - Lascaratos, A., 1993. Estimation of deep and intermediate water mass formation rates in the Mediterranean Sea. *Deep Sea Research* II, Vol. 40, 6: 1327-1332.

3 - Manca, B., Kovacevic, V., Gacic M., Viezzoli D., 2002. Dense water formation in the Southern Adriatic Sea and spreading into the Ionian sea in the period 1997-1999. *J. Mar. Syst.*, 33-34: 133-154.

4 - Gacic M., Lascaratos, A., Manca, B., Mantziafou, A., 2002. Adriatic Deep Water and Interaction with the Eastern Meditertanean Sea . Pp. 111-142. *In*: Cushman-Roisin B., Gacic M. ,Poulain P-M. and Artegiani A. (eds.), Physical Oceanography of the Adriatic Sea. Past, Present and Future. Kluwer Academic Publ.

EVOLUTION OF THE PO RIVER PLUME DURING FEBRUARY 2003

E. Mauri * and P.-M. Poulain

OGS, Borgo Grotta Gigante, 42/c Sgonico (Trieste), Italy - * emauri@ogs.trieste.it

Abstract

The Po River plume formation and evolution is studied using satellite images of sea surface temperature (SST) and ocean color, and drifter data during February 2003. Medium Po River discharges combined with sustained strong episodes of bora winds triggered the development of the plume extending to the northeast across the basin as the southern limb of a cyclonic gyre in the Northern Adriatic.

Key-words: River plume, drifters, satellite data, Adriatic Sea

Introduction

During strong bora events, the Po River plume generally extends toward the Istrian Peninsula instead of going south in the West Adriatic Current. In winter, this feature is visible both in temperature and in chlorophyll due, respectively, to the lower temperature and higher nutrients concentration of the river water compared to the surrounding sea (1). The particular structure and evolution of the Po River plume was studied using satellite and *in situ* data in February 2003 as part of the DOLCEVITA project.

Materials and methods

AVHRR data were acquired and processed at OGS using the TeraScan system to create SST maps of the Northern Adriatic. SeaWiFS data were downloaded from the DAAC, processed and extracted with the SeaDAS software to provide maps of surface chlorophyll concentration. Most of the drifters involved in the study were of the modified CODE-type and followed the currents in the first meter of water, while the optical drifters, SVP/OCM, had a drogue centered at 15 m depth (2). The drifter optical data consist of upwelling radiance and downwelling irradiance in seven visible wavelengths. The positions of the drifters were obtained through the Argos and/or the GPS systems.

Results

During February 2003, the drifter trajectories combined with the satellite data evidenced a well developed Po River plume with a cyclonic gyre in the northern part of the Adriatic. Both temperature (Fig. 1) and chlorophyll (Fig. 2) images show the formation of the plume starting on 16-17 February , its evolution on 18-23 February and its dissipation near the end of the month (24-26 February). The surface temperature of the plume is 3 °C lower then the rest of the basin and the fresh water is much richer in chlorophyll. The northeastward currents in the core of the plume computed from the drifter trajectories have speeds as large as 20 cm/s. The occurrence of the plume was concomitant with an extended episode of strongly sheared bora winds spanning 9-19 February with maximum strength around 16-17 February. During the entire month the Po river discharge remained below the climatological monthly mean. The optical drifters revealed drastic difference in the optical properties between the warm/poor waters south of the Istrian Peninsula and the cold/rich Po plume, as can be seen in spectra of remote sensing reflectance (Fig. 3).

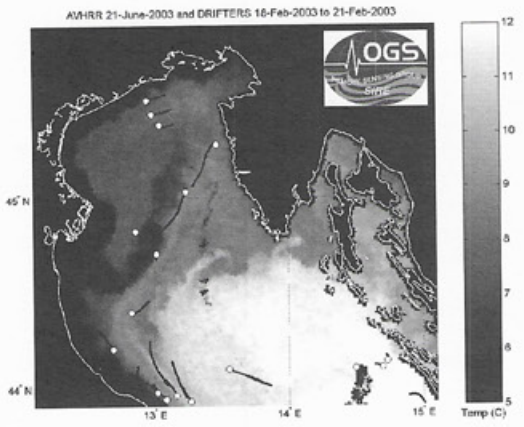


Fig. 1. AVHRR-SST image of the Northern Adriatic on 21 February 2003 at 02:07 GMT, with drifters tracks superimposed for a period of 4 days (18-21 February). White circles represent the drifter locations at midnight on 21 February.

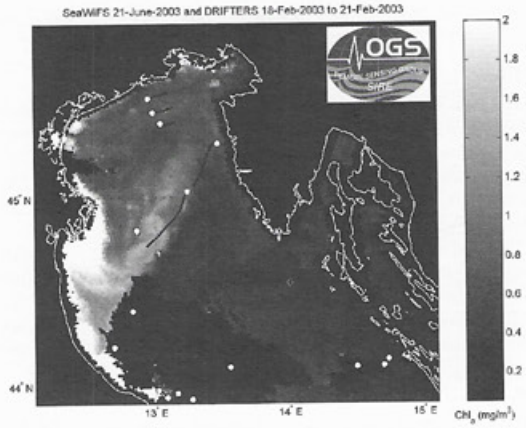


Fig. 2. Same as Figure 1 but for surface chlorophyll-a derived from SeaWiFS data. The open circle and white diamond symbols denote the positions of the optical measurements shown in Figure 3.

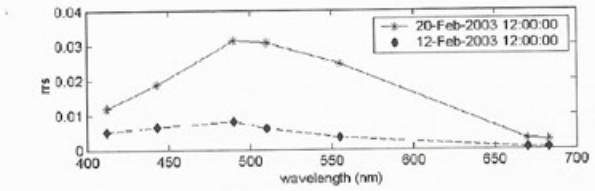


Fig. 3. Examples of remote sensing reflectance (μW/cm2/nm/sr) recorded by the optical drifters south of the Istrian Peninsula (diamond symbol) and in the Po Plume core (star symbols). The locations of the measurements are posted in Figure 2.

Acknowledgements

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References

1 - Mauri E. and P.M. Poulain, 2001. Northern Adriatic Sea surface circulation and temperature/pigment fields in September and October 1997. *J. Mar. Syst.*, 29: 51-67.

2 - Poulain P.-M., L. Ursella, E. Mauri and D. Deponte, 2003. DOLCEVITA-1 Cruise, 31 January-24 February 2003. Report of drifter-related activities. Rel. 08/2003/OGA/03, 32 p.

OPTICAL AND THERMOHALINE CHARACTERISTICS OF THE SOUTH ADRIATIC WATER IN JULY 2003

Morović Mira *, Matić Frano, Branka Grbec

Institute of Oceanography and Fisheries; Šetalište Ivana Meštrovića 63, P.O. Box 500, 21000, Split, Croatia - * morovic@izor.hr

Abstract

Vertical irradiance attenuation coefficients were determined for 14 wavelengths from recent spectral irradiance measurements in the South Adriatic, during Meduza experiment. The first results enabled optical and thermohaline characterization of the water masses.

Key words: spectral irradiance attenuation; fluorescence; thermohaline conditions.

Introduction

Thermohaline, chemical and biological conditions in the intermediate layer of the South Adriatic are influenced by inflows of more saline (1), warmer and nutrient richer LIW from the Mediterranean. These intrusions fluctuate, causing increase of temperature, salinity and productivity in the waters of the South Adriatic, influencing also optical properties (2). Summer season, like this measuring period is generally characterized by weaker influence of LIW, entering the Adriatic in the intermediate layer only.

Measurements were performed in the frame of international experiment Meduza (see www.izor.hr/meduza/index.htm) onboard the 35m long research vessel *Naše More* , from the Croatian Ministry of Science.

Materials and methods

The spectral irradiance and radiance were measured with Biospherical profiling radiometer at 14 wavelengths in the range 340-710nm, together with the PAR attenuation, and natural fluorescence. The CTD measurements were taken with the Idronaut probe. The cruise from 22-29 July 2003 was confined to the area above 1200m isobath, within 5miles around the position 42.17° N 17.82° E. The daylight attenuation measurements were performed three times, while CTD casts and other parameters (not presented here) were taken four times a day. Since measurements were repeated daily in the same time, aparent optical data with the same solar altitudes were acquired. The measurements were interupted from the noon time 25th till the morning 27th July, due to unconvenient weather conditions.

Results

Vertical attenuation coefficients for downwelling irradiance were about two times higher than the coefficients for upwelling radiance, but their spectral dependence is very similar. Considering the different solar elevation, attenuation was stronger for the lower solar elevation (3). In the investigated water column, between 0-80m, distinguished are spectral characteristics by layers (Fig. 1).

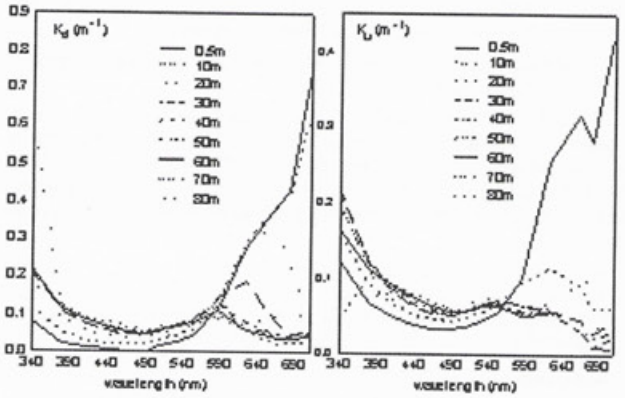

Fig 1. Vertical attenuation coefficients for downwelling irradiance and upwelling radiance for 24.07.2003, measured at the noon time.

Both attenuation coefficients for downwelling irradiance and upwelling radiance have in the first 10m maximum in the red spectrum, due to strong apsorption in water. Attenuation coeficients have minimum at 490nm, showing that South Adriatic is most transparent for this nuance. Attenuation coefficients are increasing from the blue light toward the UV wavelengths. Especially in the deep layers, coefficients for UV are high, while the minimum is reached in the first few meters.

Since the area of measurements is far from the coast in the oligotrophic sea, it is assumed that principal factor influencing optical properties is phytoplankton, and eventualy its decomposing products. Therefore, part of attenuation in UV and blue spectral region come from chlorophyll.

From the natural fluorescence channel Lu(chl), vertical profile was obtained (Fig. 2). In addition to exponential decrease of Lu(chl), in deep layers, increased upwelling signal from fluorescence appears from the first deep chlorophyll maximum. Depth of more intense fluorescence signal moved around 60 to 80m during the measuring period. These data, together with the rate of PAR attenuation enabled calculating fluorescent flux (4).

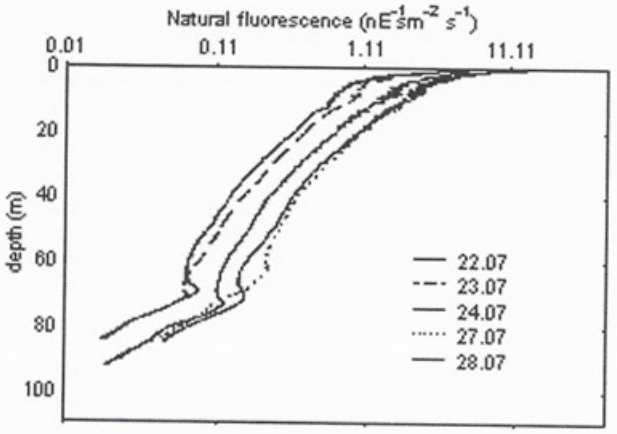

Fig 2. Natural fluorescence signal determined from upwelling radiance Lu (Chl) during 22-28.07. period at 18h.

The thermohaline conditions during the cruise were characterized with very warm and stratified surface layer (around 27°C). Relatively shallow thermocline for the mid-summer at only 10m is caused by the lack of stronger wind action this summer. Salinities were high (>38.7), but within the usual range for the recent period and for the summer season.

Conclusions

The surface 80 meters of the South Adriatic are the most transparent for 490nm, as expected for the oligotrophic waters. Depth dependence of attenuation coefficients and natural fluorescence indicate the presence of higher chlorophyll concentrations in the deep layers around 60-80m.

Optical measurements performed for the first time in the Eastern part of Adriatic waters with sofisticated instrumentation, opened new possibilities for obtaining high resolution vertical profiles of chlorophyll concentration, and primary production estimates.

References

1 - Zore-Armanda, M., 1969. Water exchange between the Adriatic and the Eastern Mediterranean. *Deep-Sea Research*, 16: 171178.

2 - Marasović I., Grbec, B., Morović, M., 1995. Long-Term Production Changes in the Adriatic. *Netherlands Journal of Sea Research*, 34(4): 267-273.

3 - Lundgren, B. and N. Højerslev, 1971. Daylight measurements in the Sargasso sea; Results from the «Dana» expedition January-April, 1966, Copenhagen University, Institut od Physical Oceanograph, *Report No* 14: 1-33.

4 - Chamberlin, W.S., C.R. Booth, D.A. Kiefer, J.H. Morrow, and R. C.Murphy, 1990. Evidence for a simple relationship between natural fluorescence, photosynthesis and chlorophyll in the sea. *Deep-Sea Research*, 37(6): 951-973.

XBT MEASUREMENTS IN THE DUBROVNIK-BARI TRANSECT - VOS2 ADRICOSM EXPERIMENT

Morović Mira [1]*, Vlado Dadić [1], Frano Matić [1], Giuseppe Manzella [2],
Branka Grbec [1], Franco Reseghetti [2], Damir Ivanković [1]

[1] Institute of Oceanography and Fisheries, Šetalište Ivana Meštrovića 63, P.O.Box 500, 21000 Split, Croatia - * morovic@izor.hr
[2] Ente per le Nuove tecnologie, l'Energia e il' Ambiente, Centro Ricerce Ambiente Marino, Pozzuolo Di Lerici, P.O. Box 224, 19100 La Spezia, Italy

Abstract

The temperature data from recent XBT measurements were acquired during the October 2002 to September 2003 period, at the two transects, one across and the other along the Adriatic, during the first year of the ADRICOSM experiment. Through the data analysis, different phenomena were observed. The data from Dubrovnik-Bari transect were analysed, with a reference to the other measurements in the area.

Keywords: Adriatic Sea, temperature, salinity

Introduction

Thermohaline conditions of the South Adriatic behave in a slightly different way from East to the West coast. Intermediate layers of the South Adriatic are influenced by inflows of more saline (>38.7 PSU) (1, 2), and nutrient richer LIW water from the Mediterranean, while bottom layers of the West coast are under the influence of the NAdDW. The intrusions of LIW bring warmer water into the Adriatic (3), while those at the West coast bring less saline and colder waters. The LIW intrusions are stronger in the winter period especially when driven by the strong atmospheric pressure fluctuations (4) over the area wider than Mediterranean, however the condition for formation of NAdDW and stronger LIW intrusions seems to coincide, since both occur during cold winters.

The VOS2 ADRICOSM experiment performed in the Southern Adriatic enabled following a number of phenomena in a near real time. Combining these data with the other sea truth data acquired in the same area and time, and meteorological data, we were able to get better explanation about these phenomena.

Materials

Starting from October 2002, fourteen VOS XBT measurements (10 stations) were performed within a year period: monthly in the cold season and with almost fouthnight frequency in warm season. Transect between Dubrovnik and Bari was survayed underway regular ferry connection. The ferryboat almost repeated the route (Fig. 1).

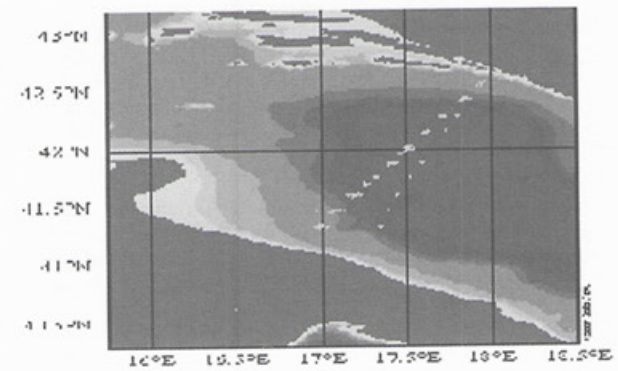

Fig. 1. Position of measuring stations with GPS, installed onboard the ship. During most of the VOS measurements, transects were very close, except in December 2002, when the ships' route deviated from usual.

Preliminary results

In the eastern side of the Adriatic temperature was higher in the whole water column most of the year, except in July, when the first meters of water were warmer in Italian side. The difference of almost 2°C between the surface temperature of the two sides was observed in December (Fig. 2). The temperature difference in deeper layers between the two sides may indicate intrusions of warmer LIW towards the Eastern coast.

The summer 2003 was dry and with moderate winds; especially the ethesian wind Maestral was not strong and frequent as usually. This resulted in a shallow thermocline ill the end of July. Only in September, after episodes of strong winds thermocline reached 30m.

Reference is also given to the measurements of the other VOS1 ADRICOSM group (OGS, Trieste), from Susac-Brindisi transect, that brought information about the longitudinal movements in the Southern Adriatic.

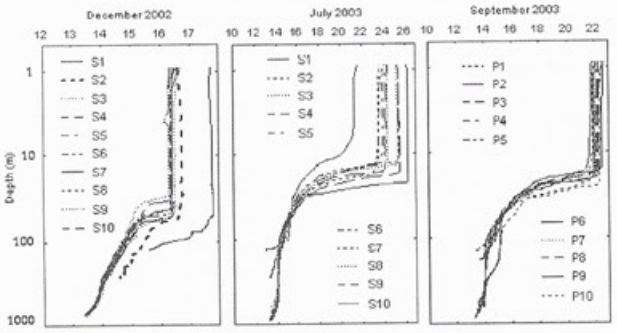

Fig. 2. Vertical temperature profile in the stations nearest to Dubrovnik and Bari, and the station in the middle of the transect.

The comparison was done between XTB data and CTD measurements acquired during the summer cruise of the international project Meduza (www.izor.hr/Meduza/index.htm) and the data measured through 2002-2003 period, in the frame of Jadran project (Croatian National Monitoring Program), both in close locations and times to XBT stations. From these data we tried to control salinity calculated from the sound velocity and temperature.

The measurements from the Southern Adriatic were supported with ECMWF reanalysis data for the region.

Through the ADRICOSM VOS2 experiment we were able to observe, in a near real time, a number of phenomena like evolution and breakdown of seasonal thermocline, effect of turbulent mixing due to the action of wind, spreading of the cold water vein along the Italian coast, intrusions of warmer LIW towards the Eastern coasts etc.

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References

1 - Zore-Armanda, M., 1969. Water exchange between the Adriatic and the Eastern Mediterranean. *Deep-Sea Research,* 16: 171178.
2 - Buljan, M. & M. Zore-Armanda, 1976. Oceanographical properties of the Adriatic sea.-oceanogr. *Mar. Biol. Ann. Rev.,* 14: 11-98.
3 - Zore-Armanda, M., 1971. Influence of the long term changes in oceanographic /meteorological conditions in the North Atlantic on the Mediterranean. The ocean World, Proc. Joint Oceanogr. Assembly, Tokyo 1970, pp. 151-154.
4 - Grbec, M., Morović and M. Zore-Armanda, 2003. Mediterranean Oscillation Index and its relationship to inerannual salinity fluctuations in the Adriatic Sea, *Acta Adriatica,* 44(1): 61-76.

CORRECTION OF MODELED SEA SURFACE WIND IN ORDER TO IMPROVE WAVE FORECAST

A. Murashkovsky *, I. Gertman

Israel Oceanographical and Limnologial Research, National Institute of Oceanography, Haifa 31080, Israel - * amur@ocean,org.il

Abstract

A method for correcting wind input to WAM model is proposed in order to reflect wind gusts, otherwise not present in the atmospheric models output. The method is based on wind field vorticity analysis and does not require any external data. The wave forecast resulting from winds corrected by this method was compared to real data, as well as to forecasts resulting from a different correction technique.

Keywords: wind gusts, WAM model

Introduction

Operational wave forecasting system based on WAM model for the Eastern Mediterranean was implemented in IOLR since fall 1997 [1]. The results of the wave forecast and hindcast produced by the system were compared to true data from Hadera GLOSS station from the beginning of the project.

From the very beginning the comparisons showed that H_s is underestimated and this fault increased with H_s increases. The problem of the wave model underestimating H_s isn't new, it was addressed before, e.g. Cavalieri [2], and it is attributed to negative errors in closed basins. However, it was suggested that during severe storms another factor may influence the H_s growth, namely wind gusts, which, typically, are not represented in the output of meteorological models.

Several methods have been suggested for the introduction of wind gustiness into wave model input. Abdalla and Cavalieri [3] used fluctuations represented by Gaussian process, characterized by coherence in time. Another method proposed adding a constant factor to the wind field. Wave Watch III, as of ver. 1.18 [4] used term dependent on T_{air}-T_w difference to represent atmospheric instability and calculate an effective wind speed.

This paper proposes a new method, based on the assumption that most severe wind gusts occur during the passage of atmospheric fronts, and are indicated by significant changes in the wind direction.

Methods and materials

Hess [5] defines an atmospheric front as zone of rapid transition from one temperature to another. It also noted that significant wind direction changes occur in frontal zones. The frontal zones are characterized by strong atmospheric instabilities, often resulting in severe weather, and are usually accompanied by strong wind gusts.

The quantitative characteristic of vector field direction change is its curl, which leaded to defining "gustiness" of the wind field as

$$G = \left[\partial(\vec{\nabla} \times \vec{U}_{10}) / \partial U_X + \partial(\vec{\nabla} \times \vec{U}_{10}) / \partial U_Y \right] \cdot \left| \vec{U}_{10} \right|$$

The actual correction was calculated using measured data at Hadera GLOSS station, and resulted in $G_{corr} = 0.399 * Ln(G) + 0.65$

Results and discussion

Two sources of wind input were used during the verification of the method: the SKIRON forecasting system from University of Athens (output every 6 hours, 0.2x0.2° resolution); and the Bracknell model by UKMO (output every 6 hours, 0.833x0.566° resolution). Both T_{air}-T_w and wind vorticity correction techniques were applied and the results were compared to the measured data. The immediate result of the comparisons revealed that the impact of both methods on low resolution wind was insignificant, so that only SKIRON wind was utilized subsequently.

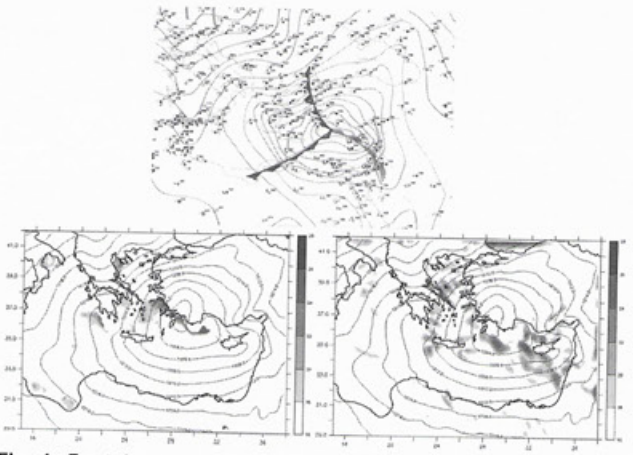


Fig. 1. Frontal zone wind correction, calculated by different methods during severe storm. Top : synoptic map; bottom left : dT derived correction; bottom right : vorcity derived correction.

On the synoptic map three frontal zones are clearly visible: a hot one and two cold ones. Predictably dT derived correction is very small in the hot frontal zone, while the vorticity derived correction produces significant values. The correction based on vorticity also increased near the shores, where wind changes its direction.

Another comparison was carried out by using the WAM model for the Levantine basin to produce wave hindcast with wind input corrected by various methods. The results were compared to data measured at Hadera GLOSS station. It is clear that both methods improve the forecasts significantly, when compared to forecasts produced with uncorrected wind input. The preliminary studies confirm that both methods produce similar results, while vorticity derived technique requires less data.

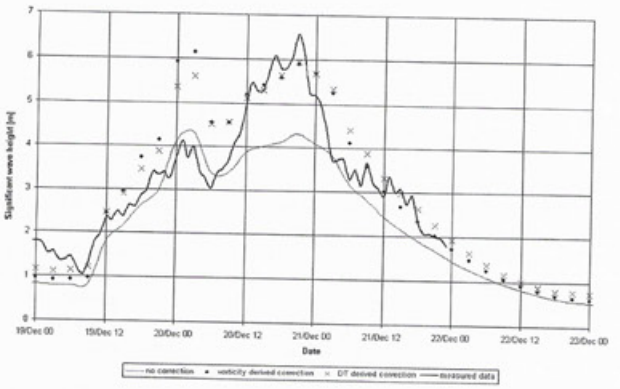


Fig. 2. Comparison of significant wave height with wind input produced by different methods.

Acknowledgments

We want to thank sincerely to Prof. G. Kallos from SKIRON group for providing us with wind data for this work.

References

1 - Gertman I. Rosen D.S., Sandler K. and Raskin L., 2000. Comparison of two years of wind and wave hindcast via WAM based operational forecasting system versus field and other models data. Proceedings of 6th international workshop on wave hindcast and forecast. pp 91-98.

2 - Cavalieri L., 1994. Orographic Effects, pp. 293-294. *In:* Komen G.J (ed) Dynamics and Modeling of Ocean Waves. Cambrige Univ. Press, New York.

3 - Abdalla S. and Cavalieri L., 2002. Effect of wind variability and variable air density on wave modeling. *Journal of geophysical research,* 107: 17-1 – 17-17.

4 - Tolman H. L. 1999a. User Manual and system documentation of Wavewatch-III, ver 1.18. *OMB Contribution No 166.*

5 - Hess S. L., 1959. Introduction to theoretical meteorology. Holt, Rinehart and Winston, New York.

DECADAL SCALE CLIMATIC WARMING AND ITS IMPACTS ON ECOLOGICAL REGIME OF THE BLACK SEA DURING 1990S

Temel Oguz

Institute of Marine Sciences, Middle East Technical University, Erdemli, Turkey - oguz@ims.metu.edu.tr

Abstract

The Black Sea is shown to experience intensive warming of its surface waters during 1990s at a rate of ~0.25 °C per year. Following a strong cooling phase in early1990s, the most intense warming event with ~2 °C increase in the SST took place during winters of the 1994-1996 period. This event was accompanied by 4 cm yr-1 net sea level rise in the basin, and two-fold increase of the annual mean net fresh water flux, as well as a gradual depletion of the Cold Intermediate Layer (characterized by T<8 °C) throughout the basin. Consequently, from 1996 onwards, upward nutrient supply to surface waters was reduced substantially, giving rise to bottom-up limited unfavorable phytoplankton growth, and reduced stocks of mesozooplankton, gelatinous macrozooplankton and pelagic fishes. The climate-induced changes therefore had a strong impact on dramatic reduction of pelagic fish stocks observed during the second half of 1990s.

Key words: Black Sea, climatic warming, ecological changes

Changes in large scale atmospheric pressure and precipitation patterns cause interannual-to-multidecadal scale climatic variations both locally and in remote areas via teleconnection patterns in the form of the quasi-periodic sea level changes, warming and cooling cycles of the sea surface temperature, and ultimately impose significant impacts on ecology and economical wellfare of societies. Even it is an isolated and relatively small sea, far from direct impacts of major oceans, the Black Sea is found to possess a strong climatic signature at interannual-to-multidecadal scales. The most recent example of such climatic effects emerges in the form of a warming cycle of the entire upper layer waters since 1994 (1).

The basin-averaged winter (December-March)-mean and annual-mean sea surface temperature (SST) data, derived from 9 km monthly, gridded NOAA/NASA AVHRR Oceans Pathfinder data set, reveal an intense cooling period of the early 1990s, evident by the minimum winter-mean SST of 6.8 °C in 1993 followed by an equally strong winter warming phase characterized by an almost 2 °C rise during 1994-1996. The winter warming phase is maintained during the rest of the 1990s by a more gradual temperature variations by retaining at least their 1997 level of warming, and occasionally having values as high as ~10 °C in 2001. These warmer winter SSTs were correlated with milder winters characterized by relatively higher air temperatures, weaker heat loss to the atmosphere and weaker wind stress forcing exerted on the sea surface . The warming trend is also well-pronounced in the annual-mean data in the form of linear SST rise by about 2°C from 1993 to 2001. The annual-mean tended to increase linearly SSTs from 14.2 °C in 1993 at a rate of 0.25 °C per year, with the highest annual mean value of ~16.4 °C measured during 2001. The subsurface signature of the warming can be traced from the structure of the Cold Intermediate Layer (CIL), characterized traditionally by temperatures colder than 8 °C. This cold water mass, convectively generated every winter within the upper 50-75 m of the water column, preserves its identity between the seasonal and permanent thermoclines during rest of the year. As shown for a station along the northeastern coast, off Gelendzhik, the average winter CIL temperature shows a linear trend of increase from its minimum value of 6.2 °C in 1993 to around 7.7 °C during the winters of 2000 and 2001. This trend follows quite closely the air temperature variations at the same site. Moreover, approximately 5-10 m rise of the anoxic interface level during the second half of 1990s might reflect destabilization of the permanent pycnocline as a consequence of warming of the surface waters.

As pointed out by Stanev and Peneva (2), the warming period may well be teleconnected to changes in the North Atlantic Oscillation (NAO) cycle, and the climatic warming trend of the Northern Hemisphere. Their analysis has indicated that the constant sea level rise of ~12 cm in the Black Sea from 1993 to 1996 is correlated with the increased net fresh water flux into the basin, which in turn is correlated with the dramatic decrease of the NAO index (from +2 to –2) during the same period. These changes in the physical climate of the sea imply disintegration of the prevailing basinwide cyclonic circulation cell (3), and weakening of the associated upward motion within the interior part of the basin after 1995.

The intimate relationship between climatic warming and form of the annual phytoplankton production can be inferred by the composite ocean color data set representing the monthly mean chlorophyll contcentrations since 1996 onwards. It indicates steady winter values of about 0.5 mg m^{-3} in contrast to a well-pronounced peak of ~2.0 mg m^{-3} in the data set prior to the mid-90s. Weaker turbulent mixing and stronger stratification during mild winters of all these years should be responsible for more limited nutrient supply from the nutricline, and consequently erosion of the late winter-early spring peak of the annual surface chlorophyll distribution by more than half after the mid-90s. Such a poor new production-based biological activity in February-March is followed by equally poor regenerated production during rest of the spring season. The annual structure acquires only a weak autumn peak of about 0.75 mg m^{-3} comparable to its counterpart in the former data set.

The measurements also reveal similar adverse changes in the annual mesozooplankton biomass distributions after 1995. The early-spring mesozooplankton bloom is no longer a dominant feature of their annual structure due to the bottom-up resource limitations in the spring primary production. The autumn mesozooplankton biomass distributions after the mid-1990s are also somewhat lower than those of the early 1990s. These changes are reflected at higher trophic levels in the form of decreasing trends in both the gelatinous carnivore biomass and the anchovy catch data during the second half of the 1990s. As warming prevails longer, both mesozooplankton and pelagic fish stocks are expected to decline further due to stronger bottom-up limitation associated with continual loss of nutrients from the euphotic zone against their more limited supply from subsurface levels. From the fishery perspective, a closer look at future evolution of plankton community structure is therefore of critical economical importance, and may ultimately serve for predicting timing of the forthcoming shift of the present warming cycle by a cooling cycle and subsequent increase in fish stocks.

References

1 - Oguz, T., Cokacar, T., Malanotte-Rizzoli, P., and Ducklow, H.W., 2003. Climatic warming and accompanying changes in the ecological regime of the Black Sea during 1990s. *Global Biogeochem.* Cycles, in press.

2 - Stanev, E.V., and Peneva, E. L., 2002. Regional sea level response to global climatic change: Black Sea examples. *Global and Planetary Changes,* 32: 33-47.

3 - Korotaev, G., Oguz, T., Nikiforov, A., and Koblinsky, C., 2003. Seasonal, interannual and mesoscale variability of the Black Sea upper layer circulation derived from altimeter data. *J. Geophys. Res.,* 108: 3122, doi:10.1029/2002JC001508.

A CLIMATOLOGICAL SIMULATION FOR THE MIDDLE ADRIATIC COASTAL AREA

Mirko Orlic [1], Gordana Beg Paklar [2]*, Branka Grbec [2], Mira Pasaric [1], Zoran Pasaric [1]

[1] Andrija Mohorovicic Geophysical Institute, Faculty of Science, University of Zagreb, Horvatovac bb, 10000 Zagreb, Croatia
orlic@olimp.irb.hr, mpasaric@rudjer.irb.hr, pasaric@rudjer.irb.hr

[2] Institute of Oceanography and Fisheries, Set. I. Mestrovica 63, 21000 Split, Croatia - *beg@jadran.izor.hr, grbec@jadran.izor.hr

Abstract

Numerical model is designed and used to reproduce seasonal cycle of thermohaline and dynamical properties of the middle Adriatic coastal area. Results of a three-year long experiment with perpetual atmospheric and riverine forcing reveal strong seasonal signal, which agrees with temperature and salinity data originating from the permanent oceanographic stations along Split-Gargano transect and with some early current measurements.

Keywords: numerical model, seasonal cycle, Adriatic Sea

Introduction

High-resolution oceanographic model, called ASHELF-2, was developed for the middle Adriatic coastal area and was used to simulate its climatological characteristics. Successful simulation of the climatological variability of the thermohaline and dynamical properties is needed as a starting point for the reliable oceanographic short-term forecast of the studied area.

The ASHELF-2 model is nested into the whole-Adriatic model (AREG) (1) and is run with the perpetual atmospheric and riverine forcing. Numerical model results are compared with climatological temperature and salinity data obtained at permanent oceanographic stations and with some early current measurements in the area (2).

Model setup

The oceanographic model used is modification of the Princeton Ocean Model (POM) (3). The ASHELF-2 model uses the grid of constant horizontal resolution of 1 km, which covers the studied area with 189x106 points. Along the vertical, 16 sigma levels were defined with finer distribution near the surface and bottom.

The oceanographic model was forced with monthly varying fields of surface momentum, heat and water fluxes and monthly discharges from four rivers: Jadro, Zrnovnica, Cetina and Neretva. Surface heat fluxes diagnosed by AREG were linearly interpolated onto the ASHELF-2 grid and corrected during 'perpetual year' simulation to produce seasonal climatology using ATOS data set (1). Surface water fluxes, computed from evaporative heat flux, precipitation data and monthly runoff from four rivers discharging into the ASHELF-2 domain, were also corrected during simulation to produce seasonal climatology and to avoid the excessive freshening of the basin that could result from the use of the climatological forcing.

At both open boundaries of the ASHELF-2 model a simple one-way nesting technique was applied. Nesting procedure is designed to satisfy the volume conservation constraint, which can be violated due to interpolation of the data from the coarse resolution model onto the open boundaries of the fine resolution model (1).

Results and discussion

Three-year long numerical simulation under climatological surface forcing has been carried out.

The general flow in the ASHELF-2 domain is directed northwestward with prominent wakes occurring behind Dalmatian islands during the greater part of the year (Fig. 1). Current reversal obtained between islands Hvar and Vis in August agrees with previous current measurements, which indicate strong seasonal signal in the surface current field with oppositely directed alongshore flow in the winter and summer seasons (2).

The importance of the properly imposed open boundary conditions can be seen by comparing current fields modelled for January with and without nesting procedure. In the numerical experiment without nesting, surface current field shows numerous cyclonic and anticyclonic gyres. In the similar numerical experiment with nesting most of the gyres disappear and the flow is dominantly of the northwest direction.

Modelled temperature annual cycle at the points that correspond to the coastal and open sea stations shows good agreement with observations, although modelled annual amplitude is lower than the one obtained from the data. Surface salinity measured at two coastal stations shows lower values and higher annual amplitudes than those obtained in numerical simulations. Discrepancy between modelled and measured surface salinity in the coastal area can be partly ascribed to the climatological salinity field used in correcting procedures, in which coastal areas are not well resolved. Better

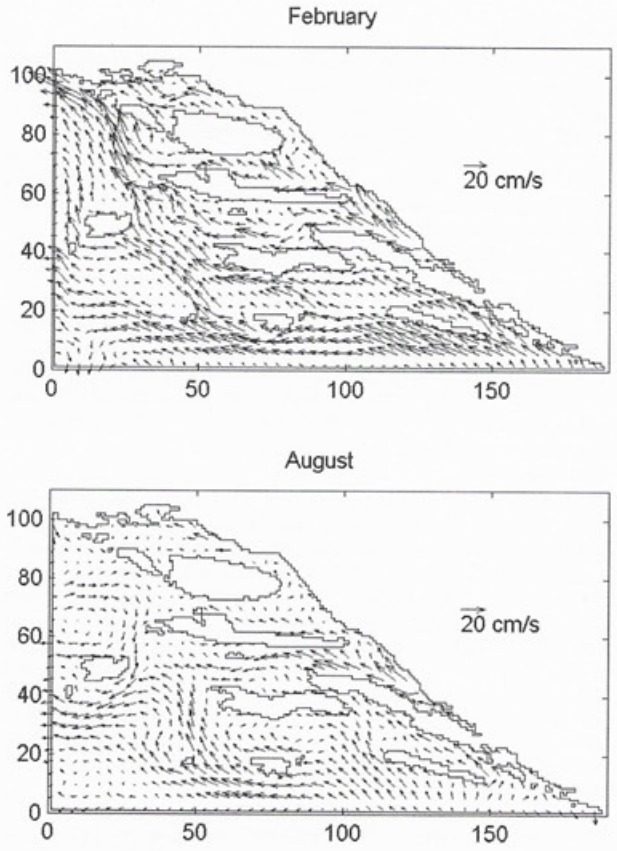


Fig. 1. Surface currents in the ASHELF-2 domain in February and August.

agreement between measured and modelled time series is obtained for the open sea stations although lower annual amplitude is again obtained by the model.

Acknowledgement. The work reported here has been sponsored by the Italian Ministry for the Environment (project ADRICOSM, coordinated by Istituto Nazionale di Geofisica e Vulcanologia) and by the Croatian Ministry of Science and Technology.

References

1 - Zavatarelli M., and Pinardi N., 2003. The Adriatic Sea modeling system: A nested approach. *Ann. Geophys.*, 21: 345-364.

2 - Zore-Armanda M., 1967. On the seasonal variations of the surface currents in the Adriatic (in Croatian). *Hidrogr. God.*, 66: 69-74.

3 - Blumberg A. F., and Mellor G. L., 1987. A description of a three-dimensional coastal ocean circulation model. Pp 1-16. *In:* Heaps N. S. (ed.), Three-dimensional coastal ocean models. AGU, Washington.

EAST ADRIATIC CURRENT IN WINTER AND SPRING 2003

M. Orlic [1] *, V. Dadic [2], B. Grbec [2], N. Leder [3], G. Beg Paklar [2], D. Ivankovic [2], A. Marki [1], F. Matic [2], H. Mihanovic [3], M. Pasaric [1], Z. Pasaric [1], M. Pavic [1], I. Vilibic [3]

[1] Andrija Mohorovicic Geophysical Institute, Faculty of Science, University of Zagreb, Horvatovac bb, 10000 Zagreb, Croatia
* orlic@olimp.irb.hr

[2] Institute of Oceanography and Fisheries, Setaliste I. Mestrovica 63, 21000 Split, Croatia

[3] Hydrographic Institute of the Republic of Croatia, Zrinsko-Frankopanska 161, 21000 Split, Croatia

Abstract

An experiment, comprising long-term ADCP measurements, repeated CTD profiling and meteorological data collection, was carried out between November 2002 and June 2003 in the east Adriatic coastal waters. Preliminary findings, particularly those concerning the spatial and temporal variability of the East Adriatic Current and its dynamics, are presented.

Keywords: currents, buoyancy forcing, winds, Adriatic.

Introduction

It is well known that the Adriatic general circulation consists of currents flowing into the basin along the east coast and outflowing along the west coast, with some smaller-scale gyres embedded in it (1). East Adriatic Current (EAC) is considered to vary seasonally, being strongest and most wide-spread in winter, weak and narrow in summer. Moreover, there is some evidence that the current attains a maximum speed in a core which occurs up to Zadar, with the current being more uniform further north.

In winter and spring 2003 an experiment – East Adriatic Coastal Experiment (EACE) – was organized on a polygon off Dugi otok, with the aim of documenting spatial and temporal variability of EAC and understanding its dynamics. The experiment was part of a large international effort, comprising long-term recording of currents at a number of stations, several cruises in the North and Middle Adriatic, and intensive program of meteorological measurements. EACE was preceded by some preliminary modeling, which helped to organize the measurement program in a best possible way.

The experiment

Measurements were carried out on a polygon comprising 21 stations. Currents were recorded at two stations, using barny-mounted ADCPs, between 30 November 2002 and 14 June 2003, with a 15-min sampling interval, bin size of 2 meters and contaminated layers of about 4 meters. CTD profiling was done at all stations on seven occasions between deployment and recovery of current meters. Meteorological (solar and net radiation, air temperature, humidity, precipitation, air pressure, wind speed and direction) and oceanographic (sea temperature) data were collected at nearby station Veli Rat, which was installed on 2 November 2002 and operated until 27 June 2003 with a 10-minute sampling interval. Information about the instruments used and data taken may be found at the project web site (http://www.izor.hr/eace).

Three Croatian research vessels (*Bios*, *Palagruza* and *Hidra*) were used in the experiment. The greatest challenge proved to be deployment and recovery of barny-cum-ADCPs. *R/V Bios* had to be equipped with new A-frame and winch, whereupon the operations were successfully carried out, resulting in the longest continuous current records collected up to now in Croatia. The data are still undergoing a detailed quality check, but some preliminary results are already emerging.

Results

Basic statistical analysis of meteorological data reveals that both winter 2003 and subsequent spring were anomalous: February 2003 was exceptionally cold and dry whereas spring 2003 was considerably warmer and drier than usual. The sea responded promptly to these weather conditions. The winter cooling resulted in lower-than-average temperatures, which persisted in the intermediate and bottom layers throughout the spring season. Surface temperatures gradually became greater than long-term averages, due to intensive spring heating. Salinities were close to the averages during winter, but surpassed them – without any sign of haline stratification – during spring, reflecting anomalously dry atmospheric conditions, accompanied by weak river inflows.

Monthly mean currents measured on the EACE polygon are shown in Fig. 1. Inflow prevailed at the onshore station throughout the six-month interval, whereas currents were weaker at the offshore station and did not indicate inflow during December 2002 and January and February 2003. Obviously, the onshore station was positioned closer to the EAC core. The currents were almost uniform along the vertical.

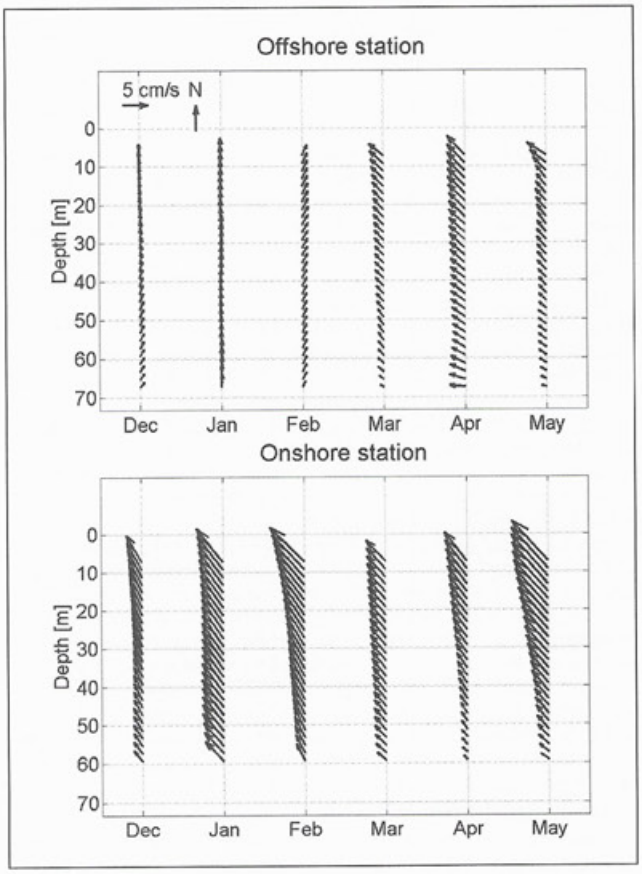


Fig. 1. Monthly mean currents at each depth cell of the two ADCP stations, calculated over the complete months of measurement period (December 2002 – May 2003).

Temporal variability of the currents did not follow the expected pattern, since at the onshore station the inflow was strongest in February and May 2003, whereas at the offshore station it was actually better developed in spring than in winter. Obviously, there are two possible explanations of this finding: either it is an anomaly due to atypical meteorological and hydrological conditions or the classical notions on the seasonal variability are wrong.

Acknowledgement. EACE was sponsored by the USA Office of Naval Research and Croatian Ministry of Science and Technology.

References

1 - Cushman-Roisin B. *et al.* (eds), 2001. Physical Oceanography of the Adriatic Sea. Kluwer, Dordrecht, 304 p.

ALIASING DUE TO SAMPLING OF THE ADRIATIC DENSITY ANOMALY IN SPACE

Zoran Pasaric [1]*, Mirko Orlic [1], Craig M. Lee [2]

[1] Andrija Mohorovicic Geophysical Institute, Faculty of Science, University of Zagreb, Horvatovac bb, 10000 Zagreb, Croatia - *pasaric@rudjer.irb.hr, orlic@rudjer.irb.hr

[2] Applied Physics Laboratory, University of Washington, 1013 NE 40th St. Seattle, WA 98105-6698, USA - craig@apl.washington.edu

Abstract

Errors associated with coarse sampling of the sub-surface density anomaly over the middle and north Adriatic are analyzed, using underway data collected within the DOLCEVITA project. The errors are seasonally and spatially dependent. They are larger in spring then in winter and also over the shallow Italian part as compared to the deeper Croatian part of the basin. The results should be relevant for the planning of future CTD measurements in the region.

Keywords: spatial aliasing, density anomaly, Adriatic Sea

Introduction

The present work is based on the sub-surface temperature and conductivity data measured with high spatial resolution during two cruises (31 Jan – 24 Feb and 26 May – 15 Jun 2003) conducted by the *R/V Knorr* over the middle and north Adriatic within the DOLCEVITA project. High spatial resolution enabled *a posteriori* analysis of sampling errors that would occur if the same measurements were performed with coarser spatial sampling.

Data and Analysis Procedure

Underway sea surface temperature and conductivity were measured using a Falmouth Scientific thermosalinograph (OCM-TH-212) which is part of the *R/V Knorr* meteorological (IMET) sensor system. The sensors were mounted on the bow at 5 m depth. Readings were averaged and recorded at one-minute time intervals along the whole ship path (7000 km for the winter and 6700 km for the spring cruise) together with time and location. The typical cruising speed of 8 knots gives the distance between data samples of ca. 250 m.

After basic quality check, the density anomaly was calculated and subsequently analysed. First, the data measured while sailing speed was below 4 knots were discarded and linear interpolation was performed every 100 m along the ship track. Next, sub-sampling was performed with various spatial steps (Δx = 1, 2, 5, 10 km), the sub-sampled series were linearly interpolated back to 100 m intervals, and the squared differences were calculated between this and the original series. The starting point for sub-sampling was systematically varied within the first Δx kilometers of the sequence (with step of 100 m), and squared differences obtained were averaged. Finally, we covered Adriatic with rectangles (bins) of 2 by 2 km, averaged all the differences that fall within particular rectangle, and took square root. The root mean square (RMS) sub-sampling density anomaly error thus obtained was plotted as a 3D bar graph.

Discussion and conclusions

We discuss briefly results for 5 km sampling interval. Large sub-sampling errors are associated with the presence of small scale features in the density field. For winter situation (Fig. 1) the error is generally small. The 'island' of large errors in the middle part of northern Adriatic is associated with the light, Po River water that has been advected by bora (see e.g. [3]) which blew during the greater part of the February cruise. Other occurrences of large errors are also associated with the Po River outflow, aligned with the Italian coast. In spring (Fig. 2) large errors cover the wide area along the Italian coast, whereas maximum is reached in the front of the Po River mouth. In the middle part of the basin, as well as close to the Croatian coast, errors are generally small, except close to the cap of Istria peninsula (probably influence of bora) and at the very south-east corner (probably influence of Dalmatian rivers). For 1 km sampling interval the error is typically below 0.01 kg/m^3 in winter and 0.04 kg/m^3 in spring. However, it may still be very large over some small regions (not shown).

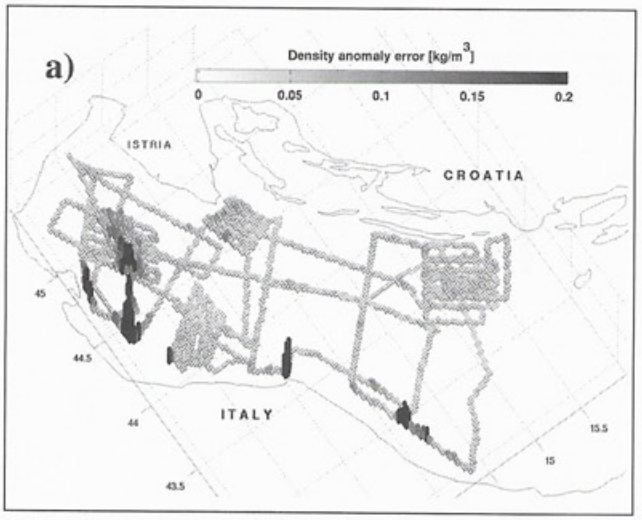


Fig. 1. Sub-sampling RMS error of density anomaly along the ship path for the winter. The error is proportional to the height of each bar and is also indicated by the gray level. Black bar implies error that is larger than 0.2 kg/m^3.

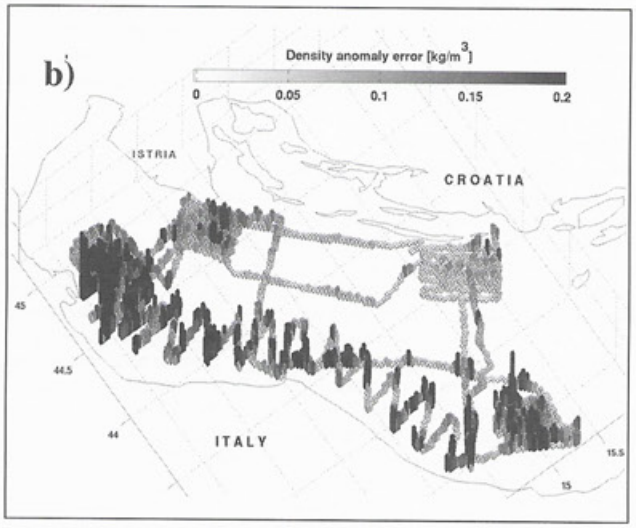


Fig. 2. Sub-sampling RMS error of density anomaly along the ship path for the winter for the spring cruise. The error is proportional to the height of each bar and is also indicated by the gray level. Black bar implies error that is larger than 0.2 kg/m^3.

It may be concluded that spatial variability of sub-surface density field over the middle and north Adriatic is much greater in spring (i.e. warm part of the year) than in winter (cold part of the year). Also it is bigger over the shallow, Italian part (influenced by the Po River) than over the deeper, Croatian part of the basin. The spatial aliasing error associated with this variability is quantified which, we feel, may be helpful for planning the future CTD measurements in the region.

References

1 - Orlic M., Kuzmic M., Pasaric Z., 1994. Response of the Adriatic Sea to the bora and sirocco forcing. *Continental Shelf Research*, Vol. 14, No 1: 91-116.

ANNUAL CYCLE OF RIVER DISCHARGE ALONG THE ADRIATIC COAST OF CROATIA

Mira Pasaric

Andrija Mohorovicic Geophysical Institute, Faculty of Science,University of Zagreb, Horvatovac bb, 10000 Zagreb, Croatia - mpasaric@rudjer.irb.hr

Abstract

Time series of monthly mean river discharge along the Croatian coast of Adriatic are analysed. The pronounced interannual variability is related to (*i*) direct antropogenic impact and (*ii*) to natural climatic fluctuations. The mean annual cycle of river discharge shows significant changes over the last decades.

Keywords: river discharge, annual cycle, interannual variability, Adriatic Sea

Introduction

Freshwater discharge by rivers and land runoff is the mayor mechanism controlling density field of the Adriatic coastal waters. It has a strong impact on the boyancy driven general circulation in the basin, its spatial patterns and seasonal variability. Freshwater inflow into the Adriatic has been analysed by Sekulic and Vertacnik [1], but with no reference to seasonal variability. Raicich [2] examined annual cycle of river discharge around the basin. However, results for the greater part of east Adriatic were based on indirect estimates, with evenly distributed inflow along the coast. The aim of this study is to evaluate mean annual course of freshwater discharge by mayor rivers along the Croatian coast, with special reference to its temporal variability.

Data

Records of mean monthly discharge were analysed at all Croatian rivers where measurements are made regularly. At the Neretva River, due to strong tidal influence, the discharge is measured far from the river mouth in Bosnia and Hercegovina. Most of the time series span over 40 years or so. Several have long gaps in the last decade, due to war actions in the area.

Results and Discussion

Mean annual cycle is usually determined as long-term average of mean monthly values. However, over the period of measurement, all the time series of river discharge exhibit a more or less pronounced interannual variability. Here results for two rivers are presented – the Cetina River which is under strong antropogenic influence [3] and Mirna River where the variability is related to natural climatic fluctuations. Construction of numerous hydraulic structures for power plants on the Cetina River has largely changed its natural regime (Fig. 1). The mean annual discharge has diminished, while the redistribution of flow throughout the year has significantly flattened its annual course. The flow of Mirna River is closer to its natural regime. However, here too significant interannual variations are present (Fig. 2). They result in a changed shape of the mean annual cycle when calculated over the last decade. The change is consistently seen at all the studied rivers, including the ones that are strongly controlled by human activities. The interannual variability of discharge is closely related to precipitation anomalies. The wet and dry anomalies are likely a part of large-scale precipitation patterns associated with the Mediterranean Oscillation [4].

Acknowledgements. The study was sponsored by the Italian Ministry for the Environment (Project ADRICOSM, coordinated by Istituto Nazionale di Geofisica e Vulcanologia) and by the Croatian Ministry of Science and Technology.

References

1 - Sekulic B., and Vertacnik A., 1996. Balance of average annual fresh water inflow into the Adriatic Sea. *Water Resources Development*, 12: 89-97.

2 - Raicich, F., 1994. Note on the flow rates of the Adriatic rivers. Pp 8. Tech. Rep., RF 02/94. CNR, Ist. Sperim Talassogr., Trieste.

3 - Bonacci O., 2001. Hydrological changes along the Cetina River course (in Croatian). *Hrvatske vode*, 37. 395-401.

4 - Conte M, Giuffrida S., and Tedesco S., 1989. The Mediterranean Oscillation: Impact on precipitation and hydrology in Italy. Pp. 121-137. *In*: Conference on Climate and Weather, vol 1. Academy of Finland, Helsinki.

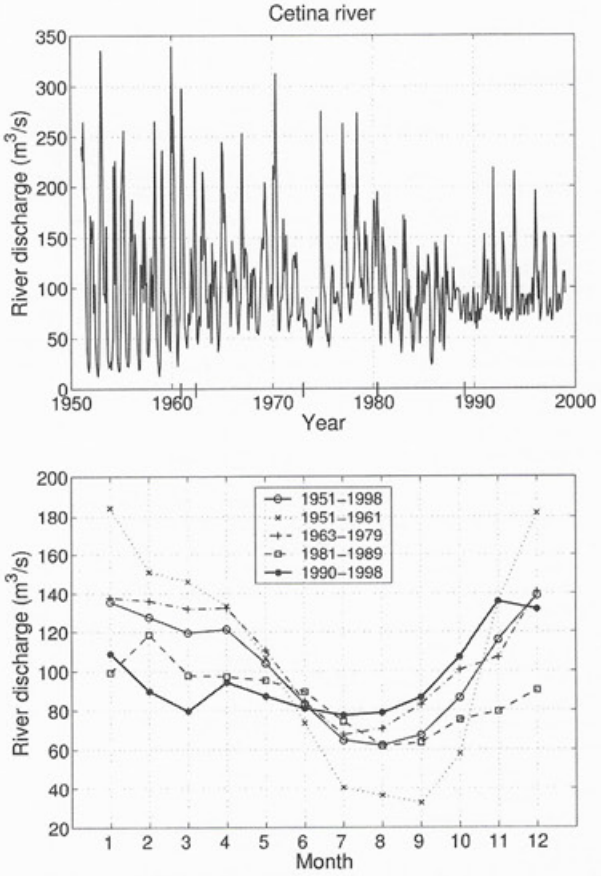


Fig. 1. Monthly mean discharge of the Cetina River; dashes on the horizontal axis show times when mayor hydrological constructions were put in operation (*upper panel*). Mean annual cycle of river discharge, determined over different intervals of the measurement period (*lower pannel*).

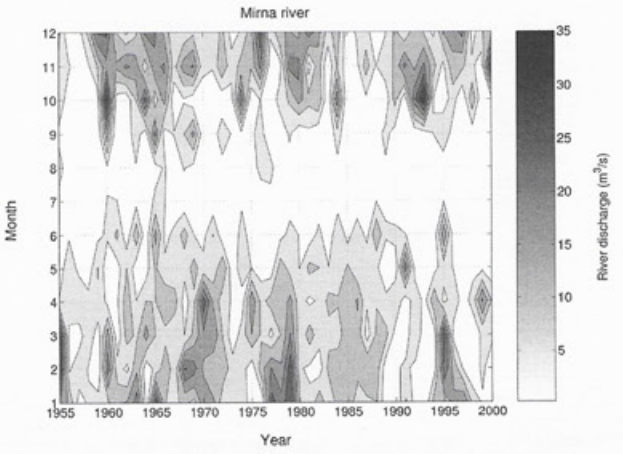


Fig. 2. Isolines of monthly mean discharge of the Mirna River.

THE WINTER CIRCULATION SYSTEM OF THE IZMIR BAY UNDER THE INFLUENCE OF WIND AND THERMOHALINE FORCES

Idil Pazı * and Erdem Sayın

DEU Institute of Marine Sciences and Technology, Izmir, Turkey - * idil@imst.deu.edu.tr

Abstract

The aim of the study is to examine seasonal circulation pattern of the Izmir Bay under the influence of wind and thermohaline forces. The general water movement characteristics in the Bay are given as a result of analysis of observed current data together with Killworth's general circulation model. The wind from north direction is constant feature. The model is forced using wind data obtained from the Çiğli Meteorological Centre. To set a realistic stratification, measured CTD data is prescribed in the model as initial condition. The wind stress constitutes the main forcing for rotational barotropic motions in the Izmir Bay.

Keywords: circulation pattern, spectra, Izmir Bay

Common oscillations

The current measurements between 1994 and 1998 have been performed by the Institute of Marine Sciences and Technology of Dokuz Eylül University with the R/V *K. Piri Reis*. The locations of current meters are shown in Figure 1. As a result of current and wind spectral analysis the frequencies belong to relevant processes are investigated. The corresponding frequencies can be analysed in four groups. First group has daily period (5 days) related to the large-scale cyclonic motion in the Aegean Sea. The second group is usually affected by sun and moon, includes diurnal and semi-diurnal tide's periods. The most important tides are diurnal-luni solar (K1), diurnal-principal solar (P1), semi-diurnal luni solar (K2) and semi-diurnal principal solar (S2). The third group considers the inertial oscillations and the last group is seiches. But last cannot be resolved by hourly collected data (1).

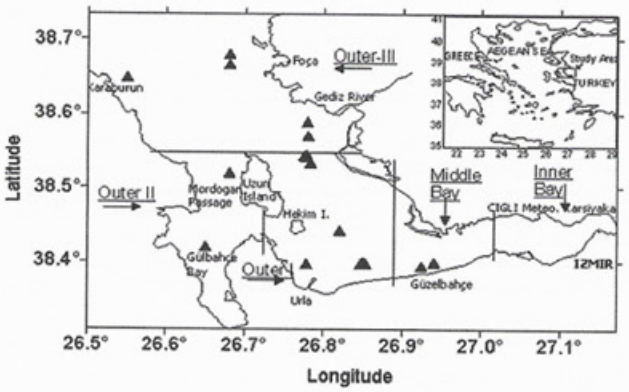


Fig. 1. The location of current meters

Winter current pattern

The circulation system of the Izmir Bay is determined mainly by three factors: the wind, the sea level changes due to the large-scale motion in the Aegean Sea and thermohaline forces. In summer, two-layer stratification occurs in the water column. This two-layer water is destroyed in winter as a result of convective and turbulent mixing. The circulation in the Izmir Bay is not only wind-driven, it is also density-driven especially in summer time, and the circulation due to sea level elevation is not negligible (4).

Model study: The Bay is very dynamic region according to the eddy activities. The generation of eddies are seen in Outer I and Outer III (Fig. 2). The reason of the formation of eddy (Middle Gyre) in Outer I is due to increasing depth to 55 m, so that relative vorticity tends to increase conserving absolute vorticity with an assumption of coriolis does not change in a short distance. The increasing coastal current due to wind-driven circulation enhances the vorticity in eddy generation areas. It is not always the case whole water from Aegean Sea enters Mordoğan Passage and tends to turn back. It causes also an increasing in vorticity in Outer III. The dominating feature of selected circulation pattern is cyclonic in winter and anti-cyclonic in summer. The eddies, that are formed in the entrance of Aegean Sea, in the middle of Bay and in the Inner Bay are very dynamics. The eddy formed in the Outer I propagate with a velocity 0.4 km/day to the North to combine with the Eddies in Outer III. Barotropic current pattern during January 1997 is two cyclonic eddy in the Outer Bay III. Their meridional diameters are about 17 km and 7 km respectively and the shape of eddies is more ellipse-like (5).

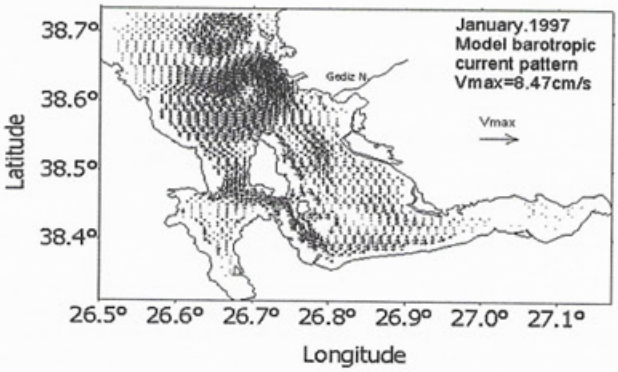


Fig. 2 . January 1997 curent pattern.

Eddies are mostly concentrated in the Outer I and II. The surface current enters the Bay near Foça and separates into two branches. One branch flows to the west and enters to the Mordoğan Passage near the west side of Uzun Island. The second branch flows near east of Uzun Island and combines with first one and together they flow towards Middle Bay. The maximum surface current is nearly 18 cms-1.

References

1 - Sayın E. and Üçüncüoglu E., 1999. Statistical approach to wind data and its effects on the currents of Izmir Bay. Pp. 391-402. *In*: Abdalla, S., Özhan, E. (eds.), The International MEDCOAST Conference on Wind and Wave Climate of Mediterranean and Black Sea. Antalya/Turkey.

2 - Özsoy E., 1981. On the Atmospheric Factors Affecting the Levantine Sea. European Center for Medium Range Weather Forecasts, Technical Report No. 25: 29 p.

3 - Pazı I., 2000. The Current System and Its Effect on the Pollution in Izmir Bay. Master of Science in Institute of Marine Science Technology, submitted to the Dokuz Eylul University, Graduate School of Natural and Applied Sciences, Izmir, Turkey.

4 - Sayın E., 2003. Physical features of the Izmir Bay. *Continental Shelf Research*, 23: 957-970.

5 - Pazı I. and Sayın E., 2003. Analysis of current system in the Izmir Bay. (submitted to *Continental Shelf Research*).

A SIMPLE BAROCLINIC MODEL FOR DIFFUSIVE VORTICES

J. L. Pelegrí [1] *, M. Auladell [1, 2], E. García-Ladona [1], J. Font [1], and P. Sangrà [2]

[1] Institut de Cienciès del Mar, CMIMA-CSIC, Barcelona, Spain

[2] Facultad de Ciencias del Mar, ULPGC, Gran Canaria, Spain

Abstract

A simple layered diffusive model describes the temporal evolution of the angular velocity and vertical structure of oceanic vortices. An initial state specifies the core angular velocity of each layer and the density changes between adjacent layers. The temporal evolution of the angular velocity for each layer is explicitly obtained solving the radial diffusive equation, with the diffusion coefficient determined from a stability analysis, and the shape of the interfaces follows from the assumption of gradient flow.

Keywords: oceanic vortices, radial diffusion, inertial stability, layered model.

Transient mesoscalar vortices are a common feature in the Mediterranean. A simple model for vortex evolution consists on radial diffusion of angular velocity $\omega(r,t)$,

$$\frac{\partial \omega}{\partial t} = K \frac{\partial^2 \omega}{\partial r^2}, \tag{1}$$

where $K(t)$ is a horizontal diffusion coefficient, for an initially rotating cylinder

$$\omega(r, t=0) = \begin{cases} \omega_0, & |r| \le a \\ 0, & |r| > a \end{cases}, \tag{2}$$

where a and ω_0 are the vortex's initial radius and angular velocity (positive/negative for cyclonic/anticyclonic). The solution, for constant K, is [1]:

$$\omega(r,t) = \frac{\omega_0}{2}\left\{ erf\left[\frac{r+a}{(4Kt)^{1/2}}\right] - erf\left[\frac{r-a}{(4Kt)^{1/2}}\right]\right\} \tag{3}$$

Figure 1a displays this solution at several times for an initial cyclonic vortex with $a = 25$ km, $|\omega_0| = 3 \times 10^{-5}$ s^{-1} (period 2.5 days), and $K = 90$ m^2 s^{-1}. The size of the vortex slowly increases with time while a central core remains in near solid body rotation. This core remains discernable in time, although after some 30 days its rotation rate decreases.

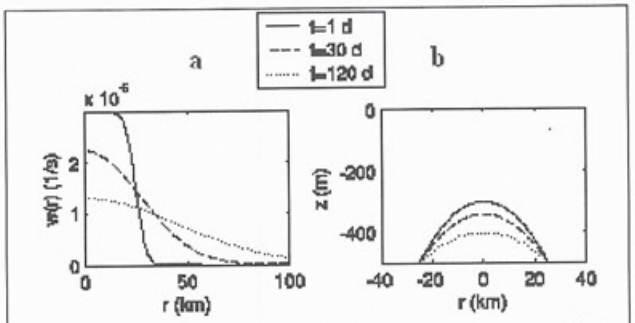


Figure 1. (a) ω at $t = 1$, 30 and 120 days for $K = 90$ m^2 s^{-1}, (b) corresponding depths of the upper layer interface h.

The above model may be generalized to a layered ocean (Fig. 2), with a time-dependent $K(t)$ for each layer, provided that $|\partial K/\partial t| << |\omega K|$. The pressure p is hydrostatic and the interfaces' shape may be determined under the assumptions that (a) the deep flow is motionless and (b) the flow in each layer is in gradient balance:

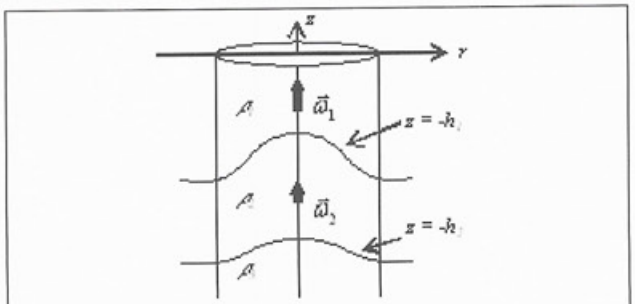


Figure 2. Model schematics.

$$\frac{v_\theta^2}{r} + f v_\theta = \frac{1}{\rho}\frac{\partial p}{\partial r}, \tag{4}$$

where f is the planetary vorticity. For a 1.5 layer model this equation gives the slope of the active only interface,

$$\frac{\partial h}{\partial r} = \frac{\omega(\omega + f) r}{g'}, \tag{5}$$

where $g' \equiv g(\rho_2 - \rho_1)/\rho_1 \equiv \delta\rho/\rho_1$ and ρ_1, ρ_2 are the upper and lower layer densities. The actual interface depth is obtained through integration from a distant unperturbed radial coordinate, $z = -H$. A first approximation has the vortex in solid body rotation $\omega(r=0,t) \equiv \omega_c$ for $|r| \le a$, the interface $h(r,t)$ becoming a function of ω_c:

$$h = \begin{cases} H + \dfrac{\omega_c(\omega_c + f)(r^2 - a^2)}{2g'}, & |r| \le a \\ H, & |r| > a \end{cases} \tag{6}$$

Figure 1b illustrates the interface evolution for a cyclonic vortex at 52°N, the sloping interface resembling observations of tilted isopycnals in vortices.

The model requires a knowledge of $K(t)$ for all layers. Within each layer the angular velocity is approximately constant at the vortex core so any diffusion there simply redistributes particles with similar angular velocities. Hence, for each layer the effective diffusion coefficient depends on the stability at the vortex edge, which we assess using the theory of radial stability in barotropic structures [2]. At lowest order the radial velocity is unstable when $\Omega\Omega_{sb} < 0$, where

$$f + 2\omega + r\frac{\partial \omega}{\partial r} \text{ and } \Omega_{sb} \equiv f + 2\omega.$$

Figures 3a,b show the radial distribution of $\Omega\Omega_{sb}$ for a cyclonic vortex, at different times, using two different diffusion coefficients. For cyclonic vortices edge stability leads to estimates of $K(t)$: a negative minimum at the vortex edge is interpreted as a too small coefficient (Figures 3a,b). For anticyclonic vortices the eddy's edge is rather stable leading to a small effective diffusion [1].

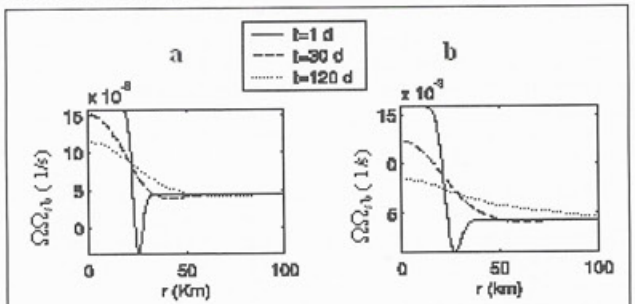


Figure 3. $\Omega\Omega_{sb}$ radial distribution at $t = 1$, 30, and 120 days for (a) $K = 30$ m^2 s^{-1} and (b) $K = 90$ m^2 s^{-1}.

References

[1] Sangrà P., Pelegrí J.L., Arregui I., Martín J.M., Hernández-Guerra A., Marrero-Díaz A., Martínez A., and Rodríguez-Santana A., 2004. Life story of an anticyclonic eddy. *J. Geophys. Res.*, submitted.

[2] Hopfinger E.J., and Van Heijst G.J.F., 1993. Vortices in rotating fluids. *Ann. Rev. Fluid Mech.*, 25: 241-289.

PRELIMINARY RESULTS OF MEDARGO: A EUROPEAN PROFILING FLOAT PROGRAM IN THE MEDITERRANEAN

P.-M. Poulain [1] *, J. Font [2] and S. Le Bras [3]

[1] OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico (Trieste), Italy - * ppoulain@ogs.trieste.it
[2] CMIMA-CISC, Passeig Marítim 37-49, 08003 Barcelona, Spain - jfont@icm.csic.es
[3] IFREMER, BP 70, 29280 Plouzané, France - Sylvie.Le.Bras@ifremer.fr

Abstract

Four profiling floats were deployed in the Catalan Sea and provided temperature and salinity (TS), and subsurface displacement data for more than a month in fall 2003. The float data revealed high mesoscale variability in the upper sea and a strong shear in the currents between the surface and intermediate levels.

Key-words : Temperature and salinity, subsurface floats, Catalan Sea

Introduction

In the framework of MEDARGO, which is part of the EU-sponsored MFS project (1), profiling floats will be deployed throughout the Mediterranean starting in late summer 2004 to provide TS data in near-real time to forecasting models of the Mediterranean. In order to assess the functionality of the floats and define their sampling characteristics, four units were operated in the Catalan Sea in fall 2003. Details about the floats' hardware and software, about their cycling and sampling and about the data telemetry are given hereafter. The float data in the Catalan Sea are described and interpreted, with particular focus on the thermohaline structures and the vertical shear of the currents.

Materials and methods

Two types of profiling floats were operated, one called APEX (manufactured by Webb Research Corporation, USA) and the other one PROVOR (produced by Martec, France). The APEX is the successor of the ALACE (2) whereas the PROVOR is based on the MARVOR technology (3, 4). Two units of each type were acquired. All floats were equipped with Sea-Bird CTD sensors (model 41 pumped MicroCAT). They were programmed in the "Park and Profile" configuration with a neutral parking depth of 350 m (near the salinity maximum of the Levantine Intermediate Water - LIW) and a maximum profiling depth of 700 m, with total cycle periods of 3.5, 4 and 7 days. When at surface, the floats are located by, and transmit data, to the Argos system onboard the NOAA satellites. The data are processed and archived in near-real time at the CORIOLIS Data Center (Brest, France; 4) and are disseminated on the GTS following the standards of the international ARGO program. The two APEX floats were deployed in the Catalan Sea on 26 September 2003. A week later, on 2-3 October 2003, the two PROVOR floats were deployed with the R/V *Garcia del Cid* in the vicinity of the APEX floats. CTD casts (from the ship) were made close to the float profiles. All floats were operated in "Park and Profile" mode until 7 November 2003 providing a total of 35 ascending TS profiles. Thereafter, the floats remained at surface until they were recovered.

Results

The floats were deployed in an area where the prevailing slope currents are generally southwestward (Northern Current; 5). After showing some indication of subsurface flow towards the northeast after deployment, all the floats were trapped in the Northern Current and moved to the southwest (Fig. 1). Speeds at the 350 dbar level vary between 1 and 6 cm/s. Displacements during the time spent at surface can be of the same order of magnitude as the deep displacements especially for float 6900226. They show no preferential direction due to the large variability of the surface currents at meso and inertial scales. In some cases, the surface and intermediate displacements are in opposite directions, revealing a significant shear between the two levels.

The TS profiles obtained by the floats are typical for the region, with a marked salinity maximum in the LIW at about 400 m. The structure in the upper layer is highly variable and the depth of the seasonal thermocline varies between 30 and 70 m.

Acknowledgements. We wish to thank the crew of the R/V *Garcia del Cid*, A. Julià, M. Emelianov, L. Ursella, R. Barbanti and S. Le Reste for their skilled and enthusiastic assistance for the float deployment and recovery operations. This work was supported by the European Commission (V Framework Program - Energy, Environment and Sustainable Development) as part of the MFSTEP project.

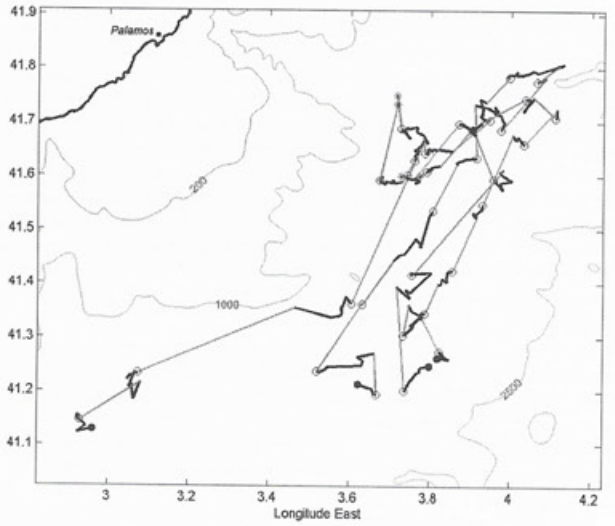


Fig. 1. Float trajectories in the Catalan Sea. Thin straight (heavy curvy) segments denote the subsurface (surface) float displacements. Star and solid circles represent the deployment and last profile locations, respectively. Open circles represent the locations of the TS profiles. The 200,1000 and 2500 m isobaths are shown.

References

1 - Pinardi, N., I. Allen, E. Demirov, P. De Mey, G. Korres, A. Lascaratos, P.-Y. Le Traon, C. Maillard, G. Manzella and C. Tziavos, 2003. The Mediterranean ocean forecasting system: first phase of implementation (1998-2001). *Ann. Geophys.*, 21: 3-20.

2 - Davis, R.E. , D.C. Webb, L.A. Regier, and J. Dufour, 1992. The Autonomous Lagrangian Circulation Explorer (ALACE). *J. Atmos. Ocean. Tech.*, 9: 264-285.

3 - Loaec G., N. Cortes, M. Menzel and J. Moliera, 1998. PROVOR: a hydrographic profiler based on MARVOR technology. *IEEE-Oceans'98*, September 1998, vol. 1: 42-45.

4 - Loaec G., Carval T., Le Reste S., Maudire G., 1999. Provor and Coriolis Data Center: a step towards operational oceanography; *Data Buoy Conference Panel Technical Document* N° 17: 1-9.

5 - Font, J., J. Salat and J.Tintoré, 1988. Permanent features of the circulation in the Catalan Sea. *Ocean. Acta*, vol.sp. 9: 51-57.

ASSESSMENT OF TEMPERATURE AND SALINITY SAMPLING STRATEGIES IN THE MEDITERRANEAN FORECASTING SYSTEM

Fabio Raicich

CNR, Istituto di Scienze Marine, Sezione di Oceanografia Chimica e Fisica, Trieste, Italy – fabio.raicich@ts.ismar.cnr.it

Abstract

Different temperature and salinity sampling strategies are studied using Observing System Simulation Experiment techniques, by assessing their impact on a Mediterranean GCM via bivariate data assimilation. Such sampling strategies consist of combinations of XBTs and CTDs deployed along Volunteer Observing Ships (VOS) tracks. The sampling strategy assessment is made by means of identical twin numerical experiments, and is quantified as the error reduction achieved in the assimilation run relative to the free run.

Keywords: Mediterranean Sea; numerical modelling; Observing System Simulation Experiments; data assimilation.

Introduction

The spatial and temporal coverage provided by oceanographic data sets is usually limited, therefore a general aim is to design as effective sampling strategies as possible, real optimization generally being difficult due to logistic and economic constraints. A programme of XBT data collection along VOS tracks was established in the Mediterranean Forecasting System Pilot Project (MFSPP) (1, 2) and is a component of the MFSTEP (MFS Towards Environmental Predictions) project. An assessment programme is included in MFSTEP to study the effectiveness of sampling strategies already used in the project or representing realistic evolutions. Sampling strategies are assessed by quantifying their impact in a Mediterranean GCM via data assimilation. To this purpose, Observing System Simulation Experiment (OSSE) techniques are used, consisting of identical twin numerical experiments.

The assessment of several sampling strategies involving temperature only was performed in the framework of MFSPP (3). That study was limited by the use of univariate temperature data assimilation, enabling only temperature correction. Present work is a preliminary assessment based on multivariate temperature and salinity data assimilation, which provides corrections for both variables.

Methods

Each twin experiment consists of: a) A control run, defined as the truth, from which temperature and salinity data for subsequent assimilation are extracted; b) an assimilation run, with different initial conditions and assimilation of temperature and salinity data taken from the control run; c) a free run, with same initialisation as the assimilation run but without data assimilation. The Mediterranean GCM is MOM-1 with 1/8°×1/8° horizontal grid spacing and 31 vertical levels, forced by ECMWF 6-hr operational analyses. Data assimilation is performed by means of the reduced-order optimal interpolation scheme implemented in the SOFA code (4) and corrections to temperature and salinity are computed every 7 days. The order reduction is achieved by projecting temperature and salinity profiles onto vertical bivariate EOFs (5). Each experiment lasts 12 weeks and is initialised on 1 February 2000, i.e. in winter conditions. The assimilation and free runs are initialised one year earlier.

The convergence of the assimilation run towards the control run is assessed by means of the standard deviation (the 'error') of the difference between assimilation and control runs. It measures the effectiveness of data assimilation in driving the model towards the truth starting from incorrect initial conditions. The analogous error involving the free run is used for reference, since it measures the model convergence due to the atmospheric forcing only. The assessment is made for the western and eastern Mediterranean regions and three vertical layers, namely surface (L1, 5-240 m), intermediate (L2, 280-400 m) and deep (L3, 440 m - bottom).

In this work the sampling strategies simulate the acquisition of temperature only or temperature and salinity profiles along the VOS tracks described in (2, 3), representing XBT and XCTD data, respectively. The latter are not yet adopted but represent a possible development of the present observing system. Each track is covered once a week except the Haifa-Messina-Gibraltar, which is covered fortnightly.

Four configurations are compared here: the first is the already studied (3) univariate assimilation of XBT data (labelled "UT"). Two other configurations involve bivariate assimilation of XBT (BT), where salinity is estimated via bivariate EOFs, or XCTD (BTS) data. The fourth consists of the periodic repetition in space of two XBT and one XCTD profiles (BTTS). It should be noted that strategy UT is the sole retaining the full temperature signal, while in the others the EOFs carry only a fraction. The profiles positions and times are the same for all configurations.

Results and concluding remarks

A general result is that temperature and salinity data impact is larger in the western Mediterranean than in the eastern, particularly in L2 and L3. This different behaviour can be related to the typical winter vertical structure of the water column, which exhibits distinct layers in the eastern Mediterranean, among which the Intermediate Levantine Water, while the western basin, frequently affected by convection, is significantly more homogenous. Strategies BTS and BTTS show essentially identical impacts on temperature and very close impacts on salinity, BTTS being slightly less effective since one third of salinity profiles is used.

Concerning temperature, in L1 all strategies are almost equivalent, with temperature error reduction of 25-30% in the western basin and 20% in the eastern. In L2 and L3 of the western basin, strategy BTS becomes the most effective only after 10-11 weeks, with 40% error reduction, while its impact is the same as UT in L2 and even smaller in L3; the error reduction reaches 20% at the end of the experiment. In the eastern basin all strategies are almost equally effective, but UT turns out to be the best after several weeks in L2 and L3 with 20 and 10% error reductions, respectively.

In the case of salinity, strategies UT and BT have negligible impact (less than 10% salinity error reduction). In the western basin the introduction of salinity data enable to achieve 30% error reduction in L1, 20% in L2 and about 10% in L3. In the eastern basin even strategy BTS does not achieve more than 10% error reduction.

The lower error reduction, i.e. data impact, in the eastern Mediterranean may be partly due to the more complex variability of the water column than in the western basin, a fact that might not be adequately captured by the EOFs.

Acknowledgements. This work was partly funded by EC Projects "Mediterranean Forecasting System Pilot Project" and "Mediterranean Forecasting System Towards Environmental Predictions".

References

1 - Pinardi N., and Flemming N.C. (eds.), 1998. The Mediterranean Forecasting System Science Plan. EuroGOOS Publication No. 11, Southampton Oceanographic Centre, Southampton, UK, 49 p.

2 - Manzella G.M.R., Scoccimarro E., Pinardi N., and Tonani M., 2003. Improved near real-time data management procedures for the Mediterranean ocean Forecasting System – Voluntary Observing Ship program. *Ann. Geophys.*, 21: 49-62.

3 - Raicich F., and Rampazzo A., 2003. Observing System Simulation Experiments for the assessment of temperature sampling strategies in the Mediterranean Sea. *Ann. Geophys.*, 21: 151-165.

4 - De Mey P. and Benkiran M., 2002. A multivariate reduced-order optimal interpolation method and its application to the Mediterranean basin-scale circulation. Pp . 279-303. In: Pinardi N., and Woods J. (eds.), Ocean Forecasting Conceptual Basis and Applications, Springer-Verlag, Berlin.

5 - Sparnocchia S., Pinardi N., and Demirov E., 2003. Multivariate Empirical Orthogonal Function analysis of the upper thermocline structure of the Mediterranean Sea from obrservations and model simulations. *Ann. Geophys.*, 21: 167-187.

RESULTS OF METEOR CRUISE M51/2 IN 2001

W. Roether [1] *, B. Klein [1], B. B. Manca [2], N. Kress [3]

[1] Institut für Umweltphysik, Univ. Bremen, P.O. Box 330 440, D 29344 Bremen, Germany
* wroether@physik.uni-bremen.de ; bklein@physik.uni-bremen.de
[2] OGS, Borgo Grotta Gigante 42/c, 34010 Sgonico, Italy - bmanca@ogs.trieste.it
[3] IOLR, P.O. Box 8030, Tel Shikmona, Haifa, 31080, Israel - nurit@ocean.org.il

Abstract

Cruise M51/2, 2001, provided an Eastern Mediterranean hydrographic survey, as a follow-up to previous, similar surveys in 1987, 1995, and 1999. The aim was to provide an additional snapshot of the evolving Eastern Mediterranean Transient (EMT). The data presented will show that by 2001 the deep and intermediate waters had relaxed after the EMT peak, but that the hydrography and circulation of the waters were still very different from the pre-EMT situation.

Keywords: Eastern Mediterranean Transient, deep waters, intermediate waters, hydrographic survey, tracer survey

Cruise M51/2 of *METEOR*, 18 October-11 November 2001, carried out a modest-resolution hydrographic survey (including the measurement of oxygen/nutrients and of transient tracers) of the Eastern Mediterranean, providing another snapshot of the EMT of the deep and intermediate waters. An oxygen section along the Eastern Mediterranean for 2001 is shown in Fig. 1. In comparison with 1995, when the EMT, caused by a bottom-concentrated intrusion of Aegean waters of enhanced density, was fully developed [1], the deep waters have been gradually returning toward horizontal homogeneity, but the basic structure of the 2001 distribution is still far different from that of the pre-EMT situation: The oxygen minimum range in 2001 is rather more ventilated, vertically more restricted and shifted to shallower depth, and in the Levantine it is underlain by more oxygenated waters, while a signature of the Adriatic deep water source at the base of the western continental slope is missing. The findings confirm absence of recent bottom water formation [2, 3]. While prior to the EMT the near-bottom flow was essentially eastward, feeding upwelling over the entire basin, the 2001 property distributions indicate westward flow over the deep sills in the Cretan Passage to both sides of the Mid-Mediterranean Ridge. The reason is a decreasing near-bottom water density westward. The Cretan Sea (southern Aegean) still contains rather dense and well ventilated water, the upper boundary of which, however, allows outflow only southeastward through the deeper Kasos Strait but not westward through Antikithera Strait [see also 3]. The property distributions furthermore confirm a cyclonic deep recirculation of the Ionian Sea [2], probably driven both by the dense waters of Aegean origin and by more recent Adriatic outflow that settled at comparatively shallower depths. Furthermore, transfer time scales are obtained using the tracer data.

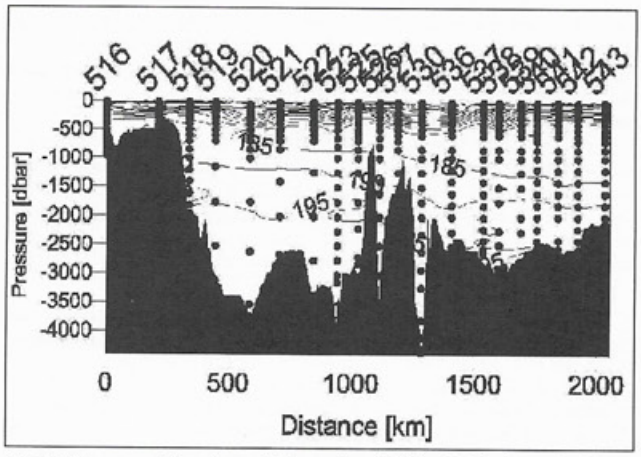


Fig. 1. Oxgen section (mmol/kg), cruise M51/2, 2001, from the Sicily channel (left) to off the Libanese coast (right).

References

[1] Roether W., Manca B. B., Klein B., Bregant D., Georgopoulos D., Beitzel V., Kovacevic V., and Lucchetta A, 1996. Recent changes in Mediterranean deep waters. *Science*, 271: 333-335.

[2] Manca B. B., Budillon G., Scarazzato P., and Ursella L., 2003. Evolution of dynamics in the eastern Mediterranean affecting water mass Structures and properties in the Ionian and Adriatic Seas. *J. Geophys. Res.*, 108 (C9): 8102, doi: 10.1029/2002JC001664.

[3] Theocharis A., Nittis K., Klein B., and Roether W., 2002. Evolution and status of the Eastern Mediterranean Transient (1997-1999). *J. Mar. Systems*, 33-34: 91-116.

THE IMPACT OF DIFFERENT APPROACHES IN ESTIMATING HORIZONTAL GEO-CHEMICAL FLUXES: AN EXAMPLE STUDY OF A NORTH ADRIATIC TRANSECT

A. Russo [1], J. W. Book [2], H. Perkins [2], R. Signell [3], M. Marini [4], E. Paschini [4], A. Boldrin [5], S. Carniel [5] *, M. Sclavo [5]

[1] Università Politecnica delle Marche - Dipartimento di Scienze del Mare, 60131 Ancona, Italy - a.russo@univpm.it
[2] Naval Research Laboratory, Stennis Space Center, MS 39529-5004, U.S.A. - book@nrlssc.navy.mil, hperkins@nrlssc.navy.mil
[3] NATO SACLANT Undersea Research Centre, 19138 La Spezia, Italy - signell@saclantc.nato.int
[4] Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine, 60131 Ancona, Italy - mauro.marini@ismar.cnr.it, elio.paschini@ismar.cnr.it
Consiglio Nazionale delle Ricerche - Istituto di Scienze Marine, 30100 Venezia, Italy - alfredo.boldrin@ismar.cnr.it,
* sandro.carniel@ve.ismar.cnr.it, mauro.sclavo@ve.ismar.cnr.it

Abstract

During the Adria02 cruise (September-October 2002), physical and bio-geo-chemical data were acquired along the Senigallia-Süsak Island line, where 7 ADCP and 3 current-meters were deployed. Through numerical model simulations higher resolution water current data are also available. Estimates were obtained of transported material fluxes entering and leaving the Northern Adriatic Sea using different methods, thus contrasting calculations made with geostrophic assumptions, hydrodynamic model simulations, and direct current measurements.

Keywords: horizontal fluxes, North Adriatic Sea.

Since the Nilo River damming at Assuan in 1970, the North Adriatic Sea receives the highest river runoff of the Mediterranean Sea, most of it coming from the Po River (Fig. 1). The shallowness of this sub-basin (average depth less than 35 m) makes its physical and ecological environment highly sensible to variations in river runoff and atmospheric conditions. River runoff affects the circulation through buoyancy input, which is one of the major driving forces of the Western Adriatic Coastal Current (WAC or WACC), and impacts the ecosystem by introducing large amounts of organic matter, nutrient salts and sediments. Some studies have attempted to quantify the exchange rates of water and transported materials between the northernmost part of the Adriatic Sea and the remainder of the basin. The first study (1) used chemical data, measured roughly biweekly in the north Adriatic at one station located in the western area and one station located in the eastern area, combining them with a water exchange rate of 10^5 m^3 s^{-1} derived by previous geostrophic calculations. A second study (2), conducted in the same area (roughly indicated by the dotted line in Fig. 1) but with different methodologies (more stations but only 4 samplings during 1995/96, with direct current measurements), quantified the outflow fluxes in summer 1995 and winter 1995/96 (only the summer values are reported in Tab. 1 as this period is more closely related to our study period). The average nutrient flux estimate for summer 2001 reported in Tab. 1 is derived by monthly estimates made in a third work (3). Physical and chemical data were collected along the Senigallia-Süsak Island transect (southeastward of the two previous studies); geostrophic velocities were computed and combined with measured nutrient salts data to obtain fluxes.

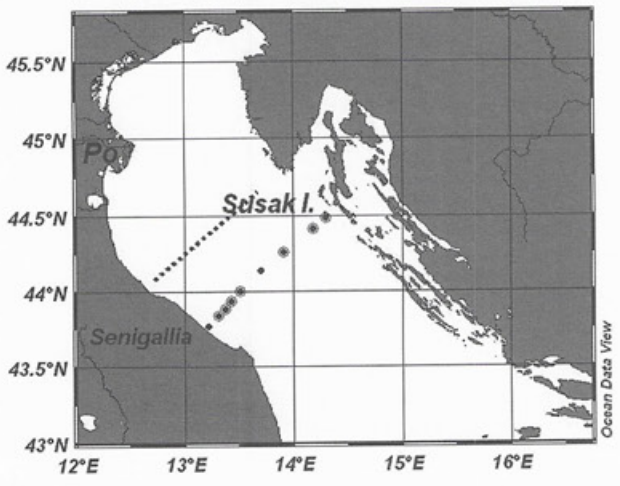


Fig. 1. North Adriatic Sea map with area of previous flux estimations (dotted line) and positions of ADCP (circled dots) and current-meter moorings (dots) along the Senigallia- Süsak Island transect.

Table 1. Flux estimates according to previous authors (2. reported DIN instead of NO_3+NO_2) and the present work.

	Degobbis Gilmartin yearly	Gacic et al. Summer 1995	Paschini et al. Summer 2001	Geostr. 28 Sep 02	Model 28 Sep 02	ADCP 28 Sep 02
Net flux						
TSM (g s^{-1})				35562	111487	313215
PO_4 (mol s^{-1})	3.90		0.82	1.13	1.70	8.63
$Si(OH)_4$ (mol s^{-1})	135.08		32.02	59.11	291.67	786.96
NO_3+NO_2(mol s^{-1})	74.52		17.02	57.56	114.41	215.77
SEward flux						
TSM (g s^{-1})		19543		151337	250243	393057
PO_4 (mol s^{-1})	6.18	0.82	2.67	4.88	9.73	14.51
$Si(OH)_4$ (mol s^{-1})	321.85	30.67	86.03	357.30	672.39	1037.58
NO_3+NO_2(mol s^{-1})	127.79	19.16	38.97	167.16	330.54	380.97

From 19 September to 8 October 2002 the international cruise Adria02 was carried out in the Adriatic Sea onboard the R/V Alliance. The simultaneous availability along the Senigallia transect of high resolution CTD casts, bio-geo-chemical sampling stations, hydrodynamic model simulations, ship-tethered ADCP surveys, and 7 bottom mounted ADCP plus 3 traditional moored current-meters at 2 sites, made possible the computation of fluxes across the transect using different methods. On 28 September all the data sets had an optimal coverage along the transect, so computations were made at this specific date; geostrophic velocities, daily averaged current data and model velocities were combined with bio-geo-chemical parameters to obtain fluxes (Tab. 1).

Fluxes based on geostrophic velocities are in good agreement with previous published fluxes, while fluxes computed using direct measurements and model velocities are in some cases several times larger. For these computations, the area northeastward of Süsak was excluded; this fact can significantly affect the net fluxes, while it can be considered negligible for the southeastward fluxes.

References

1 - Degobbis D., and Gilmartin M., 1990. Nitrogen, phosphorus, and biogenic silicon budgets for the northern Adriatic Sea. *Oceanologica Acta* 13: 31–45.

2 - Gacic M., Civitarese G., and Ursella L., 1999. Spatial and seasonal variability of water and biogeochemical fluxes in the Adriatic Sea. Pp 335-357. *In*: P. Malanotte-Rizzoli and V.N. Eremeev (eds.). The Eastern Mediterranean as a Laboratory Basin for the Assessment of Contrasting Ecosystems. Kluwer Academic Publisher, Dordrecht, NL.

3 - Paschini E., Russo A., Marini M., Grilli F., Fornasiero P., and Caccamo G., 2003. *In*: MAT Project Final Report. (in Italian).

4 - Poulain P. M., and Raicich F., 2001. Forcing. Pp 45-65. *In*: Cushman-Rosin B. et al., Physical Oceanography of the Adriatic Sea. Kluwer Academic Publisher. Netherlands.

CLIMATE VARIABILITY OF THE MED REGION DETECTED BY ERA-40 SURFACE WATER VAPOUR DATA

M.E. Schiano [1], S. Sparnocchia [2], C. Cappa [3], R. Bozzano [4*], P. Picco [5]

[1] CNR ISMAR-SP, Forte di Santa Teresa, 19036 Pozzuolo di Lerici (SP), Italy - elisabetta.schiano@sp.ismar.cnr.it
[2] CNR ISMAR-TS, Viale Romolo Gessi, 2 - 34123 Trieste, Italy - s.sparnocchia@ts.ismar.cnr.it
[3] CNR ISAC-TO, Corso Fiume 4, 10133 Torino, Italy - c.cappa@isac.cnr.it
[4] CNR ISSIA, Via de Marini 6 - 14149 Genova, Italy - *boz@ge.issia.cnr.it
[5] ENEA-CRAM, Forte di Santa Teresa, 19036 Pozzuolo di Lerici (SP), Italy - picco@santateresa.enea.it

Abstract

An analysis of the climate variability of the Mediterranean region is performed by using ERA-40 surface water vapour data. Previous studies show that this parameter may be used as an index for detecting the prevalence of weather condition more related to the tropical aspects of the Mediterranean area. The ECMWF project ERA-40 provides the long time series of values used in this investigation. The results are examined according to some climate indices and to the main pattern of variability observed in the circulation of the Mediterranean Sea.

Keywords: climate variability, surface water vapour, Mediterranean Sea

The Mediterranean basin shows a "twofold climate regime", i.e. both tropical and mid-latitude aspects are playing a role. Generally, during summer months the tropical features are more appreciable giving raise to a well-marked division between winter and summer conditions. Many signals suggest that the climate regime of this region is varying; and it would seem that the tropical features are prevailing all the year round. In order to analyse the signals of this supposed climate change, the surface water vapour density over the sea may be a good index.

The results of previous studies (1,2) show that the distribution of many quantities, strongly related to climate, versus the surface water vapour density reveals a discontinuity for values of about 15-16 gm^{-3}. This threshold does not separate winter from summer since the water vapour density may be lower than 15 gm^{-3} also during the summer months, but it evidences warm and wet weather condition, more related to the tropical aspects of the Mediterranean area.

We investigate some aspects of the interannual variability of the Mediterranean climate using the surface water vapour density over the sea as a discriminant between the different conditions. In order to perform this analysis we need a long time series of surface values with a good spatial and temporal resolution over the whole basin. At the present, only surface meteorological data from numerical models are able to satisfy this requirement. Particularly, the values obtained from re-analysis projects are very useful because they are not affected by changes of the model which introduce long-term trends in the operational analysis products.

In the present study, data from the European Centre for Medium-range Weather Forecast (ECMWF) 40 years reanalysys (ERA-40) covering the period from mid-1957 to 2001 have been used. The data extracted from the ECMWF ERA-40 archive were the 2m air temperature and 2m dew point temperature on a regular latitude-longitude grid of size 0.5°x0.5° covering the whole Mediterranean Sea from January 1 1958 to December 31 2001. The values at the four synoptic hours were used for computing surface water vapour density values, from which calculating the mean daily value. In order to estimate the accuracy of ERA-40 data we compared the data of the ECMWF re-analysis against experimental values obtained from an offshore large spar buoy in the Ligurian Sea (Northern Mediterranean Sea) from February through December 2000. The comparison was performed by using the two grid points closest to the buoy position and the result shows a significant underestimation of the model. This is in agreement with the results of a previous work (3) which indicates the difficulty in modelling the surface vapour over the Mediterranean Sea. However, the need of a continuous long time data set obliges us to accept the lower accuracy.

The Mediterranean basin was divided into four sub-basins: the North-Western area (-6.0 ÷ 9.0 °E 35.5 ÷ 39.5 °N), the South-Western area (0.5 ÷ 9.0 °E 40.0 ÷ 44.0 °N), the Central area (9.5 ÷ 20.0 °E 30.5 ÷ 45.0 °N) and the Eastern area (20.5 ÷ 35.5 °E 31.0 ÷ 40.5 °N) and an average value was calculated for the water vapour density in each region. Furthermore, we computed the water vapour density in 18 selected grid points located in areas where significant oceanographic processes occur.

A first analysis was performed by computing for each year the number of days for which the surface water vapour density overcomes the threshold of 15 gm^{-3}. This number shows a great variability until 1980 when it drops to a minimum over the whole basin. After this drop, a well marked growth begins which is persisting until the end of our time series. The analysis carried out by looking the monthly distribution reveals that this trend is mainly due to an increase of the number of days over the threshold in spring and early autumn. Even the occurrences of very high values increase in the last 15 years. The analysis of the annual averages of water vapour density shows a similar behaviour with a rise in the last 15 years partially due to a reduction of the minimum values also.

In spite of the limited accuracy of the ERA-40 data, this study seems to confirm that the tropical features of the Mediterranean Basin are becoming stronger in the last years.

In order to evidence possible connections with large scale phenomena we perform an analysis with some climate indexes. Furthermore, since we have found a strong correlation between the evolution of the upper thermal gradient in the Mediterranean Sea and the surface water vapour, we look for links with the main pattern of variability in the Mediterranean circulation.

References

1 - Schiano M.E., Borghini M., Castellari S., Luttazzi C., 2000,. Climatic features of the Mediterranean Sea detected by the analysis of the longwave radiative bulk formulae. *Ann. Geophysicae*, 18: 1482-1487.

2 - Schiano M.E., Bozzano R., Vetrano A., Castellari S., Siccardi A., Gervasio L.,. Manzella G.M, Borghini M., Luttazzi C., 2001, Preliminary study on the use of surface water vapour density over the Mediterranean sea as index for analysis of interannual variability, in Abstract of EGS, GA XXVI, Nice 2001.

3 - Bozzano R., Siccardi A, Schiano M.E., Borghini M., Castellari S., 2003, Comparison of ECMWF surface meteorology and buoy observations in the Ligurian Sea. *Annales Geoph.*, in press.

STUDY OF THE CIRCULATION IN THE ORBETELLO LAGOON, ITALY

Isabella Scroccaro [1] *, Lorenzo Cappietti [2], Andrea Cappelletti [3], Georg Umgiesser [1], Pier Luigi Aminti [2]

[1] CNR ISMAR - S.Polo, 1364 - 30125 Venice, Italy isabella - * scroccaro@ismar.cnr.it

[2] Dip. di Ingegneria Civile – Univ. di Firenze, Via S.Marta, 4 - 50139 Florence, Italy

[3] ENEA - Centro Ricerche Ambiente Marino - C.P. 224 - 19100 - La Spezia, Italy

Abstract

The combination of poor hydrodynamic activity and algal blooms in the Orbetello lagoon (Italy) is causing many problems for the water quality and the conservation of fish population, the most important resource of this ecosystem. To improve the water quality of the lagoon is necessary to know the hydrodynamic behavior. This goal was achieved using both measurements and numerical simulations, carried out with a shallow water finite element model, developed at ISMAR-CNR in Venice. The study shows that numerical models could offer a very useful tool for the management and saveguarding of the water resources.

Keywords: coastal lagoons, hydrodynamic modeling, numerical simulations, Orbetello, finite element method

The Orbetello lagoon (southern coast of Tuscany, Italy) covers an area of 27 km^2 and is composed of an eastern lagoon (12 Km^2 wide) and a western lagoon (15 Km^2 wide). The two lagoons are connected by the Orbetello isthmus and separated by a dam. The average depth is about 1 meter. The lagoon exchanges water with the Thyrrenian Sea by three narrow channels: Nassa channel, Fibbia channel and Ansedonia channel. Each inlet has its own floodgate and water pumps that may pump water from the sea into the lagoon. The lagoon is a semi-enclose coastal basin characterized by shallow water, poor hydrodynamic activity, high trophic level and algal blooms, that may cause problems for the water quality and the conservation of fish population.

Numerical simulation of the lagoon hydrodynamics was performed with a shallow water finite element model, developed at ISMAR-CNR in Venice (1,2). The finite element method gives the possibility to follow carefully the topography of the system and to better represent the zones where hydrodynamic activity is more interesting. The model uses finite elements for spatial integration and a semi-implicit algorithm for integration in time. Experimental data have been used to calibrate and validate the numerical model.

A system of gauges was designed in order to collect hydrodynamic and water quality parameters at different locations. Gauges were positioned in nine points of the lagoon, as can be seen in Figure 1. Hydro-meter, Current-meter and multi-parametric gauges, collecting water temperature, salinity, oxygen and Ph, were put in front of the channel and in the middle of the lagoon. Wind-meters were put in the middle of the lagoon, too. Registration of data began in August 2001 and is ongoing. Wind data (speed and direction) and water circulation data (speed, direction and level) are collected simultaneously every ten minutes. Moreover, a detailed topographic survey was completed to precisely map the bathymetry of the lagoon, also revealing the presence or not of algae. It appeared that in the 90% of the bottom of the lagoon there was algae presence (3).



Fig. 1. Position of the gauges. 1-4-6-9 Hydro-meter, 2-3-8 Hydro-meter; current-meter; multi-parametric gauge, 5-7 Hydro-meter; current-meter; multi-parametric gauge; wind-meter.

Results of the numerical simulations show that the inner hydrodynamics circulation is mainly due to the wind action. Tidal excursion was limited to 30 cm in this area and it is not able to induce appreciable circulation. Algae presence all over the lagoon acts as a high roughness and is the main factor responsible for low water circulation in shallow water areas. During typical hydrodynamic conditions maximum speed velocity is of the order of 1 cm/s.

Some proposals were made, trying to solve the problem of the low-speed circulation inside the lagoon.

Modification of Ponte Diga: the bridge, which divides the two parts of the lagoon, has some piers positioned at distances which are not very large. The proposal was to enlarge the openings on the dam to assess if this action could improve the circulation (4).

Excavation of channels on the bottom of the lagoon: to increase the mean water velocity in some particular areas of the lagoon, it is possible to excavate some channels; these are preferential ways for the water forced by wind to pass in, and arrive to the areas in which circulation has to be increased. This proposal seemed to be efficient, with good effects on the inner circulation of the lagoon.

The next application will be the implementation of a diffusion-reaction and radiative module to investigate the distribution of salinity, temperature and oxygen, which play an important role in the trophic processes of the lagoon.

References

1 - Umgiesser, G. and Bergamasco, A., 1993. A staggered grid finite element model of the Venice Lagoon, In: K. Morgan, E. Ofiate, J. Periaux and Zienckiewicz, O.C. (eds), Finite Elements in Fluids. Pineridge Press.

2 - Umgiesser, G. and Bergamasco, A., 1995. Outline of a Primitive Equations Finite Element Model. Pp. 291-320. In : Rapporto e Studi, vol. XII, Venice, Italy, Istituto Veneto of Scienze, Lettere ed Arti.

3 - Aminti, P.L., Cappietti, L., Tecchi, M.G., and Venturini, A., 2003. Hydrodynamics of lagoons, a case of study: the Orbetello Lagoon. Pp. 2031-2042. In : E. Ozhan (Ed.). Proceedings of the Sixth International Conference on the Mediterranean Coastal Environment, MEDCOAST 03.

4 - Scroccaro, I., Cappelletti, A. and Umgiesser, G., 2003. An idealized circulation of the Orbetello lagoon. Pp. 2087-2098. In : E. Ozhan (Ed.). Proceedings of the Sixth International Conference on the Mediterranean Coastal Environment, MEDCOAST 03.

MODELLING THE IMPACT OF THE NILE DAMMING ON THE MEDITERRANEAN THERMOHALINE CIRCULATION

N. Skliris *, A. Lascaratos, and S. Sofianos

Ocean Physics And Modeling Group, University of Athens, University Campus, Phys-V, 15784 Athens, Greece

Abstract

Changes in the Mediterranean intermediate/deep water characteristics are investigated in relation to the Nile damming in a process-oriented study. Results show that the drastic Nile runoff reduction induced a large salinity increase in the Levantine surface layer in the sixties/seventies, which enhanced the LIW production rates and salinity. This in turn resulted in the production of saltier and larger amounts of deep waters in the Adriatic and the Gulf of Lions. It also functioned as a strong preconditioning to the formation of deep waters in the Southern Aegean (EMT), following two very cold winters in the early 90's.

Keywords: Numerical modelling; river discharge; thermohaline circulation

Introduction

After building the Aswan Dam in 1964, the runoff of the Nile was drastically reduced (by more than 90%), affecting the salt budget of the Mediterranean Sea. Important changes in the characteristics of the deep waters of both the Eastern and Western Mediterranean basins during the last four decades have been associated with this event [1, 2]. The response of the Mediterranean Sea and the various sub-basins to the Nile damming is investigated in this study, using the POM model. The results are compared with previous studies and observational data, and mechanisms involved in changes of the deep water mass characteristics are investigated.

Results and discussion

The model is first integrated using climatological atmospheric forcing, derived from the ECMWF reanalysis, and values of the Nile runoff typical of the pre-damming period and reaches a steady state after 75 years of integration. Then the model is integrated using the reduced runoff values, typical of the after-damming period, to reach a new steady state (after 75 years of integration). Results show that the Nile damming induced a large increase in the surface layer salinity in the Aegean and Levantine basins exceeding 0.1 psu in the early seventies, in agreement with observations [1]. This saltier surface layer in the vicinity of the Rhodes Gyre favoured the preconditioning for the formation of the LIW, resulting in about 30% increase of its formation rate. Intermediate waters became saltier, and as they were transported westward they reduced the stability of the water column in the deep-water formation sites, namely the Southern Aegean, the Southern Adriatic and the Gulf of Lions. Thus saltier and larger amounts of dense waters were formed filling the deep parts of the Mediterranean. Salinity changes become perceptible in the deep layers of the western basin about 7-8 years after the Nile damming (Fig. 1) when the increased salinity signal reaches the Gulf of Lions via the LIW circulation. Results indicate that the Nile damming explains about 45% of the observed salinity increasing trend during the last 40 years in the WMDW. This trend is rapidly slowing down after 20 years of simulation and is almost vanished by about 2030 when a new quasi-steady state of the Mediterranean thermohaline circulation is reached. The time-scale of the Mediterranean system response to the Nile damming is in agreement with simplified box model results [2]. Furthermore, results demonstrate that the Nile damming played an important role in the long-term salt preconditioning of the surface/intermediate layers of the Cretan and Levantine Seas, contributing in triggering the two eastern Mediterranean transients [1]. Although the results indicate an increase in the deep layer salinity the model is not able to reproduce the large salinity increasing trends in the Levantine deep waters during the two transients.

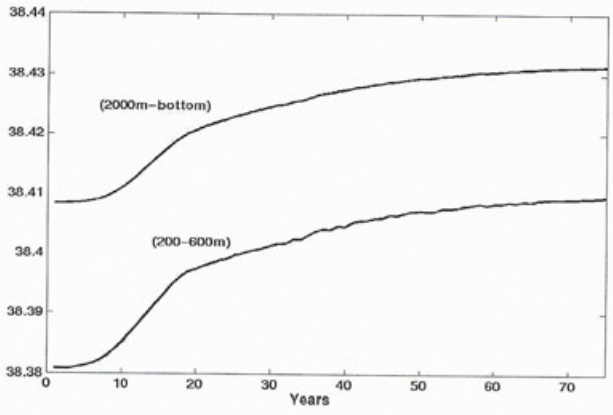


Fig. 1. Evolution of the model annual mean salinity (psu) in the Western Mediterranean basin after the Nile damming for the layers: 200-600m and 2000m-bottom.

To investigate the effect of surface cooling, the experiment was repeated imposing a -1°C drop in the SST in the Levantine for ten years corresponding to 1965-1975 (when a continuous decrease in the mean winter SST of the Levantine is observed in the data [3]) and a -2°C drop in the SST of the Aegean during the winters of 1992 and 1993. Results show that during the first period LIW formation occurs in a larger area of the northern Levantine whereas deep water formation occurs now inside the Rhodes Gyre, propagating the signature of increased salinity towards the deep layers of the Levantine. Similarly, the intense surface cooling related to the cold winters of 1992 and 1993 was found to play a crucial role in the second transient, increasing the Cretan Deep Water formation rate by an order of magnitude. The newly formed water, which outflows from the Cretan Arc straits, is much more saline and warmer than the previous existing EMDW resulting in large increasing trends in both the temperature and salinity of the deep layers.

References

1 - Theocharis A., Lascaratos A., and Sofianos S., 2002. Variability of sea water properties in the Ionian, Cretan and Levantine seas during the last century. *CIESM Workshop Series,* 16: 71-74.

2 - Bethoux J.P., and Gentili B., 1999. Functioning of the Mediterranean Sea: past and present changes related to freshwater input and climate changes. *J. Mar. Syst.,* 20: 33-47.

3 - Lascaratos A., Sofianos S., and Korres G., 2002. Interannual variability of atmospheric parameters over the Mediterranean basin from 1945 to 1994. *CIESM Workshop Series,* 16: 21-23.

MONITORING THE SAHARAN DUST DISPERSION IN THE MEDITERRANEAN SEA WITH A NUMERICAL MODEL (2001-2002)

S. Sofianos *, A. Lascaratos, and V. Vervatis

Ocean Physics and Modelling Group, University of Athens, University Campus, 15784 Athens, Greece

Abstract

A modeling system has been developed to monitor the Saharan dust cycle in the Mediterranean Sea. It is based on the Princeton Ocean Model, modified to include the physics of dust dispersion and deposition onto the ocean floor. It is shown that the atmospheric deposition has a highly episodic character, which affects gravely the patterns of oceanic distribution as well as the bottom deposition of dust. The oceanic circulation plays an important role in the dust distribution and deposition onto the sea bed.

Key-words: Saharan dust, Mediterranean Sea, Modelling

Introduction

Suspended particulate matter in the ocean plays a significant role in different biogeochemical processes and is a crucial parameter in determining the water quality (1). The case of the Mediterranean Sea is of particular interest since it borders the Saharan desert, the world's largest source of aeolian soil dust (2), and its northern coasts are located in the industrialized and semi-industrialized regions of Southern Europe, which are important sources of anthropogenic aerosols. Since direct observations of dust deposition and transport into the ocean are very difficult and costly to obtain, modelling studies become a very important monitoring tool.

Methods

The distribution and deposition of Saharan dust onto the sea bed in the Mediterranean Sea has been simulated using the Princeton Ocean Model. The horizontal resolution of the model is 1°/8x1°/8 degrees, with 25 sigma levels in the vertical. The oceanographic model was coupled with the SKIRON/Eta atmospheric model (3).

To simulate the transport and diffusion of Saharan dust in the ocean an additional advection-diffusion equation has to be solved by the model, introducing also a settling velocity of the dust in the sea water (due to its density difference from the sea water). The dust that reaches the lowest level of the model evacuates the water column and is deposited onto the seabed. During the first phase of the experiments, the atmospheric input of Saharan dust includes only one class of particles with diameter of 2μm. More realistic experiments, with four classes of particles, are also being performed.

Results and Discussion

The model has been integrated with atmospheric dust deposition for the period April 2000 to December 2002, and the results of the last two years are presented here. Although the Saharan dust cycle does not reach a steady state, basic characteristics of the cycle are already evident.

The daily atmospheric deposition of Saharan dust on the surface of the Mediterranean Sea is plotted in Figure 1a. The annual deposition over the Mediterranean for 2001 is 1.22 $g\ m^{-2}$ and 2.13 $g\ m^{-2}$ for 2002. The dust deposition on the sea surface of the Eastern Mediterranean is much larger than the dust deposition on the sea surface of the western Mediterranean, in agreement with previous observational and modeling studies (1). Another important conclusion is the highly episodic character of the atmospheric deposition. A few episodes account for the biggest part of Saharan dust deposited on the sea surface. It is characteristic that two episodes during spring 2002 account for 44% of the total deposition on the sea for this year. It is interesting to note that this episodic character can create patches of water very rich in dust with considerable effects on the area's biology and water quality.

The effects of oceanic circulation on the dust distribution and deposition onto the sea bed were found to be very important. The dust concentration is mainly defined by advection and diffusion, while the particles' settling velocity, being very small, contributes very little in the dispersion of dust into the water column. The general eastward surface flow along the African coast is currying large amounts of dust uptaken in areas of high atmospheric deposition (close to the source), thus further increasing the contrast between the western and eastern sub-basins. Other oceanic features tend to trap the Saharan dust atmospheric input creating large patches of high concentration. Figure 1b shows the mean Saharan Dust concentration for the eastern, western and the whole Mediterranean basin.

Figure 1c presents the bottom deposition for the eastern, western Mediterranean and the whole basin. The bottom deposition rate for the Mediterranean Sea is 115.8 $mgr\ m^{-2}$ and 198.6 $mgr\ m^{-2}$ per year for 2001 and 2002, respectively. The difference between the eastern and the western Mediterranean is again apparent. The deposition rate presents its highest values during winter. The highest values of Saharan dust deposition are encountered in the continental shelf of the African coast, the coasts of the southern Adriatic Sea, the Cyclades Plateau in the Aegean Sea, the Gulf of Lions and the northeastern coast of Spain. Some areas of intense local bottom deposition are associated with strong events taking place in coastal and generally shallow locations.

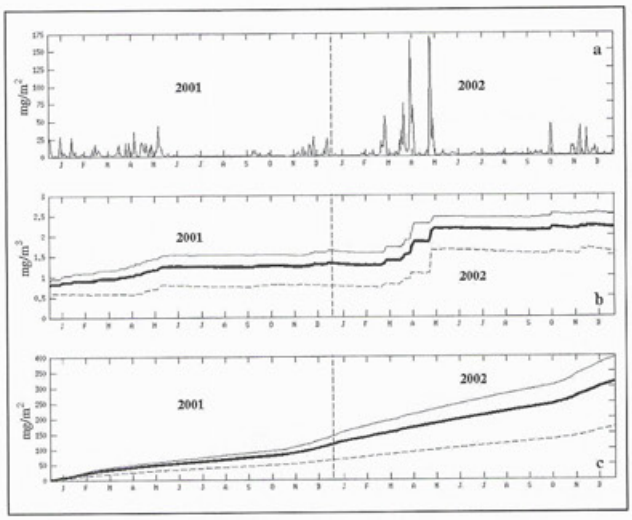


Fig. 1. (a) Atmospheric deposition of Saharan dust, (b) Saharan dust concentration in the Eastern Mediterranean (thin line), Western Mediterranean (dashed line) and whole basin (thick line), and (c) cumulative bottom deposition in the Eastern Mediterranean (thin line), Western Mediterranean (dashed line) and whole basin (thick line).

References

1 - Goudie, A. S. and N. J. Middleton, 2001. Saharan dust storms: nature and consequences. *Earth-Science Rev.*, 56: 179-204.

2 - Swap, R., S. Ulanski, M. Gobbett, and M. Garstang, 1996. Temporal and spatial characteristics of Saharan dust outbreaks. *J. Geophys. Res.*, 101(D2): 4205-4220.

3 - Kallos, G., S. Nickovic, A. Papadopoulos, D. Jovic, O. Kakaliagou, N. Misirlis, L. Boukas, N. Mimikou, G. Sakellaridis, J. Papageorgiou, E. Anadranistakis and M. Manousakis, 1997. The regional weather forecasting system Skiron: An overview, *Proc. Symp. On Regional Weather Prediction on Parallel Computer Environments*, Athens, Greece: 109-122.

FORCING MECHANISMS OF THE AEGEAN SEA CIRCULATION

S. Sofianos *, N. Skliris, and A. Lascaratos

Ocean Physics and Modelling Group, University of Athens, University Campus, 15784 Athens, Greece

Abstract

The mechanisms involved in the seasonal patterns of the Aegean Sea circulation are studied with the use of a numerical model (POM). By performing a series of experiments with different atmospheric forcing and lateral boundary conditions, which are compared with recent observations in the Aegean Sea, the surface circulation in the basin is being investigated. It is shown that both the seasonal pattern of the wind field and the seasonal thermohaline forcing are important in producing the observed circulation, while specific features of the circulation are associated to only one component of the atmospheric forcing.

Key-words: Surface Circulation, Aegean Sea, Modelling

Introduction

Despite the progress in direct observations and modeling efforts during the last two decades, the circulation of the Aegean Sea is yet far from being well defined and understood. Recent observations with Lagrangian drifters [1] emphasized the complex and variable character of the circulation pattern that can be attributed to the very irregular topography, the strong seasonality of the atmospheric forcing, and the presence of many different water masses.

If we attempt to summarize the known circulation characteristics (from historical data, recent drifter deployment, and modeling techniques), there seems to be a general cyclonic circulation in the Aegean Sea. A very important characteristic feature of the circulation pattern in the basin is the surface inflow of the brackish Black Sea Water (BSW) from Dardanelles, which creates a front with the ambient saltier waters of Levantine origin following the general cyclonic pattern. However, the most active dynamic features are the mesoscale cyclonic and anticyclonic eddies and boundary currents which can extend to several Rossby radii of deformation (around $O(10$ km)). In this study we aim to identify the mechanisms involved in basic features and the overall circulation of the Aegean Sea, performing numerical model experiments.

Method

The numerical experiments were carried out with the Princeton Ocean Model (POM) [2]. The domain is extended outside the Aegean Sea, in order to incorporate the effects of the Mediterranean Sea general circulation. In the first experiment both seasonal wind and seasonal thermohaline forcing, derived from the ECMWF reanalysis, are used to drive the model. The BSW inflow as well as major rivers runoff is also included in the model configuration. The results are compared with observations and major features of the surface circulation have been identified. The next two experiments include only one driving field, either wind or thermohaline forcing, to investigate the different role and importance of each one on the circulation pattern. Finally, the effect of different later boundary conditions (e.g. no BSW inflow) is investigated with additional experiments.

Results and Discussion

The full forcing experiment reproduces the general cyclonic patter of the surface circulation as well as the most important mesoscale features (Fig. 1). Although most of them present strong seasonality, features such as the cyclonic eddies in the Chios basin (central Aegean), the boundary current along the eastern coast of the Evoia island, the anticyclonic circulation in the northeastern Aegean, the Myrtoan Cyclone and the East Cretan Cyclone are robust in the model results.

The wind- and thermohaline-driven experiments produce results with comparable surface circulation strength, but in several cases the circulation patterns are very different. When only the wind forcing drives the model a strong current following diagonally the central Aegean is dominating. This is associated with the pattern of the wind-stress curl field which is negative north of this axis and positive in the southern part of the basin. This results to a anticyclonic circulation in the northernmost part of the basin which alters significantly the circulation pattern and a cyclonic one in the southern part of the basin. Although features such as the anticyclone in the northeastern Aegean are intensified, others such as the Evoia Current and the cyclonic features in the northern Chios basin disappear. Additionally, this circulation pattern recirculates the brackish BSW in the northern part of the basin resulting in very low surface salinity while in the same time the exchange between the north and south Aegean at the eastern part of the basin is diminished.

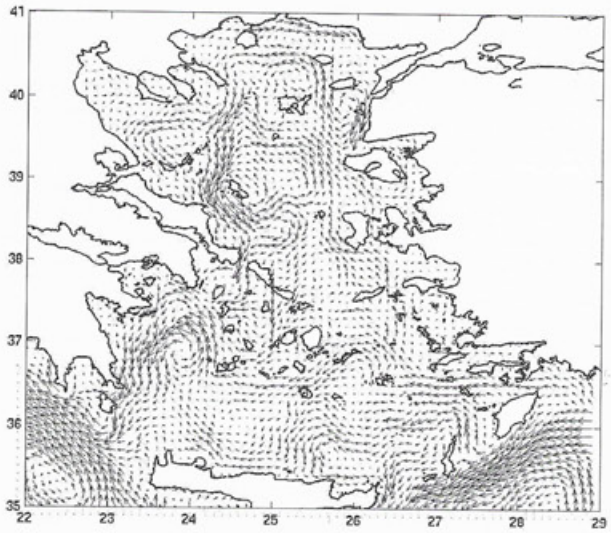


Fig. 1. Model derived surface circulation in the Aegean Sea during mid-July.

The presence of the thermohaline forcing enhances the cyclonic circulation in the northern Aegean, creating strong density fronts in the region. All the cyclonic features are present as well as the Evoia Current. The circulation around the island of Samothrace reverses most of the year.

The absence of the BSW inflow results in a considerable decrease of the surface circulation strength in the northern Aegean as a consequence of reduced density gradients there. On the other hand, the circulation in the southern Aegean remains almost unchanged, suggesting a relative decoupling between the two sub-basins.

References

1 - Olson, D. B., 2002. Circulation and mesoscale structure of flow in the Aegean Sea based on pilot drifter study. Aegean Sea Workshop, Rhodes, 8-10 October, 2002.

2 - Blumberg, A. F., and G. L. Mellor, 1987. A description of three-dimensional coastal ocean circulation model. Pp.1-16. *In:* Heaps N. S. (ed.), Three-Dimensional Coastal Ocean Circulation Models, Coastal Estuarine Science, 4, AGU, Washington D.C.

ANNUAL TO DECADAL SEA LEVEL VARIATION (35N-52N, 10W-13E)

E. Tel* and M. J. García

Instituto Español de Oceanografía (IEO), Madrid, Spain - * Elena.tel@md.ieo.es, Mjesus.garcia@md.ieo.es

Abstract

Monthly mean sea level values from tide gauges have been analysed for the area (35N-52N, 10W-13E) in the ESEAS-RI (WP3.1) project framework. Standard quality control procedures have been applied to the data and Fourier and Empirical Ortogonal Functions (EOF) analysis has been performed to the data set. Stations have been grouped in 6 region (number of significant series has been reduced from 35 to 10) obtained by EOF.

Keywords: EOF, time series analysis, mean sea level.

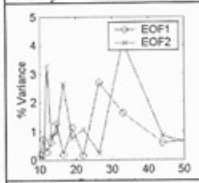
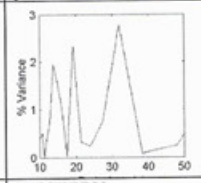
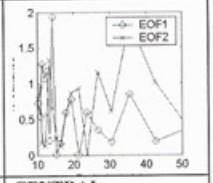
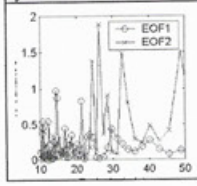
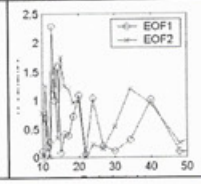
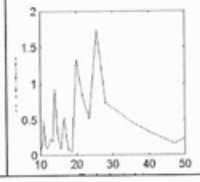
Monthly mean sea level values from the tide-gauge stations located in the area (35N-52N, 10W-13E) are analysed. Data come from the Permanent Mean Sea Level Service (PSMSL). Series of Ceuta, Cadiz, Algeciras, Tarifa and Malaga come from the IEO Data Centre because during the last years a big effort in quality control has been done, in particular in homogeneization of time series. In some cases, series has been cut in shorter ones because there are shifts along them.

Linear trend are calculated and removed at each station. Some trend values are very suspicious, probably because the sea level signal is contaminated by the instability of tide-gauges location. The clearest example is Dieppe, where its trend is bigger than other records in its area. Negative trend at P.St. Gildas and Gibraltar correspond to flagged records with stability problems. In addition, trend values depend strongly on length records. The GIA rate (1) has been used to remove the Post Glacial rebound. Annual cycles have been calculated too, and removed by subtracting means monthly values to the record anomaly.

Fourier analysis has been performed in order to identify long-period significant cycles in the detrended and deseasonalizated series. The contribution of a given frequency to the total variance of the time series is a measure of the importance of that particular frequency component in the observed signal.

EOF analysis has been done to classify the set of variables in several groups that keep common characteristics and behaviour. These groups are defined performing an EOF of a bigger area and selecting the more explicative variables. St.Helier, P.St.Gildas and Cadiz stations are eliminated in this analysis due to stability problems. In each group, the first EOF accounts for the main part of total variance in the data, the second EOF holds the maximum variance that has not been accounted by the first EOF, and so on. The kept EOF factors at this work explain, at least, 75% of total variance. As a result of this analysis, an important data reduction has been achieved. This few new variables can be used for interpretational purposes or in further analysis.

Table 1. Groups and EOFs found in the performed analysis.

ENGLISH CHANNEL 11.00, 2.50, and 1.20-1.50 years.	**GULF OF BISCAY** 5.33, 2.67, 1.60 and 1.14 years.	**IBERIAN ATLANTIC COAST** 8.87 and 5.62 years.
		
STRAIT OF GIBRALTAR 28.50, 14.25, 11.40, and 8.14 years.	**WESTERN MEDITERRANEAN** 10.00, 6.67, 1.18-1.67 years.	**CENTRAL MEDITERRANEAN** 11.75, 2.14, 1.68 years
		

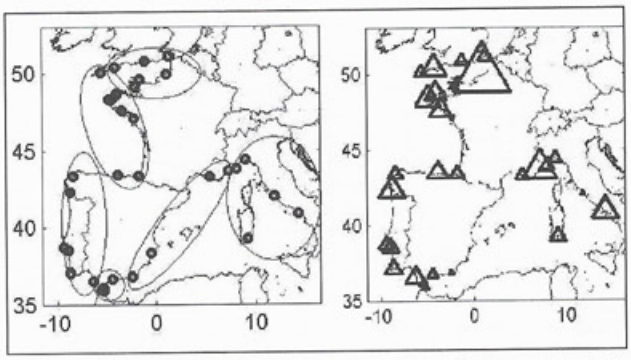


Fig. 1. Regions defined by EOF and trend values with the corresponding PGR corrections.

References

1 - Peltier, W.R., ICE4G (VM2), 2001. Glacial Isostatic Adjustment Corrections. In : Douglas, B.C., Kearney, M.S., and S.P. Leatherman (eds.), Sea Level Rise; History and Consequences. Academic Press.

THE ALGERIAN GYRES

Testor Pierre [1] *, Send Uwe [1], Millot Claude [2], Taupier-Letage Isabelle [2]

[1] Institut für Meereskunde, FB 1: Ozeanzirkulation und Klima, PO II, Düsternbrooker Weg 20, 24105 Kiel, Germany - ptestor@ifm.uni-kiel.de , usend@ifm.uni-kiel.de

[2] Laboratoire d'Océanographie et de Biogéochimie, CNRS UMR 6535, Antenne LOB-COM-CNRS, La Seyne/mer, France - itaupier@ifremer.fr , cmillot@ifremer.fr

Abstract

In the framework of the MATER programme, currents measurements have been collected in the Algerian basin from July 1997 until August 2002 with eulerian and lagrangian (isobaric and profiling)currentmeters. They have given evidence of two large scale, permanent and barotropic cyclonic circulations that we named the Algerian Gyres. These gyres seemingly follow closed f/H isolines and are forced by the alongslope circulation.

Key-words: general circulation, Algerian basin, potential vorticity conservation, lagrangian and eulerian currentmeters.

Introduction

The MATER Programme (MTP2/MAST3)involved several field experiments. In this framework, 12 RAFOS (isobaric) floats were deployed in the eastern Algerian basin from July 1997 to July 1998. They were designed to sample the LIW (they were slightly over-ballasted and drifted at ~600 m instead of 300-400 m). Simultaneously, a 9-moorings array was deployed, equipped with 5 current meters at 100, 350, 1000, 1800 and 2800 m to document the circulation of the surface, intermediate and deep layers. They were complemented in fall 1997 by 17 profiling floats, deployed to sample the TDW (7 floats drifting at ~1200 m) and the WMDW (10 floats drifting at ~2000 m) layers.

Results

The first dominant pattern showed by the current measurements, was a large scale cyclonic circulation that we call the Eastern Algerian Gyre [1]. This gyre has an elliptical shape and is characterized by a west-east extension of ~250 km and a north-south extension of 150-200 km. Typical velocities are ~5-10 cm/s at the periphery of the gyre and the corresponding rotational period is ~3-4 months. From July 1997 to July 1998, both the eulerian and the lagrangian measurements exhibit roughly the same large scale cyclonic circulation, at least at 350 m and below although such a cyclonic circulation cannot be evidenced in the surface layer due to the large intensity of the mesoscale, we suppose it occurs over the whole depth and can thus be qualified as barotropic.

From December 1999 and during 2.5 years, floats at 1200 and 2000 m showed another unexpected large scale cyclonic circulation located west of the Eastern Algerian Gyre (Fig. 1). This gyre, called the Western Algerian Gyre, has an elliptical shape extending over ~300 km from west to east and over ~150 km from north to south. Typical velocities associated with this gyre are ~5 cm/s at the periphery and the rotational period is ~4-5 months.

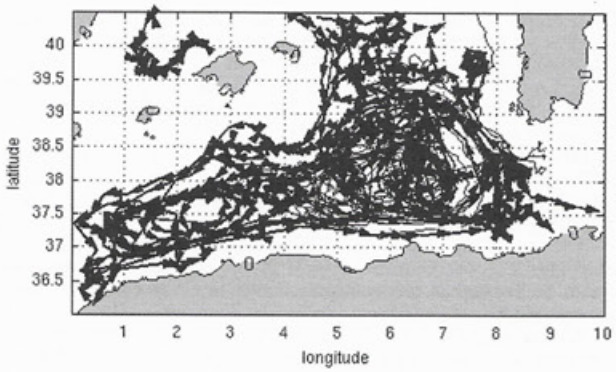


Fig. 1 Trajectories of floats from July 1997 to August 2002.

f/H isolines (combined effects of topography and planetary vorticity for barotropic motions) are closed in the whole basin (Fig. 2) in the eastern and western parts respectively. These contours correspond pretty well to both gyres.

First, this may confirm that the Eastern Algerian gyre is barotropic too and that both gyres are dynamically similar. The important role of topography is also confirmed by [2] since these general circulation patterns are better represented in numerical models with high resolution and the use of "partial cells" taking into account the bottom topography in a better way.

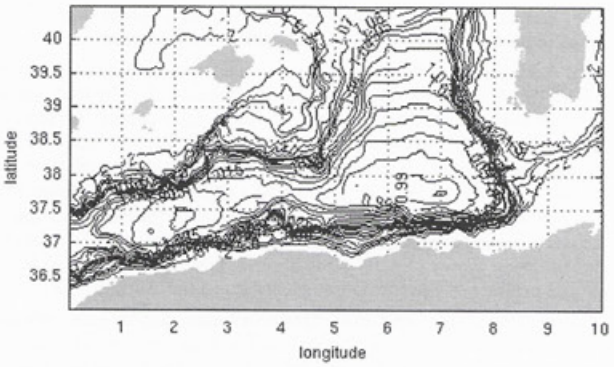


Fig. 2 contours of potential vorticity f/H normalized by f taken at 37°45 N and H = 2800 m.

Conclusion

These barotropic gyres, which correspond to a mean recirculation of ~4 Sv each, reveal new aspects of the general circulation of the western Mediterranean Sea.

They might be mainly forced, through diffusion/advection processes, by the boundary currents [3] which flow cyclonically along the continental slope.

References

1 - Gascard J.-C., Rouault C. and Testor P.1999. General ocean circulation and subsurface mesoscale eddies in the Algerian basin. 4th MTP workshop, MATER, Perpignan 28-30 Octobre 1999.

2 - Nayagum D., Alhammoud B., Testor P., Béranger K. & L. Mortier, 2003. A "partial cells" general circulation model of the Mediterranean, EGS-AGU-EUG Joint Assembly, session "The Mediterranean Sea: A Laboratory Basin for Interdisciplinary Studies", Nice, France, April 2003.

3 - Millot, C., 1999. Circulation in the Western Mediterranean Sea. *J. Marine Res.*, 20: 423-442.

THE TELECOMMUNICATION BETWEEN THE AEGEAN AND THE ADRIATIC SEAS THROUGH THE INTERMEDIATE WATERS INFLUENCES THE DEEP CONVEYOR BELT OF THE EASTERN MEDITERRANEAN (1986-1999).

Alexander Theocharis [1] * and Alexander Lascaratos [2]

[1] Hellenic Centre for Marine Research, P. O. Box 712, Anavyssos, Attiki 19013, Greece - * alekos@ncmr.gr
[2] Department of Applied Physics, University of Athens, Athens, Greece

Abstract

This work summarizes the variability of the intermediate water characteristics in the eastern Ionian during the period 1986-98, giving evidence to the indirect role that the Aegean plays in modifying the deep thermohaline cell of the eastern Mediterranean.

Keywords: intermediate waters, variability, eastern Mediterranean

The Levantine Intermediate Water (LIW), the most important Mediterranean high saline water mass, is the major constituent of the intermediate waters (200-600m) throughout the Basin. The main route of LIW is westward direct to Sicily Straits, but peeling-off branches appear as LIW is veered around the circulation features. A branch of LIW in the eastern Ionian is directed towards the Adriatic following the Greek coastline. The percentage content in LIW is highest near the coast. Within the period 1986-98, the Aegean contribution to the intermediate layers presented considerable variability (1).

The Adriatic Deep Water (ADW) is considered the source-water of the EMDW since the beginning of the last century (2). The high saline intermediate water participates in the open-ocean formation processes, occurring in the Adriatic southern pit. Salinity is the crucial factor for the density increase (3, 4). The temporal evolution of the Adriatic is attributed at a large extent to changes in the Ionian (5). Favorable winter weather conditions are the major forcing mechanism necessary for the convection. Moreover, the contribution of the North Adriatic Deep Water (NAdDW) is another key factor in determining the final product of the formation processes in the Adriatic (6).

Since 1987, the eastern Mediterranean undergoes abrupt hydrological changes due to the shift of the deep-water formation site from the Adriatic to the Aegean, namely the Eastern Mediterranean Transient (EMT) (7, 8, 9, 10, 11) .The filling of the deep and bottom layers with new denser waters of Aegean origin caused uplifting of the older EMDW and the overlaying transitional waters between the LIW and EMDW by several hundred meters. The above modification of the deep thermohaline cell has been accompanied by changes in the open conveyor belt of the Basin that comprises the intermediate waters. Significant changes in the upper thermocline circulation altered the water mass pathways. The latter along with the evolution of the Aegean to an effective source of a new type of intermediate water, the so called Cretan Intermediate Water (CIW) (11), has considerably influenced the respective layers in the Ionian. Therefore, within the LIW horizons have undergone first dilution of the waters about 30% by the uplifted less saline old mid-depth waters (12) and at a later stage replacement of LIW by the new warmer, more saline CIW (10).

The analysis of the data from "POEM", "MATER" and "NATO-RR97-Ionian" programs shows that in the period 1986-1991 the intermediate waters in the northeastern Ionian present a decreasing trend in temperature ($\Delta\theta$~0.35° C) and salinity (ΔS~ 0.05 psu), which implies an increase in density (σ_θ~0.04 kg/m^3). Thus, the Adriatic is supplied progressively with less salt, but with denser waters before and during the early stages of the EMT. During the winter 1987 strong deep-water formation was reported under very cold and dry meteorological conditions. Moreover, during the coldest winter 1991-1992, the deep density in the Adriatic reached for the last time the value of 29.3 kg/m^3. This coincides with the highest density (σ_θ=29.14 kg/m^3) of the intermediate water observed in the preconditioning period, fall 1991 in the northeastern Ionian and in winter 1991-92 in the Otranto. Until 1995, "low" salinity (S~38.74 psu) was the characteristic of the inflowing "diluted" intermediate waters and lack of deep ventilation and production of dense waters was noted (7). In January 1995, the ADW appeared in the Ionian above the Deep and Bottom Waters of Aegean origin at 1000-1500m depth (1). In 1997-99, the intermediate waters reaching the Adriatic were strongly influenced by the new CIW (S>38.90 psu) providing more salt than before the EMT period. However, their temperature increased ($\Delta\theta$ ~0.46°C) and density fluctuated (σ_θ~ 29.12-29.14 kg/m3). Even though, no deep convection (~400m) in the Adriatic was reported in 1997 and 1998, due to insufficient surface cooling and buoyancy loss (6). The ADW in late fall 1998 had not still enough density to sink to the Ionian bottom, but circulated at depths of ~1000m with salinity higher than that of 1995 by ΔS ~0.06 psu. In 1999 the ventilation in the southern Adriatic went deeper (700m), but the density of the product was insufficient to replace the bottom dense Adriatic water.

Therefore, the above confirms an Aegean remote effect on the Adriatic open-ocean deep-water formation process through the affected intermediate water and thus its indirect role in modifying the deep thermohaline cell of the eastern Mediterranean, apart from the direct influence through the formation of the densest Cretan Deep Water, after 1987.

References

1 - Theocharis A., Klein B., Nittis K., Roether W., 2002. Evolution and status of the Eastern Mediterranean Transient. *J. Marine Systems,* 33-34: 91-116.

2 - Nielsen J. N., 1912. Hydrography of the Mediterranean and adjacent waters. Report of the Danish Oceanographic Expedition 1908-1910to the Mediterranean and adjacent waters (Copenhagen), 1 : 72-191.

3 - Ovchinnikov I. M., Zats V. I., Krivosheya V. G., Udodov A. I., 1985. Formation of deep Eastern Mediterranean waters in the Adriatic Sea. *Oceanology*, 25 (6) : 707.

4 - Zore-Armanda M., 1972. Formation of Eastern Mediterranean deep water in the Adriatic. *Colloques Internationaux du C.N.R.S.,* 215 : 127-133.

5 - Klein B., Roether W., Civitarese G., Gacic M., Manca B. B., Ribera d' Alcala M., 2000. Is the Adriatic returning to dominate the production of Eastern Mediterranean Deep Water? *Geophys. Res. Lett.,* 27 (20) : 3377-3380.

6 - Manca B. B., Kovacevic V., Gacic M., Viezzoli D., 2002. Dense water formation in the Southern Adriatic Sea and spreading into the Ionian Sea in the period 1997-1999. *Journal of Marine Systems,* 33-34 : 133-154.

7 - Klein B., Roether W., Manca B. B., Bregant D., Beitzel V., Kovacevic V., Luchetta A., 1999. The large deep water transient in the Eastern Mediterranean. *Deep Sea Res.* I, 46 : 371-414.

8 - Lascaratos A., Roether W., Nittis K., Klein B., 1999. Recent changes in deep water formation and spreading in the Eastern Mediterranean Sea: A Review. *Progr. In Oceanogr.,* 44 (1-3) : 5-36.

9 - Roether W., Manca B. B., Klein B., Bregant D., Georgopoulos D., Beitzel V., Kovacevic V., Luchetta A., 1996. Recent changes in the Eastern Mediterranean deep waters. *Science,* 271 : 333-335.

10 - Malanotte-Rizzoli P., Manca B. B., Ribera d' Alcala M., Theocharis A., Brenner S., Boudillon G., Ozsoy E., 1999. The Eastern Mediterranean in the 80s and in the 90s: the big transition in the intermediate and deep circulations. *Dyn. Atmos. Oceans,* 29, 2-4 : 365-395.

11 - Theocharis A., Nittis K., Kontoyiannis H., Papageorgiou E., Balopoulos E., 1999. Climatic changes in the Aegean Sea influence the Eastern Mediterranean thermohaline circulation (1986-1997). *Geophys. Res. Lett.* 26, 11 : 1617-1620.

12 - Roether W., Klein B., Beitzel V., Manca B. B., 1998. Property distribution and transient-tracer ages in Levantine Intermediate Water in the Eastern Mediterranean. *J. Marine Systems,* 18 : 71-87.

LAGRANGIAN MEASUREMENTS OF SURFACE CIRCULATION AND KINETIC ENERGY DISTRIBUTION IN THE NORTHERN ADRIATIC

L. Ursella *, P.-M. Poulain and R. Barbanti

OGS, Borgo Grotta Gigante 42/c, Sgonico, Trieste, Italy - * lursella@ogs.trieste.it

Abstract

The near-surface circulation of the Northern Adriatic is explored using Lagrangian drifting buoy measurements obtained between September 2002 and October 2003. The data set presents a very good coverage over the studied area and within the measurement period. The main pathways of the surface waters are defined and the major persistent surface features are described, together with their variability. Mean kinetic energy (MKE) and eddy kinetic energy (EKE) have been calculated and their spatial and seasonal variability is presented. Autumn and winter have been found to be the most energetic seasons.

Key-words: Surface Circulation, Energy, Adriatic Sea

Introduction

As part of the ONR-sponsored DOLCEVITA program, more than 120 surface drifters were deployed in the Northern Adriatic starting in September 2002 to monitor the surface circulation in most areas of the Northern Adriatic until the end of 2003.

Data and methods

Two versions of the CODE drifter were mainly used: the first one uses the standard ARGOS telemetry [1] and the second one is equipped with an additional GPS system, which permits to obtain a finer resolution both in time and space. Position sampling for GPS-CODE drifters was programmed at 0.5 or 1 hour intervals. The data set analyzed in this paper starts on 21 September 2002 and ends on 1 October 2003. Both ARGOS and GPS position data have been quality controlled, while only ARGOS data have been objectively interpolated every 2 hours, low-pass filtered (36 hour cut-off) and re-sampled every 6 hours. Surface velocities have been then calculated as finite differences of the position data. The Northern Adriatic is well covered by drifters, with maximum density in the northernmost part of the basin, due both to a major number of deployments and to a larger time of residence of drifters in that zone. The total number of drifter-years for the ARGOS data set is 21.33.

Mean Circulation and Energy

The mean surface flow has been calculated for the whole period from the low-passed data binned in circles of 10 km of radius, separated by 10 km. The mean surface flow field reveals the well-known persistent features of the Adriatic surface circulation, such as the Western Adriatic Current (WAC) along the Italian coast, the Eastern Adriatic Current (EAC) along the Croatian coast that re-circulates partially around the Middle Adriatic Pit (MAP) and partially to the south of Istria, and finally the northernmost cyclonic gyre [1, 2]. A zone of almost no flow and no variance is present in front of the tip of Istria, showing an almost steady pool all over the period. From the mean flow field and variance, the MKE and EKE have been calculated. They are depicted in Figure1a and 1b, respectively. The highest values for MKE are found in three zones: i) in front of the Po river delta, ii) along the Italian coast south of the delta, and iii) over the MAP. The maximum value, equal to 362 cm^2/s^2, is located north of Ancona, where the EKE is the same order of magnitude (107 cm^2/s^2), indicating an equal partition of energy between the two. On the contrary, the zone south of Ancona is characterized by the maximum in EKE (about 256 cm^2/s^2), indicating a highly variable zone with current reversals. The already mentioned zone in front of the tip of Istria shows very low values for MKE (<5 cm^2/s^2) with higher values for EKE (about 30 cm^2/s^2). Calculating the ratio EKE/MKE, the lower values are found principally in the zones of re-circulation of the EAC and along the Italian coast near Ancona. The temporal distribution of the kinetic energy for the whole basin shows that autumn and winter are the more energetic seasons, both in MKE and in EKE. In autumn the MKE is strong along the Italian coast, probably due to strong Po River outflow, and around the MAP, with high values for EKE in front of the Po River and south of Ancona. In winter, the MKE is particularly strong in the zone between the tip of Istria and the Italian coast, due to strong Bora wind activity. In spring large values for the MKE and the EKE are found only to the south of Ancona. Finally, in summer the MKE is weak all over the basin, with EKE strong only along the Italian coast south of Ancona.

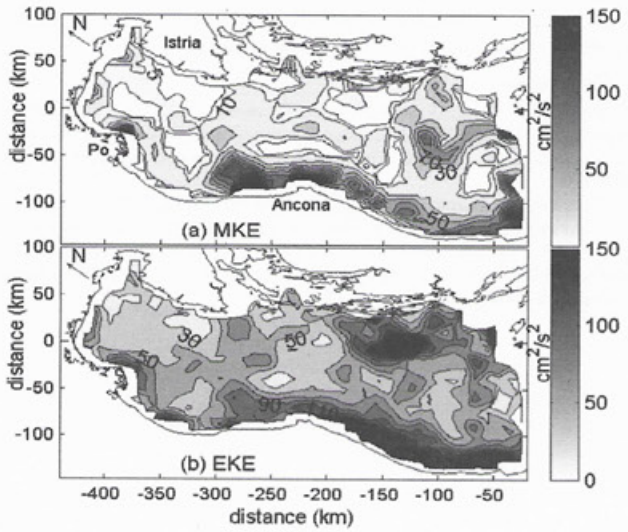


Fig. 1. Mean kinetic energy (a) and eddy kinetic energy (b) in the rotated Northern Adriatic for the period 21 September 2002 to 1 October 2003. Only bins with more than 10 observations have been taken into account.

Conclusions

Direct surface measurements obtained from drifting buoys over one year, provided the first detailed description of the circulation in the northern Adriatic. The mean flow pattern confirmed the major well-known features but also evidenced new structures with their spatial and temporal evolution. The calculated kinetic energy shows an almost permanent and very energetic zone along the Italian coast. Energy results maximum in autumn and winter, while it is very weak in summer.

Acknowledgments. The authors are grateful to all the people who deployed drifters in the Adriatic Sea. This research was supported by the Office of Naval Research under grant N000140310291.

References

1 - P.-M.Poulain, 2001. Adriatic Sea surface circulation as derived from drifter data between 1990 and 1999. *J. Mar. Syst.*, 29: 3-32.

2 - B.Cushman-Roisin, M.Gacic, P.-M.Poulain and A.Artegiani, 2001. Physical Oceanography of the Adriatic Sea. Kluwer Academic Publishers, 304 p.

NEW FEATURES IN THE CIRCULATION OF THE SURFACE WATERS IN THE BALEARIC AREA

Vélez-Belchi P. [1]*, López-Jurado J. [2], González-Pola C. [3]

[1] Instituto Español de Oceanografía, C.O. de Canarias, crta de San Andrés N°45, 38180 , S/C Tenerife, Spain - * pedro.velez@ca.ieo.es
[2] Instituto Español de Oceanografía, C.O. de Baleares, Muelle de Poniente s/n, 07080 Palma de Mallorca, Spain - lopez.jurado@ba.ieo.es
[3] Instituto Español de Oceanografía, C.O. de Gijón, Avda. Príncipe de Asturias 70 bis, 33212 Gijón, Spain - cesar.pola@gi.ieo.es

Abstract

The surface circulation around the Balearic Archipelago offers interesting new features as the control of the inflow of atlantic waters trough the channels by the presence or not of Anticyclonic eddies in the southern part the archipelago. In the present paper, with the help of three surveys during the summers of 2001, 2002, 2003, this new features, together with others, are presented.

Keywords: surface circulation, Balearic Sea, Algerian eddies

Due to the importance of the Balearic islands as a barrier for the southern propagation of the northern colder waters and the northward propagation of the southern atlantic waters several observational programs has been working on that area [1]. In spite of that, there are still some unknowns. In the present study, and with the help of three hydrographic surveys carried out in the waters around the Balearic islands during the summers of 2001, 2002 and 2003, we will point out some features not observed before and some others not totally confirmed. In general, the observed situation confirms the Balearic Sea as a transitional region between the northward Atlantic waters and the southward Mediterranean waters, being characterized by intense frontal systems and an intense geostrophic circulation.

During the three years the northward path of the atlantic waters was controlled by the presence or not of atlantic anticyclonic eddies in the southern side of the archipelago. In summer 2001 (Fig. 1), there were two inflows of waters of Atlantic origin (S<37), progressing northwards through the Ibiza and Mallorca channels and converging

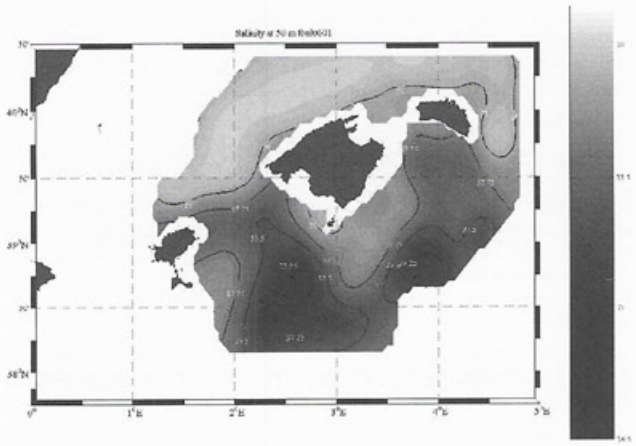


Fig. 1. Horizontal distribution of salinity at 50m during summer 2001.

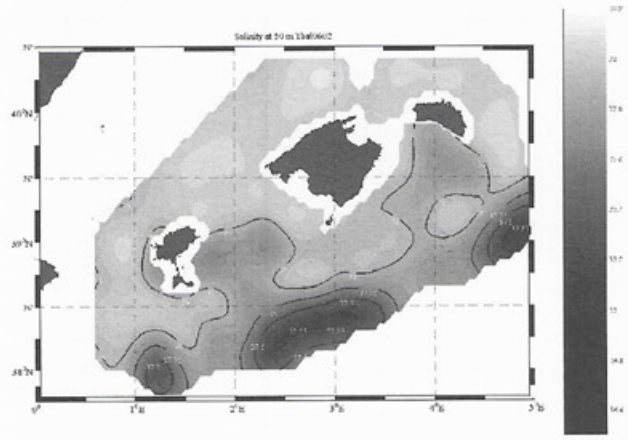


Fig. 2. Horizontal distribution of salinity at 50m during summer 2002.

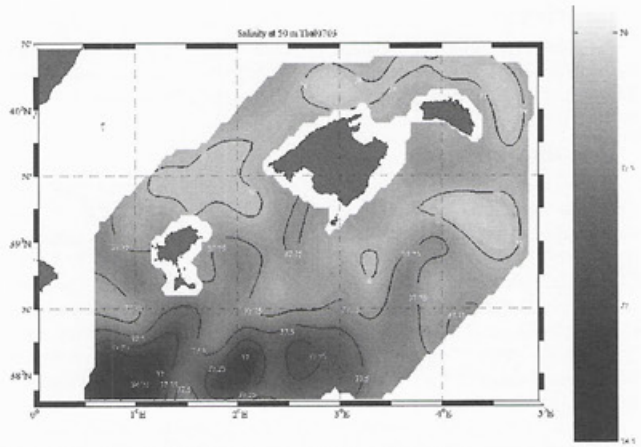


Fig. 3. Horizontal distribution of salinity at 50m during summer 2003.

at the north-east of Ibiza Island, where formed a density front is formed. On the other hand during the 2002 and 2003 summers the encounter of water masses of Atlantic origin with those of Mediterranean origin occurred in the south of the Balearic Archipelago, and consequently with low transport of atlantic waters through the channels. The northern part of the survey area, including the channel areas, was occupied with waters of Mediterranean origin. During these years, the intrusion of the superficial Atlantic water masses was hindered by two anticyclonic gyres in the southern and southeast region of the survey area (Figs. 2,3). Besides that, the south of Menorca was occupied by small eddies during the three years, therefore having good conditions for the spawning of Tuna [2]. A recurrent pattern also observed during the three years is the existence of deep eddies in the Mallorca channel, with clear influence of WIW, these eddies are probably trapped by topographic features in the Mallorca channel as the seamounts east off Ibiza.

References

1 - Pinot J.M., Lopez-Jurado J.L. and Riera M., 2002. The CANALES experiment (1996-1998). Interannual, seasonal, and mesoscale variability of the circulation in the Balearic Channels. *Progress in Oceanography*, 55: 335-370.

2 - Alemany, F., García, A., Gonzalez- Pola, C., Jansà, J., López Jurado, J.L., Rodríguez ,J.M., Vélez-Belchí, P. Oceanographic characterization of bluefin tuna (*Thunus thynnus*) spawning grounds and associated tuna species off the Balearic archipelago (western Mediterranean), 26th Annual Larval Fish Conference, Bergen, 2002.

SURFACE CIRCULATION AND FLUXES INSIDE THE CENTRAL MEDITERRANEAN SEA

Vetrano A., G.P. Gasparini * and M. Astraldi

Consiglio Nazionale delle Ricerche, Istituto di Scienze MARine, Sezione territoriale di La Spezia, S. Terenzo loc. Pozzuolo, La Spezia, Italy - anna.vetrano@sp.ismar.cnr.it

Abstract

A composite data set of hydrographic measurements, SST and current data was used to describe the Atlantic Water circulation in the Central Mediterranean Region during different seasonal periods. While the mean current features were estimated applying to the region an inverse box model, the shorter variability was investigated using the remote sensing SST and currentmeter measurements. A special attention was devoted to understand the role played by the wind field in determining the main features and their variability.

Keywords: Sicily Strait, Sardinia Channel, Inverse box model, surface circulation

Introduction

The Central Mediterranean connects the Ionian basin with two main basins of the Western Mediterranean: the Tyrrhenian and the Algerian Seas. The principal water masses forming the circulation of the Mediterranean Sea are forced to flow through the region, which then become essential for the assessment of water budget of the whole basin. For these reasons, the area has been extensively investigated since the '70s (1; 2; 3). Recently (4) have qualitatively described the general circulation of the area while (5) have provided a quantitative estimates of seasonal water fluxes. This present work is devoted to improve the resolution of the surface mesoscale structures and to explore the main forcing of the region.

Seasonal hydrographic surveys were conducted in the Central Mediterranean between November 1993 to June 2000 (Fig. 1). The data-set includes CTD measurements along several sections, long-term current measurements and several VM-ADCP data. The data-set has been integrated with the ECMWF data at 10 m, used to define the wind stress curl field with a spatial resolution of a half degree. Moreover, several remote sensing SST images have been retrieved during a period including the CTD cruise spanning-time. This was done in order to follow the time evolution of the mesoscale structures pointed out through hydrographic measurements (usually extending over a period of about 20 days).

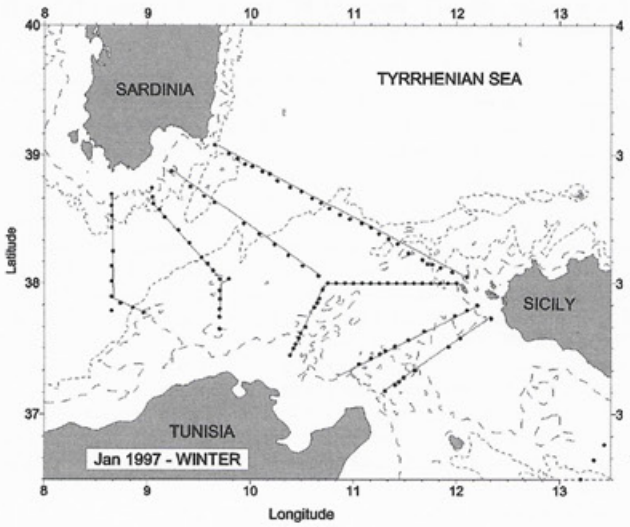


Fig. 1. Measurement sites in the Central Mediterranean Sea during January 1997.

Results

The result of the model is a mean circulation over the region. The reference velocity, obtained as the system solution by SVD inversion method (6), is applied to the initial geostrophic velocity field, to obtain the absolute geostrophic flow. The surface flux patterns shows a main vein of Atlantic Water flowing from the Algerian Basin ranging from 2.24 to 0.97 Sv. The major part enters into the eastern Mediterranean basin. This vein is subject to important mesoscale phenomenon inside the Sicily strait region, where the recirculation may have the same relevance of the mean flow. Similar recirculation also occurs inside the Sardinian Channel, and it was estimated to be about half of that occurring at the sill strait region. The vein entering the Tyrrhenian Sea varies from 0.1 to 1.2 Sv. It recirculates cyclonically into the basin and exits along the Sardinia cost. This outflow varies between 0.38 and 0.82 Sv.

The main structures estimated by the model are in good relation to the remote sensing SST and current-meter data relative to the measurements period. Two relevant features can be observed: a cold and salt cyclonic circulation subsists to the northwestern side of the region, whereas a warmer and fresher anticyclonic structure prevails to the south. The wind stress curl was calculated from ECMWF and related to the circulation and SST fields. The analysis confirms that both structures are wind-driven and may have a significant role in modulating the mean flow through the region.

References

1 - Garzoli S. and C. Maillard, 1979, Winter circulation in the Sicily and Sardinia Strait region. *Deep-Sea Res.*, 26A: 933-954.

2 - Grancini G. F. and A. Michelato, 1987, Current structure and variability in the Strait of Sicily and adjacent area. *Ann. Geophys.*, 5B, 75-88.

3 - Astraldi M., G.P. Gasparini, S. Sparnocchia, M. Moretti and E. Sansone, 1996, The Characteristics of the water masses and the water transport in the Sicily Strait at long time scales. In: Dynamics of Mediterranean straits and channels, CIESM Science Series n.2, *Bull. Inst. Oceanograph., Monaco,* n. special 17: 95-115.

4 - Astraldi M., G.P. Gasparini, A. Vetrano and S. Vignudelli, 2002, Hydrographic characteristics and interannual variability of water masses in the central Mediterranean: a sensitivity test for long-term changes in the Mediterranean Sea. *Deep-Sea Res.*, 49: 661- 680.

5 - Vetrano A. G.P. Gasparini, R. Molcard and M. Astraldi, 2003, Water Flux Estimate in the Central Mediterranea Sea from an Inverse Box Model, *J. Geophys. Res.*, in press.

6 - Wunsch C. , 1996. The ocean circulation inverse problem, Cambridge University Press, 442 p.

SIMULATIONS OF THE PHYSICAL AND BIOLOGICAL VARIABILITY AT A NORTHERN ADRIATIC SEA STATION: THE IMPACT OF TURBULENCE CLOSURE SCHEMES AND BOUNDARY FORCING

Marcello Vichi [1], Sandro Carniel [2]*, Lakshmi Kantha [3], Mauro Sclavo [2]

[1] Istituto Nazionale di Geofisica e Vulcanologia, Via D. Creti, 12, Bologna I-40100, Italy - vichi@bo.ingv.it
[2] National Research Council, Istituto per le Scienze del Mare San Polo 1364, Venice I-30125, Italy
* Sandro.Carniel@ve.ismar.cnr.it - Mauro.Sclavo@ve.ismar.cnr.it
[3] Department of Aerospace Engineering Sciences, CB 431, University of Colorado, Boulder, CO 80309, United States
kantha@colorado.edu

Abstract

A 1-D model, coupling the physical model GOTM and the ecosystem model ERSEM, has been used to hindcast physical and biological variability in the northern Adriatic Sea. We studied the impact of the turbulence closure model (TCM) on the thermal structure and biological productivity. Results compare favorably with physical observations (Fig. 1). The hindcast of biological variables is however less satisfactory. The results are not sensitive to the second moment TCM used. Changes are however, striking when different boundary conditions are applied on nutrients (Fig. 2). This suggests that sources of uncertainties other than the TCM, need to be explored to hindcast the biological state better.

There is a generalized, widely-held view that an accurate simulation of the physical state is a pre-requisite to the proper simulation of the biological state. Biology is expected to directly respond to physical variability, and ecosystem models should be able to encompass this dynamical behavior. The aim of this work was to investigate how relevant the description of physical processes is in the dynamics of shallow ecosystems with respect to other potential sources of uncertainties.

Therefore, a 1-D coupled physical-biological model has been used to hindcast the observed seasonal variability for the year 2001 at a shallow water station in the northern Adriatic Sea of approximately 29m depth (Lat 45.25° N, Long 12.76° E).

The model couples two existing state-of-the-art submodels: the General Ocean Turbulence Model (GOTM, [1]) and the most recent version of the European Regional Sea Ecosystem Model (ERSEM III, [2]).

A relatively high abundance of biological observations are available at this site for comparison with the model results.

We tested a variety of turbulence closure models (TCMs) and boundary forcings, and assessed their impact on the simulation of the thermal structure (Fig.1) and primary producers (e.g. flagellates, Fig. 2) at the station. The chosen schemes were: 1) k-epsilon; 2) generic length scale; 2) k-omega and 3) a simple 1-equation model.

Significant differences in the thermal cycle between the model and the observations become evident only when low-order TCMs are adopted (see differences between k-epsilon and 1-equation in Fig. 1) or when the surface forcing is incomplete (e.g., salinity prescribed only at surface) or when the frequency of surface forcing is changed (e.g., wind stress from hourly to 6-hourly). Significant differences also show up in the biochemical variables under these conditions (Fig. 2).

The use of high-frequency physical forcing lets the model achieve a satisfactory agreement between modeled and measured temperatures in the water column The results differ only slightly when different state-of-the-art second order TCMs are used, which suggets

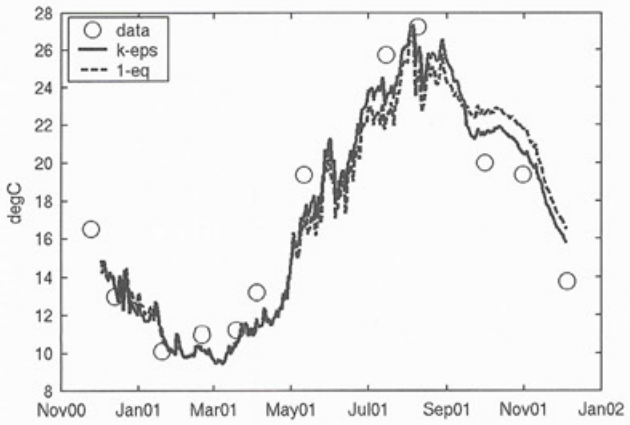


Fig. 1. Model-data comparison for temperature. Model results obtained with the k-epsilon and the 1-equation TCMs.

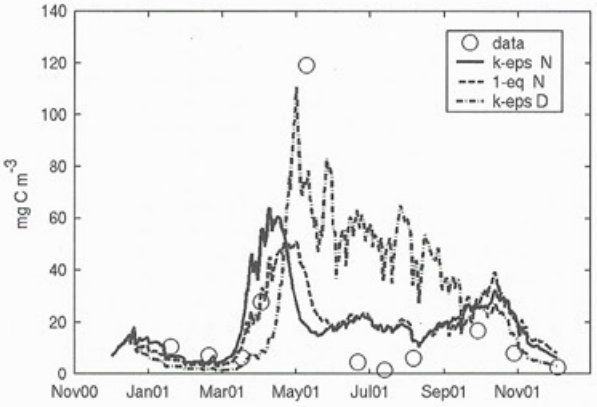


Fig. 2. Model-data comparison for phytoplankton (e.g. flagellates). k-eps N = k-epsilon TCM with Neumann BC; 1-eq N = 1-equation TCM with Neumann BC; k-eps D = k-epsilon TCM with Dirichlet BC

that these TCMs have converged in recent years. Biological variables in these cases are mostly unaffected by the changes in TCM.

Our conclusions are that, at least in this case, the current status of physical model is such that it is able to provide a sufficiently accurate description of the physical state of the water column.

However, the description of the observed biochemical variability is still far from satisfactory. Therefore, we investigated the importance of other potential sources of unertainty, as for example the ways of including the nutrient data as boundary conditions (BC), which are extremely important in this area due to the presence of the Po river. Fig. 2 shows how phytoplankton results are strongly sensitive to the change of BC from von Neumann to Dirichlet methods. Similar results are obtained if other important model parameters are varied, such as the ones involved in the C:Chl ratio dynamics.

It appears thus necessary to focus on the refinement of the parameterization of biochemical processes, and explore the interactions with other unknown factors such as the proper assimilation of external inputs.

References

1 - Burchard, H., Bolding, K., Villarreal, M.R., 1999. GOTM, a general ocean turbulence model. Theory, implementation and test cases, European Commission, Report EUR 18745, 103 p.

2 - Vichi, M. Baretta, J.W., Baretta-Bekker, J.G., Ebenhöh, W., Kohlmeier, C., Ruardij, P. European Regional Seas Ecosystem Model III. Review of the biogeochemical equations. http://www.bo.ingv.it/ersem3

PRESSURE-GENERATED WAVES IN THE MIDDLE ADRIATIC SEA

Ivica Vilibic [1]*, Nenad Domijan [1], Nenad Leder [1], Mirko Orlic [2]

[1] Hydrographic Institute of the Republic of Croatia, Zrinsko Frankopanska 161, 21000 Split, Croatia - * ivica.vilibic@hhi.hr
[2] Andrija Mohorovicic Geophysical Institute, Faculty of Science, University of Zagreb, Horvatovac bb, 10000 Zagreb, Croatia

Abstract

The paper documents the appearance of large air pressure wave which travelled over the Middle Adriatic region on 27 June 2003. Some coastal areas were flooded due to the generation of resonant waves in the sea, coupled with the seiches and enlarged by the topography. Available air pressure and sea level records are examined and interpreted using 2D numerical model. The model successfully reproduced strong sea level oscillations and strong currents in some parts of the region.

Introduction

The generation of waves in the sea by travelling air pressure disturbance, also known as Proudman resonance, can produce rather high sea level oscillations in some bays throughout the world seas [1-2]. In the Adriatic Sea the most outstanding event happened in June 1978, when the great part of Vela Luka city was flooded by the waves with amplitude of approx. 3 m and period of 15 min [3]. Later on, the resonance was examined in the Split Harbour [4], but fortunately it resulted in no flooding and damages.

This paper will document the appearance of large air pressure travelling wave which hit the Middle Adriatic region (Fig. 1) in morning hours of 27 June 2003. The wave resonantly excited its counterpart in the sea and flooded lower parts in the city of Stari Grad, also destructing a number of shelf plants in the Mali Ston Bay. Available air pressure and sea level data were analysed, supplemented by 2D numerical model which was calibrated and verified by using Split and Sucuraj tide gauge data. The model was forced by air pressure disturbance only, as measured on the Split digital pressure gauge, travelling with constant speed and direction of propagation. The latter was obtained from barograms collected at the number of meteorological stations (see Fig. 1).

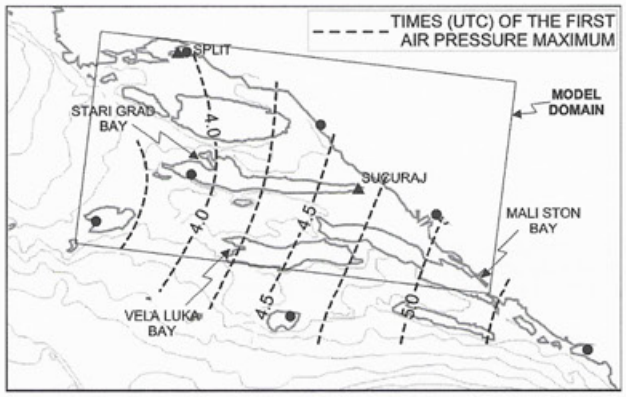


Fig. 1. The area of Middle Adriatic northeastern region, with locations of air pressure stations (circles), tide gauges (triangles) and domain of 2D numerical model. Times of occurrence of the first air pressure maximum on 27 June 2003 are shown too (dashed lines).

Results

Time series of air pressure recorded on 27 June at Split is given in Fig. 2, whereas the appearance of the first maximum in air pressure, extracted from the barograms, is displayed in Fig. 1. Air pressure wave travelled over the area with the average speed of 22 m/s in the ESE direction, being accelerated somewhat towards the Mali Ston Bay. The shape of the disturbance did not change much in space over the region, keeping its cosine-like appearance at all meteorological stations. It should be added that a gust of wind was recorded during the event; however, it lasted less than 10 min and did not have significant influence on the sea dynamics.

In line with this, model was forced with travelling air pressure wave, as measured at the Split pressure gauge with 2-min sampling interval. Therefore, high-frequency air pressure oscillations (i.e. those having period below 15 min) were also supposed to travel with the major disturbance, which is probably not true and may result in artificial high-frequency sea level response. Thus, sea level series are smoothed by 15-min running average (Fig. 2). Nevertheless, major disturbance is correctly simulated, especially as the model successfully reproduced sea levels measured at Split and Sucuraj tide gauge stations (Fig. 2). Sea level changes were pronounced at the end of the Mali Ston Bay, having the amplitude of about 50 cm, whereas the current amplitude surpassed 50 cm/s at the bay mouth. On the other hand, the model did not reproduce the flooding of the Stari Grad city, as it has too coarse resolution to catch topographical features that are responsible for the event. Consequently, modelling efforts should continue with the aim of constructing high-resolution nested models of the regions of interest.

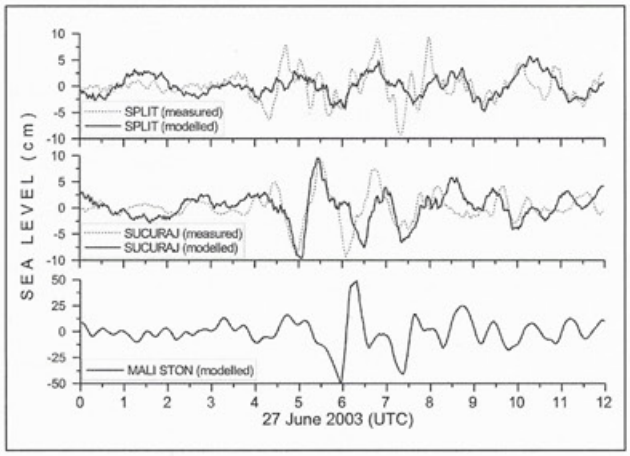


Fig. 2. Air pressure series measured at Split, together with observed and modelled sea levels (smoothed with 15-min running average) at Sucuraj and Mali Ston Bay.

References

1 - Rabinovich A.B., Monserrat S., 1998. Generation of meteorological tsunamis (large amplitude seiches) near the Balearic and Kuril Islands. *Natural Hazards*, 18: 27-55.

2 - Hibiya T., Kajiura K., 1982. Origin of the Abiki phenomenon (a kind of seiche) in Nagasaki Bay. *Journal of the Oceanographic Society of Japan*, 38: 172-182.

3 - Orlic M., 1980. About the possible occurrence of the Proudman resonance in the Adriatic. *Thalassia Jugoslavica*, 16, 1: 79-88.

4 - Vilibic I., Mihanovic H., 2003. A study of resonant oscillations in the Split harbour (Adriatic Sea). *Estuarine Coastal and Shelf Science*, 56: 861-867.

SYNTHETICALLY GENERATED ERRORS IN TIDAL CONSTITUENTS

Ivica Vilibic

Hydrographic Institute of the Republic of Croatia, Zrinsko Frankopanska 161, 21000 Split, Croatia - ivica.vilibic@hhi.hr

Abstract

The paper comprises the calculations of amplitudes and phases of tidal harmonic constituents, performed on hourly sea level data recorded at Split tide gauge in the period 1957-2001. Interannual changes have been detected, stronger in phases than in amplitudes. The differences are presumably generated by clock error, uncertainties in time positioning of the charts and the errors within the digitalisation process. Therefore, two groups of artificial sea level series have been generated, in order to simulate time drift and shift in the series and to verify their impact on the constituents.

Keywords: tide gauge, chart record, harmonic analysis.

Introduction

The computations of tidal amplitudes and phases can incorporate artificial errors if extracted from analogous chart records [1], which were commonly operated in the Adriatic Sea in the last half a century. The first calculation of Adriatic harmonic constituents was based on Bakar data measured in 1950, extracting 7 significant constituents with amplitude higher than 1 cm. Polli [2] performed a comprehensive tidal analysis (29 stations) and plotted amplitudes and phases for the whole Adriatic, but using rather old data collected at the beginning of 20th century.

Data and methods

The analysis of sea level data collected in 1957-2001 period at Split chart-recording tide gauge will be performed in this work, in order to check quality of the data and practicability of previously estimated harmonic constants in tidal forecasting. The digitalisation of the charts has been performed using two different software packages: (1) the charts from 1978 to 2001 were digitalised on an older VAX system, thus the data is more prone to digitalisation errors (T3 period), and (2) the charts older than 1978 were digitalised recently using PC based package, and therefore it is expected to result in more accurate data than the older one (T1 period – low quality charts, T2 period – high quality charts). Harmonic analysis was performed using TASK package (Tidal Analysis Software Kit) developed at Proudman Oceanographic Laboratory. Furthermore, simulations of time drifts and shifts in the series was carried out in order to evaluate the influence of errors that may occur during digitalisation process, both on the amplitudes and phases of major tidal constituents.

Results

Fig. 1 shows interannual variability of diurnal tides calculated at Split for period 1957-2001. The difference between the constants seems to be rather significant. For example, amplitudes are the lowest in the T1 period (except of N_2 tide), oppositely to phases which are commonly the largest in the T1 period (except of K_2). Additionally, T1 period is characterized by the highest standard deviations. The amplitudes in T3 period are even a bit higher, whereas the phases are lower compared to T2 period.

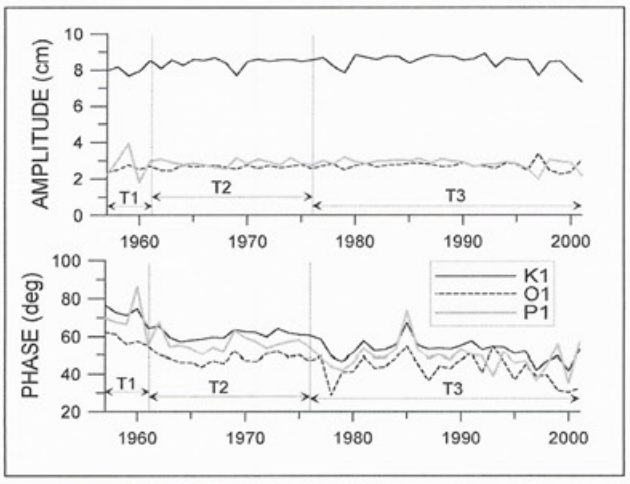


Fig. 1. Annual amplitudes and phases of diurnal constituents at Split.

Simulated changes in constituent amplitudes and phases due to the simulated artificial drift in time series are shown in Fig. 2. One can see that the changes in amplitude are not as pronounced as the changes in phase, both for semidiurnal and diurnal constituents. Nevertheless, if the drift is large enough, semidiurnal amplitudes decrease rather rapidly, while the phases change linearly as a function of the drift rate. The exception is P_1 tide, which increases in amplitude when the drift rate is negative. Such behaviour is a result of artificial energy transfer from K_1 to P_1 tide, as K_1 tide has a period rather close to the P_1 (23.93 h of K_1 *versus* 24.07 h of P_1).

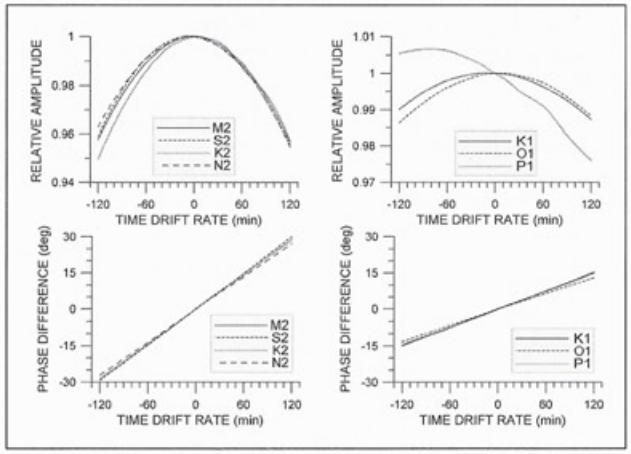


Fig. 2. Simulated changes in relative amplitudes and phase differences versus time drift rate. The respective amplitude and phase are supposed to be 1 and 0 when no time drift was simulated.

Generally, time variations of the tidal constituents have been presumed to come from systematic errors that occurred during sea level measurements, and during the digitalisation process of the charts. The changes seem to be dependent on the digitalisation technique, clock errors as well as on the uncertainties in the time positioning of the charts. The phases of the harmonic constituents are more vulnerable to all of the errors, while the amplitude suffers only when large time drift and shift are presented in the series. In particular, semidiurnal tides with low amplitudes such as K_2 and N_2 can be significantly changed, whereas diurnal tides are relatively stable in amplitude.

Acknowledgement. A part of sea level charts has been digitised within ESEAS-RI project (EU funded project EVR1-CT-2002-40025). Permanent Service for Mean Sea Level kindly provided TASK software package.

References

1 - UNESCO, 1985. Manual on sea level measurement and interpretation. Volume I – Basic procedures. IOC Manuals and Guides 14, 83 p.

2 - Polli S., 1960. Le propagazione delle maree nell' Adriatico (in Italian), Atti del IX Convegno dell' Associazione Geofisica Italiana, Roma, 1-11.

THE MEASUREMENTS OF WATER EXCHANGES AT THE VENICE LAGOON INLETS

L. Zaggia [1]*, A. Mazzoldi [1], M. Gacic 2, F. Costa [1]

[1] CNR-ISMAR, Istituto di Scienze Marine, Venezia, Italy - * luca.zaggia@ve.ismar.cnr.it
[2] OGS, Istituto Nazionale di Oceanografia e Geofisica Sperimentale, Trieste, Italy

Abstract

The quantification of the water and sediment exchanges through the inlets of the Venice Lagoon is a fundamental requirement for designing interventions aimed at protecting the lagoon environment against exceptional tides and erosion processes. Acoustic Doppler current profilers are now being extensively used for the continuous monitoring of the flow to investigate the hydrodynamic characteristics and sediment transport in the cross-section of three inlets. An overview of researches undertaken and the main results so far obtained is given.

Keywords: Venice Lagoon, Adriatic Sea, water exchange, acoustic-Doppler profilers, sediment transport

The water exchanges between the lagoon of Venice and the Adriatic Sea are ensured by three inlets: Lido, Malamocco and Chioggia (from North to South). Their widths varies from about 450 m, of the Malamocco inlet, to about 900 m of the Lido inlet, while their depth is at most 20 m. The flow is essentially driven by the tide excursion in the northern Adriatic Sea even if some influence of wind forcing may affect the water circulation under extreme meteorological conditions.

The overall water volume of the lagoon is about 550 millions of m^3. Although the residence times of lagoon waters can vary considerably in the different compartments - in relation to the distance from the inlets, the morphology of the shallow-water areas and the characteristics of the drainage pattern – it can reasonably be presumed that such a volume is renewed on a relatively short time-scale (1-2 days). Flow rate as high as of 8000 m^3/s in a single inlet were in fact estimated by previous investigators with a modelling approach.

The tidal exchange is, therefore, the chief controlling factor for processes affecting the life and evolution of the lagoon ecosystem such as:
– thermal exchanges between the lagoon and the open-sea and their effects on the biological communities and algae production;
– sediment transport within the lagoon and exchanges of materials with the sea and the nearby littorals and their effects on the erosion-deposition balance;
– oxygen supply in the shallows and marginal areas;
– supply of nutrient substances to lagoon organisms and the removal of decomposition products;
– reproduction and migratory cycles of the fauna;
– human activities in the urban areas and minor isles.

Monitoring the exchanges of water, sediments and dissolved substances at the three inlets of the Venice Lagoon is, therefore, fundamental for the management of interventions aimed at safeguarding the lagoon environment and defending it from exceptional high tides. As like many other environmental variables, these evaluations must necessarily be based on sufficiently long records (time series). This will permit to identify evolutionary tendencies and to minimise the negative impacts of ongoing transformations on the planned interventions.

Regardless of the widely recognised priority of studies on the water and sediment exchanges between the Venice lagoon and the Adriatic Sea, the absence of a continuous series of observations of the flow at the inlets has always represented a serious obstacle to the progress of the research in the above-mentioned fields.

Acoustic Doppler current profilers (ADCP) have been recently employed for the continuous recording of the flow at the sea inlets permitting the acquisition of a two-year long time series of discharge for each of the three inlets. The trend of average annual/seasonal fluxes, and the variations induced by particular weather and sea conditions, such as those responsible for exceptional tides and flooding, are jointly investigated by CNR-ISMAR and OGS research teams. A CNR-ISMAR research group also investigates the hydrodynamics and evolution of velocity fields in the inlet cross-sections as well as suspended sediment transport. The activities so far performed were granted by two main research projects:
– "Quantità e Qualità degli Scambi tra Laguna e Mare", funded by CO.RI.LA - Consorzio Ricerche Lagunari, Venice;
– "Misure del Trasporto alle Bocche di Porto e nei Canali Lagunari", funded by A.P.A.T - Agenzia per la Protezione dell'Ambiente e per i Servizi Tecnici, Venice.

Bottom-mounted ADCPs have recorded current speed and directions along the vertical profile, at approximately the mid portion of the main channel of each inlet, since January 2001. The analysis of time series permitted a description of the temporal evolution of tidal currents. A study of the water exchange rates was also possible after determining the relationship between the vertically averaged current and the magnitude of flow rate obtained from transects acquired by vessel-mounted ADCPs. The scatterplot obtained for the Lido inlet (Fig. 1), shows the good correlation found between discharge and the average tidal current. Instantaneous discharge values as high as 8000 m^3/s are associated with the maximum current speeds (about 1.2 m/s) measured in this inlet. The average magnitude of tidal exchanges between the whole lagoon and the open sea is, therefore, of the order of 10,000 m^3/s, which implies a mean residence time of water masses of the order of one day, or a full tidal cycle [1].

It would be expected that the observed magnitude of the exchange rates has strong implications for the transport of suspended sediments, particularly when wind-induced stress in shallow water areas of the lagoon resuspend large amounts of sediments. For these reasons the research work has now been extended to monitoring suspended sediment fluxes and the study of their variation over time. Sediment transport mechanisms within the inlets will also be investigated by applying the Sediview software procedure to the ADCP transect acquisitions which will permit a better spatial resolution than conventional techniques.

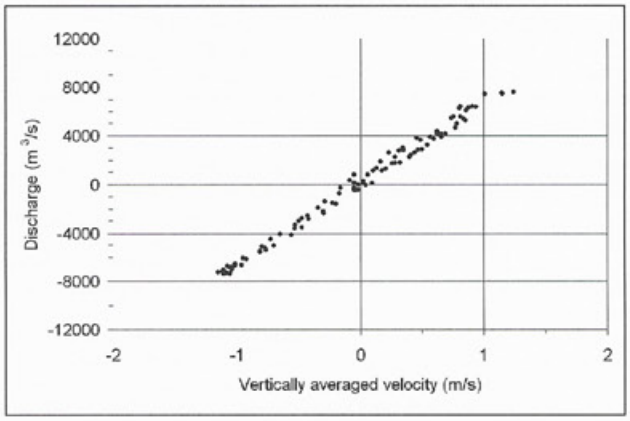


Fig. 1. Scatterplot of vertically averaged current velocity and discharge for the Lido inlet.

References

1 - Gačić M., Kovčević V., Mazzoldi A., Paduan J., Arena F., Mancero Mosquera I., Gelsi G., and Arcari G., 2002. Measuring Water Exchange between the Venetian Lagoon and the Open Sea. *Eos T. Am. Geophys. Union*, 83 (20): 217-222.

MULTIPARAMETRIC MARINE MONITORING FROM AUTOMATIC COASTAL PLATFORMS

Zappalà G.*, Caruso G., Azzaro F., Crisafi E.

CNR - Istituto per l'Ambiente Marino Costiero (IAMC) – Section of Messina, Italy - * zappala@ist.me.cnr.it

Abstract

New devices were developed in the framework of the Italian MIUR Cluster 10 programme to fulfil the need for low-cost, reliable, automatic systems for coastal marine monitoring. The main device is a system acquiring and transmitting in real time physical, chemical and physico-chemical parameters of seawater together with meteorological observations, able also to control an automatic water multisampler for off-line bacteriological determinations. Measuring systems are hosted in seven platforms, moored in selected Sicilian and Apulian sites, which are affected by anthropic, urban or industrial inputs. Some data acquired by two of these platforms are here presented.

Keywords: Monitoring, coastal area, Mediterranean Sea

Introduction

Improvement in the technological instrumentation and equipment for coastal monitoring represents the challenge for future development in the field of environmental assessment. In the last decade, advanced devices have recently been designed to be used as components in networks of multiparametric observation systems (1).

The paper describes two examples of application of our automatic monitoring platforms, showing their capability to evaluate both the trophic condition of a coastal site, as performed in a Tyrrhenian ecosystem, and the anthropic input in a semi-enclosed area, as in Messina harbour.

Materials and methods

Measured Parameters

Measurements were performed by two platforms (2), hosting a system that pumps water samples from five depths into a measurement chamber where a IM50 CTDO probe with fluorometer and turbidimeter is fitted; the same water is also used to feed a Systea Nutrient Probe Analyser and a bacteriological multisampler expressely designed to store and fix eight 250 ml samples. The temperature at the sampling depths was measured by five SBE39 *in situ* probes. A meteorological station equipped with temperature, pressure, solar radiance, wind direction and speed sensors completed the equipment present in all platforms.

Messina platform also included an IM50 probe for *in situ* subsurface measurements and an Aquadopp 600 ADCP.

All the measuring operations were controlled by an expressely designed data acquisition and transmission system, fully manageable and reprogrammable via GSM and SMS, transmitting the acquired data via e-mail in real time.

Studied area

The Gulf of Milazzo is a coastal Tyrrhenian area receiving consistent continental outflow and is characterised by an anticyclonic water circulation. Due to its past tendency towards the eutrophy, this area was monitored for the main hydrological parameters (temperature, conductivity, dissolved oxygen, nutrients) driving biological processes (3). The Straits of Messina, a transition area between Ionian and Tyrrhenian waters, are characterized by two main alternating currents, called "montante", from the Ionian Sea northwards, and "scendente", from the Tyrrhenian Sea southwards. Water circulation is affected by this continuous water mass exchange; microbial pollution was monitored in this area, where different sewages are discharged along the shoreline (4).

Results

Nutrient measurements performed on subsurface samples using the NPA in Milazzo Platform are reported in Fig. 1. During the period examined, no significant variations were found; ammonia, nitrites and orthophosphates showed low concentrations, while substantially high nitrates values were measured.

Total bacterioplankton counts by DAPI staining (Fig. 2), obtained in surface samples collected in Messina harbour by the automatic multisampler, showed a quite regular course, with repeated peaks at 6.00 a.m. on the first sampling days, and then shifted 6 hours later in the successive days. This might be explained by the arrival of high amounts of organic matter, such as those drawn from the alternating "scendente" and "montante" currents, that stimulated bacterial growth.

Discussion

The systems here described proved to be reliable tools for the monitoring of coastal environment; their real time capability enables to use them in the management of natural resources and protection of environmental quality level (nowcasting and early warning). The ability to acquire long-term time series allows the development of forecasting models.

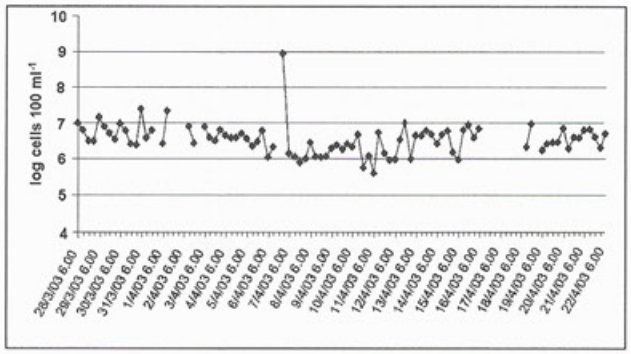


Fig. 1. Nutrients in Milazzo Gulf

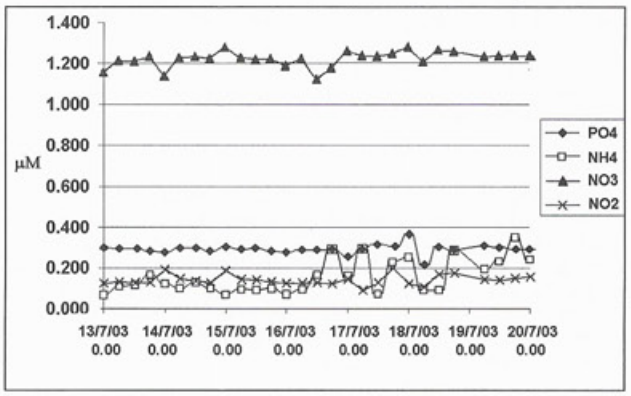


Fig. 2. Bacterioplankton density in Messina harbour

Acknowledgements. Work funded by the MIUR Cluster 10 SAM research programme

References

1 - Zappalà, G., Caruso, G., & Crisafi, E., 2002. Design and use of advanced technology devices for sea water monitoring. *In:* Flemming N.C., Vallerga S., Pinardi N., Behrens H.W.A., Manzella G., Prandle D., Stel J.H. (eds.), Operational Oceanography. Implementation at the European and Regional Scales. Elsevier Oceanography Series, 66.

2 - Zappalà, G., Caruso, G., Azzaro, F., & Crisafi, E., 2003. Integrated Environment Monitoring from Coastal Platforms. Pp. 2007-2018. *In:* Proc Int. Conf. On the Mediterranean Coastal Environment, MEDCOAST03.

3 - Decembrini F., Azzaro F., Galletta M. G., Raffa F., 2004. Short-term changes of hydrobiological features in the Gulf of Milazzo (Tyrrhenian Sicily). *Rapp. Comm. int. Mer Medit.* this issue.

4 - Zappalà G., Crisafi E., Caruso G., Azzaro F., Magazzù G., 1998. Coastal monitoring by an advanced technology platform. Pp. 69-84. *In*: Proc. Oceanology International '98 Conference.

A SUB-REGIONAL COASTAL FORECASTING AND OBSERVING SYSTEM IN THE LEVANTINE BASIN

George Zodiatis [1, 2 *], Robin Lardner [1, 2], Georgios Georgiou [2], Encho Demirov [3], Giuseppe Manzella [4] and Nadia Pinardi [3]

[1] Oceanography Centre, DFMR, Nicosia, Cyprus
[2] Computational Oceanography Group, MAS, University of Cyprus, Nicosia, Cyprus
[3] Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy
[4] ENEA CRAM, La Spezia, Italy

Abstract

The countries surrounding the Mediterranean Sea have joined together in several multinational initiatives to conduct long-term, integrated, operational oceanographic observations and modelling of this important region. An operational high resolution oceanographic forecasting and observing system has been developed in Cyprus and has been operational since early 2002. The system is called CYCOFOS-Cyprus Coastal Ocean Forecasting and Observing System and is a component of the Global Ocean Observing System (GOOS), and its European (EuroGOOS) and Mediterranean (MedGOOS) modules. CYCOFOS at present consists of several operational modules, among them flow and offshore waves forecasts, satellite remote sensing, coastal monitoring stations and end-user-derived applications. This sub-regional operational system provide regular near-real-time information, both to local and sub-regional end users throughout the Eastern Mediterranean Levantine Basin.

Keywords : operational oceanography, forecasting, monitoring, Levantine Basin

Preface

The development and promotion of the operational forecasting activities in the Mediterranean and European seas is carried out in the framework of several European Union funded research projects and international activities, which include MFSPP, MFSTEP, MAMA. MERSEA-Strand-1,EuroGOOS, MedGOOS, MedGLOOS (1,2,3).

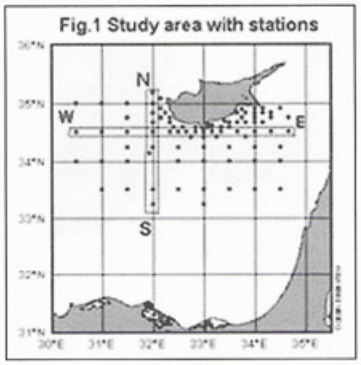


Fig.1 Study area with stations

The Cyprus coastal ocean forecasting and observing system was first developed within the framework of the above EU research projects(4). At present CYCOFOS provides near-real-time operational forecasts of sea currents, water temperature, salinity, sea level, significant wave height and direction, as well operational *in situ* observations of sea water temperature, sea level, and satellite remote sensing of sea surface temperature in the sea areas around Cyprus and in the Levantine Basin. CYCOFOS consists of forecasting (flow and sea state), observing (in-situ and remote sensing) and end-users modules :

The MFS Cyprus Near Real Time Ocean Forecasts in the NE Levantine

The CYCOM, a high-resolution (2.5 km) flow model based on the POM model, is in use for operational flow simulations in the coastal and open sea areas in the NE Levantine Basin. It has two open boundaries and is nested operationally into the coarse grid of the MFSTEP basin model. The CYCOM flow model provides weekly forecast for the forthcoming week, daily forecasts of currents, sea temperature, salinity and sea level.

The Cyprus Offshore Wave Forecasts in the Levantine Basin

The CYWAM wave model, which is a version of the WAM model, is in use for offshore wave forecasts in the Levantine Basin. The fine resolution Levantine CYWAM model is nested in a coarse Mediterranean CYWAM model. CYWAM provides operationally high-resolution forecasts of significant wave height and wave direction. The CYWAM model initially used the ECMWF wind forcing, while at present uses the 3-hourly winds from the 72-hour *SKIRON* weather forecasting system.

The coastal MedGLOSS Paphos Station

Within the framework of the Mediterranean network of Global Sea Level Observing System, a sea level station was set up in September 2001 at Paphos Harbor, on the western coast of Cyprus. The station's primary aim is to collect long-term systematic measurements, monitoring the sea level rise, which may be caused by melting of polar ice as a result of global warming. At present hourly sea level, water temperature and atmospheric pressure are provided by this coastal observing system. Expansion of the Cyprus MedGLOSS in the near future will include similar stations on the south and east coasts of Cyprus.

The CYCOFOS Satellite Ocean Remote Sensing

The CYCOFOS satellite ground receiving station has been providing regular daily high resolution (1 km) remote sensing SST images of the Levantine Basin since 2001. An HRPT (High Resolution Picture Transmission) SmartTech Professional Researcher model engine is operated by the CYCOFOS team. Depending upon the satellite's orbit, it is capable of covering in one single capture the Eastern Mediterranean and Black Seas up to 2-3 times per day.

The CYCOFOS Ocean Observatory

As part of the MAMA/MedGOOS initiative, and to promote deep sea operational *in situ* observations, the CYCOFOS Ocean Observatory is currently under preparation for deployment in the Levantine Basin, off the southern coast of Cyprus. The CYCOFOS Ocean Observatory is scheduled for deployment jointly with Harris Maritime Communication Services, USA. A similar Ocean Observatory was deployed in 2003 in the Western Mediterranean, off the coast of Sardinia.

The end-users derived applications

To provide the scientific basis for any user-derived application that tries to manage either the exploitation or the protection of the marine environment, it is necessary to offer an efficient and quality-controlled estimate of marine state variables. In view of the above, additional components of CYCOFOS, *MEDSLIK* oil spill model and the *MEDPOL* general dispersion model, were developed specifically for end-user-derived applications, employing the MFSTEP, CYCOFOS and SKIRON products.

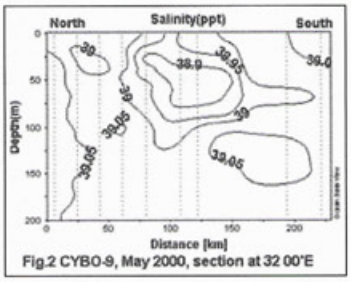


Fig.2 CYBO-9, May 2000, section at 32 00'E

CYCOFOS products on the Internet

The near-real-time operational forecasting and observing products from the above CYCOFOS modules, such as daily flow forecasts for the NE Levantine Basin on a weekly basis, 3-hourly sea state forecasts for the Levantine Basin on a 60 hours basis, daily remote sensing sea surface temperature for the Levantine Basin and hourly in-situ sea level and water temperature at certain coastal sea stations are available to the end-users at the web page www.ucy.ac.cy/cyocean.

Recent CYCOFOS developments

The MFS Cyprus flow model used in CYCOFOS was downloaded to 1.8 km, while the area of the processed satellite remote sensing SST was extended as far west as the strait of Sicily and as far north as the Aegean Sea. Moreover, weekly CYCOFOS forecasting data are provided at the CYCOFOS web page for the end-users derived application, both to suite operationally that of the MEDSLIK oil spill model and that of the MEDPOL general dispersion model.

Acknowledgements. The development of the CYCOFOS modules has been partially carried out in the framework of EU research projects and other international activities: MFSPP, MFSTEP, MAMA, MERSEA-1 and MedGLOSS. The authors acknowledge the support of the EC programmes, contract MAS3-CT98-0171, EVR1-CT-2001-20010, EVK3-CT-2002-0089 and EVK3-CT-2002-00075, the CIESM providing the equipment for the MedGLOOS station, the SKIRON weather forecasting system providing access to weather forecasting products, the Director of DFMR Dr G.P. Gabrielides and Prof. G. Kallos coordinator of SKIRON system. We are also grateful to Dr. D. Rosen, coordinator of MedGLOSS and his scientific team from IOLR, Dr I. Gertman, L. Raskin and Y. Tsehtik, all CYCOFOS collaborators T. Eleftheriou, D. Soloviev, E. Koufou, V. Fomin, S. Savva and M. Ioannou, and Dr. A.Clark of MCS, USA for support of the CYCOFOS Ocean Observatory.

References

1 - EuroGOOS , 1997, The strategy for EuroGOOS. EuroGOOS Pupl., 1, 132 p.
2 - MAMA group, 2002, MAMA-towards a new paradigm for ocean monitoring in the Mediterranean. 3rd EuroGOOS Conference, Athens, 3-6 December.
3 - Pinardi N., Allen I., Demirov E., De Mey P., Korres G., Lascaratos A., Le Traon P.-Y., Maillard C., Manzella G. and Tziavos C., 2003, The Mediterranean ocean forecasting system: first phase of implementation, 1998-2001, *Annales Geophysicae, 21: 3-20.*
4 - Zodiatis et al., 2003, The Cyprus coastal ocean forecasting and observing system, Sea Technology, 10-15, October.

MODIFIED ATLANTIC WATER IN THE SE LEVANTINE BASIN (1995-2003)

George Zodiatis [1] *, Panos Drakopoulos [2] and Isaac Gertman [3]

[1] Oceanography Centre, DFMR, Nicosia, Cyprus
[2] Technological Educational Institute of Athens, Greece
[3] Israel Oceanographic and Limnological Research, Haifa, Israel

Abstract

The seasonal and inter-annual variability of the Modified Atlantic Water (MAW) in the Levantine Basin, particularly in the broader area south of Cyprus, is examined based on new data sets collected in the frame of the CYBO (Cyprus Basin Oceanography), CYCLOPS (Cycling of Phosphorous in the Mediterranean) and HaiSec (Long-term Haifa Section) projects, carried-out between 1995-2003. This new high resolution data sets provide quite strong evidence on the existence and the spatial/temporal fluctuation of the MAW and of the MMJ (Mid Mediterranean Jet). The MAW was traced during summer and winter to flow eastward, as transferred by the MMJ. The MMJ was well pronounced, both from in-situ and satellite SST, to meander eastward close to the south of Cyprus, along the periphery of the Cyprus eddy and of the re-appeared Shikmona gyre. The present investigations vividly shown that the MMJ in fact is a major driving mechanism responsible for the eastward spreading of the MAW in the Levantine Basin.

Keywords: Levantine Basin, Mid Mediterranean Jet, Modified Atlantic Water

Preface

One of the most variable water masses of the Levantine Basin is the subsurface less saline MAW. The high rates of the summer heating and evaporation, dominating the Levantine Basin, transform the upper layer of MAW to the most saline and warm (up to 39.6 ppt and 29 deg. C in summer 2003) surface waters in the Mediterranean. Generally, the inflow of the MAW in the Mediterranean is the result of the water volume compensation for the sea water evaporation in the Levantine Basin and the outflow of the Levantine Intermediate water (LIW) in to the North Atlantic [1]. The MAW, after its entry into the Mediterranean through the Gibraltar, spreads as far east as the Levantine Basin. There the MAW can be found as a subsurface layer spanning from 50 to 80 meters [1,2,3]. During mid 80's [3,4] it was observed that the main mechanism for transferring the MAW within the eastern sub-basin was the Mid Mediterranean jet. It is considered that this jet is the result of the interaction between cyclonic (Rhodos gyre) and anti-cyclonic (Mersa Matruch and Shikmona gyries) activities with the eastward movement of the waters passing the Cretan passage.

Results and Discussion

In this paper we examine more than 15 seasonal cruises held in the Levantine Basin with the frame of CYBO, CYCLOPS and HaiSec projects between 1996-2003 (Fig. 1). It is apparent that the MMJ, which carries the MAW in the area, enters from the southwest (Fig. 2), meanders eastward along the periphery of the Cyprus eddy and periodically bifurcates along the western coast of Cyprus. Recurrent Cyprus and Shikmona eddies, as well as, smaller scale cyclonic and anticyclonic eddies increase the complicatedness of the flow path of the MMJ and subsequently of the MAW transport. During summer the minimum salinity layer is well defined at a depth below the thermocline of about 50m and with a value as low as 38.65-38.75 psu, while during winter (as in January 1999) can be found with similar or higher salinities. However, during severe winter weather conditions the present of the MAW is difficult to be traced, either was complete vanished due to winter mixing processes. Moreover, the MAW during winter was found to occupy also the surface layer down to 100 meter, in the area offshore of southwest Cyprus, before its interaction with the Cyprus eddy.

In the last three years the significant spatial displacement of the Cyprus eddy to the west (60 nm from it original position) caused an even more complicated flow path for the MMJ. Particularly, in May 2001 the northward extend of the Cyprus eddy caused for a short period the restriction of the eastward transfer of the MAW. The flow path of the MMJ was now northward, as opposed to its usual eastward direction. Moreover, a secondary new anticyclonic eddy established between southeast of Cyprus and offshore Lebanon, resulted in a more complicated displacement for the MAW. It was observed bellow this new anticyclone at greater depth than usual (down to 200m). The latter suggests that the MAW after its eastward advection along the Cyprus eddy was picked up by the new anticyclone.

References

1 - Ovchinnikov *et. al.,* 1976, Hydrology of the Mediterranean Sea, Gidrometeoizdat, Leningrad.
2 - Hecht *et al.,* 1988. Currents, water masses, eddies and jets in the Mediterranean Levantine Basin. *J. Phys. Oceanography*, 18, 10: 1320-1353.
3 - Ozsoy *et al.,* 1991. A review of the Levantine basin circulation and its variability during 1985-1988. *Dyn. Atmos. Oceans*, 15: 421-456.
4 - POEM group, 1992. General circulation of the eastern Mediterranean sea. *Earth Sci. Rev.,* 32: 285-309.

Table-ronde :
Operational Oceanography

MEDGOOS – BUILDING A STRONG REGIONAL PARTNERSHIP FOR OPERATIONAL OCEANOGRAPHY IN THE MEDITERRANEAN

Drago A. [1]*, Vallerga S. [2] and the MAMA Consortium

[1] Aldo Drago, MedGOOS Secretariat, IOI-Malta Operational Centre, University of Malta, c/o 43/1 Valley Road, B'Kara BKR 10, Malta
aldo.drago@um.edu.mt

[2] Silvana Vallerga, CNR-Istituto per l'Ambiente Marino e Costiero, c/o IMC, Località Sa Mardini, Torregrande, Oristano, Italy
vallerga@nameserver.ge.cnr.it

Abstract

A sustained regional system for marine monitoring and forecasting needs an enduring collaboration among the neighbouring countries, supported by the willingness to share efforts, resources and knowledge. MedGOOS, the Mediterranean association of marine organisations, fosters institutional cooperation for the establishment of the Global Ocean Observing System (GOOS) in the region. A special emphasis is on the early dialogue between all the countries to ensure common ownership, and equal benefits and opportunities to all the riparian coastal peoples. MAMA, a 3-year thematic network project shared by leading marine research institutions from all the Mediterranean countries, is putting in place the institutional and scientific platform to establish operational oceanography in the region.

Keywords : Operational oceanography; Ocean monitoring; Forecasting; Networking; Sustainable Development

Throughout history the sea has played a crucial role in the socio-economic development of the Mediterranean region. Today the quest for environmental security, based on the concepts of sound ocean governance, sharing of knowledge and the sustained use of resources, is the precursor for prosperity, sustainability and peace. The importance of marine resources to our well-being calls for the sustainable use of the sea in both open and coastal domains. There is an ever increasing responsibility on the scientific community to provide accurate and routinely updated information for decision–making. Furthermore there is a recognition of the opportunities emerging from regional cooperation on marine research and monitoring for a sound ocean management policy in the Mediterranean.

The UN Convention on the Law of the Sea (UNCLOS) as well as the outcomes of the United Nations Conferences of Rio De Janeiro in 1992 (UNCED) and of Johannesburg in 2003 (WSSD), have prepared the legal and intergovernmental framework for cooperation among States for sustainable development. In the Mediterranean this has led to growing understanding that equitable sustainability is based on inter-sectorial and cross-border co-operation. North-North and North–South co-operation among Mediterranean countries is needed for the benefit of both developed and developing countries alike. Better co-ordination between the work of the Barcelona Convention bodies and the 27-nation Euro-Mediterranean Partnership is urged with the perspective of broadening the focus of the latter on environmental issues. Moreover the implementation of sustainable development requires improvements in the organisational, technological and human resource capabilities for environmental management. It builds on the applications of science to public policy needs, and the design of monitoring and assessment systems that secure a sustained development approach.

MedGOOS tackles these needs with a strong regional partnership. Sustained operational marine monitoring is planned for the benefit of a wide range of users. Applications and services are addressing the requirements of governments to enable an equitable and sustainable growth. The mission of MedGOOS is to facilitate the inter-institutional co-operation right from the planning and design stages, and considers the full regional scale involvement as a vital element for a durable and secured implementation of a marine monitoring system, based on existing assets and addressing national and regional needs. The regional dimension of the MedGOOS network is ramified at national level, thus involving a wide participation of stakeholders. This will improve the provision of data and information on the marine environment, integrated basin-wide, useful to policy makers in addition to scientists.

The MedGOOS members work as a coherent team in the region, and lead the promotion of GOOS in their respective countries. Their coordinating role as a national focal point, the establishment of links with the local scientific community, with relevant public authorities, environmental agencies, end-users and stakeholders, and the awareness activities provide a main thrust for the promotion of the Mediterranean GOOS. The members constitute an enabling asset to the future projection into long-term commitments at governmental level. Recently four new members joined MedGOOS which now counts 20 institutions from 17 countries.

National initiatives have established routine marine observations using automated systems in several shelf sea areas along the northern perimeter of the basin. A number of RTD projects have in the last few years provided a framework for the regional networking of the marine scientific community to underpin research in operational oceanography. The Mediterranean Forecasting System Pilot Project – MFSPP – [1] has started to develop and test the science base for the implementation of a Mediterranean ocean forecasting system. The ongoing project MFSTEP [2] (Mediterranean ocean Forecasting System: Towards Environmental Predictions) is a follow-up to MFSPP that will integrate and extend the observing system, demonstrate the feasibility of regional and coastal scale forecasting in several Mediterranean areas, develop biochemical modelling and data assimilation towards environmental predictions, and start the development of end-user interfaces for the exploitation of the project products.

In 2002, the project MAMA - Mediterranean network to Assess and upgrade Monitoring and forecasting Activity in the region [3] was launched. The project is funded by the Programme, *Energy, Environment and Sustainable Development*, EC 5th Framework Programme. MAMA brings together a consortium of major marine institutions from all the Mediterranean countries. It is staging a concerted effort of all Mediterranean countries to put in place the institutional and scientific links for the regional platform that will enable the implementation of MedGOOS. MAMA is contributing to the initial phase of the EC-ESA initiative GMES - Global Monitoring for Environment and Security [4], pooling together the national scientific and technological resources. The specific aims of the project are to share experiences, transfer of expertise, and bring capacities in ocean monitoring and forecasting in the basin at a comparable level. The joint effort is planning the initial observing and forecasting system in the Mediterranean. Demonstration products and results are disseminated, national awareness campaigns are organized to build momentum towards long term commitments by governments. After the first 18 months several activities are well underway. The network is working in harmony and a strong partnership has been established. MAMA is pioneering the implementation of GOOS by an unprecedented endeavour and novel approach that will put the region at the forefront of ocean monitoring and forecasting. Further details can be found on the project website (www.mama-net.org).

Acknowledgements

MAMA is a thematic network funded under the EC Programme Environment and Sustainable Development, 5th FP (contract EVR1-CT-2001-20010).

References

1 - Pinardi N., Allen I., de Mey P., Korres G., Lascaratos A., Le Traon P.Y., Maillard C., Tziavos C., 2003. The Mediterranean Ocean Forecasting System: First phase of implementation (1998-2001), *Annales Geophysicae*, 25: 1-18.

2 - Pinardi N., Auclair F., Cesarini C., Demirov E., Fonda-Umani S., Giani M., Montanari G., Oddo P., Tonani M. and Zavatarelli M., 2001. Toward marine environmental predictions in the Mediterranean Sea coastal areas: a monitoring approach. In: Pinardi N. and Woods J. (eds.), Ocean Forecasting: Conceptual basis and applications, Springer-Verlag.

3 - Vallerga S., Drago A. and the MAMA Consortium, 2002. MAMA – Towards a new paradigm for ocean monitoring in the Mediterranean, 3rd EuroGOOS Conference, December, Athens.

4 - GMES Support Team, 2003. GMES Vision and Targets 2008, Information document for the 3rd GMES Forum.

ADRIATIC SEA INTEGRATED COASTAL AREAS AND RIVER BASIN MANAGEMENT SYSTEM PILOT PROJECT (ADRICOSM)

Nadia Pinardi, Anita Grezio, Paolo Oddo and the ADRICOSM partners (www.ingv.it/adricosm)
INGV, Via Donato Creti 12, Bologna, Italy

Abstract
The ADRICOSM (ADRIatic sea integrated COastal areaS and river basin Management system pilot project) represents an innovative application of data assimilation to a forecasting system in the coastal areas. A key step toward integrated coastal area management is to connect the catchment basin runoff and the wastewater management with marine environment monitoring and forecasting since the coastal areas are strongly forced by the drainage basin inputs and disperse these inputs in a complex hydrodynamic environment.

Keywords: data assimilation, Adriatic Sea, Coastal Management, Ocean Forecasts

Introduction

During ADRICOSM the implementation of an integrated coastal zone management system in the Adriatic Sea, consisting of a predictive circulation module and a river basin and wastewater management module, has taken place. The aims are:

1) the demonstration of the capability to monitor and predict in real time the shelf and coastal currents variability;

2) the implementation of the monitoring and modelling scheme for a river basin and its associated wastewater system in a test site;

3) the integration of the river basin modelling with the coastal current prediction system.

ADRICOSM is possible because several of its components have been developed in the past ten years, but they have never been put together or applied to the Adriatic Sea or in a coastal region.

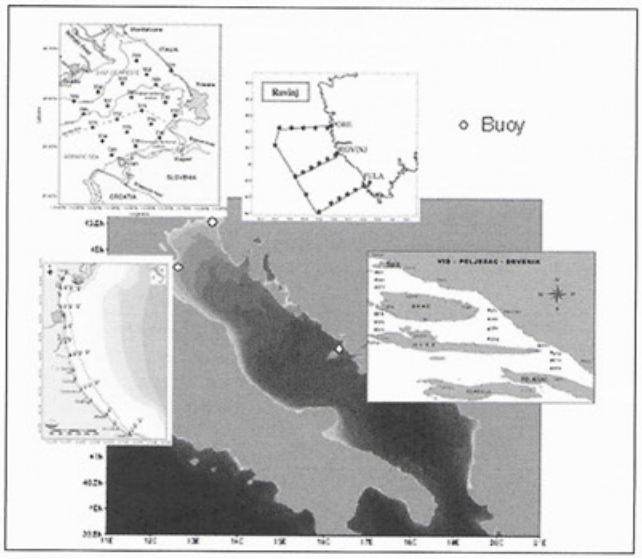
Results

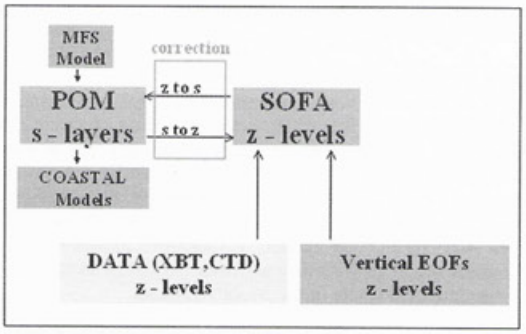
The Mediterranean marine Forecasting System (MFS) experience has demonstrated that the forecasts is applicable also in critical shelf area at weekly time scales. In particular the MFS activities have been developed in a way which takes in account the proper momentum and tracer fluxes at the Adriatic Sea open boundaries. The interface between the MFS model and the Adriatic fields permits the selection of the lateral boundary (T, S, u, v) during the data assimilation and the forecasting.

Both large scale and coastal observations are utilized efficiently in a data assimilation scheme that uses sequential estimations to prepare initial fields for subsequent forecasts. Sea Surface Temperatures (SST) from satellite are available daily and are used for the surface heat fluxes corrections in the Adriatic model.

Coastal network provides CTD data localized in 4 regions: the Emilia Romagna Coast, the Golf of Trieste, the Slovenia Coast and the Croatian Coast. In addition, XBT temperature profiles up to 900 m depths are collected by VOS (Voluntary Observation Ships) along the Ploce-Malta and the Split-Bari tracks.

Salinity and Temperature coming from CTD stations and temperature coming from XBT-VOS are assimilated in the Adriatic





Model (Fig. 1), which is POM (Princeton Ocean Model) [1] implemented by Zavatarelli *et al.* (2) for the Adriatic Sea. The model has a horizontal resolution of 5 km and 21 layers in the vertical, high frequency forcing and daily Po river run off. The assimilation system is SOFA (System for Ocean Forecasting and Analysis) [3], which is a multivariate reduced-order optimal interpolation method. This assimilation system has been successfully applied in the MFS and the innovative part in ADRICOSM is the sequential assimilation of the multivariate parameters (T, S profiles from CTD) and univariate parameters (T profiles from XBT). The sequential assimilation improves the system and the Adriatic model is efficiently corrected during the date assimilation using a coordinate transformation from sigma to z and *vice versa* (Fig.2). Moreover, nested shelf and coastal models receive the forecasting boundary conditions in "slave mode". A simulation systems for the river basin and the coastal currents has been coupled for the study case of the Cetina river in the Croatian coastal area.

Conclusions

ADRICOSM started to forecast in real time in May 2003 and it is continuing. Forecasts are done once a week and for seven days in the future. Assimilation of coastal CTD and open ocean XBT data is carried out by an Optimal Interpolation scheme, adapted to the coastal areas. Data assimilation improve the representation of the ocean processes by optimally combining a dynamic model and *in situ* data and provides better initial conditions for weekly coastal ocean forecasting.

References

1 - Blumberg A.F., Mellor G.L., 1987. A description of a three dimensional coastal ocean circulation model. Pp. 1-16.In : N.S. Heaps (ed.), Three dimensional ocean models, Coastal Estuarine Sci., AGU Washington D.C.
2 - Zavatarelli M., N. Pinardi, V.H. Kourafalou and A.Maggiore, 2002. Diagnostic and Prognostic model studies of the Adriatic Sea General Circulation: Seasonal variability. *J. Geophys. Res.*,107: 3004-3025.
3 - De Mey P., Benkiran M.,2002. A multivariate Reduced-order Optimal Interpolation Method and its application to the Mediterranean Basin-scale Circulation. Pp. 281-305. In : N. Pinardi, J.Woods (eds.), *Ocean Forecasting.*

THE MEDITERRANEAN MARINE FORECASTING SYSTEM: STATUS OF IMPLEMENTATION

Nadia Pinardi, Giovanni Coppini and MFSTEP partners
Istituto Nazionale di Geofisica e Vulcanologia, Via D. Creti, 12, Bologna I-40100, Italy
n.pinardi@ambra.unibo.it, coppini@bo.ingv.it

Abstract
The Mediterranean ocean Forecasting System (MFS) has started operational activities in January 2000. Presently it produces daily analyses and weekly 10-days forecasts of currents and temperature and salinity fields for the entire Mediterranean at approximately 10 km resolution. The main elements of the MFS - simultaneously operating in near real time the observational data network, a general circulation model and the data assimilation scheme- were implemented as part of an EU funded project called Mediterranean Forecasting System Pilot Project (MFSPP, IV Framework Program). The second phase will be undertaken by another EU funded project, called the Mediterranean ocean Forecasting System: Toward Environmental Predictions (MFSTEP, V Framework Program), which is seeking further consolidation and expansion of the MFS.

Keywords: Mediterranean Sea, Ocean forecasts, Operational oceanography.

Results and future developments

MFSPP (1) lasted 3 years and ended in 2002 and achieved the following goals: 1) the first basin scale real time observing system was set up and operated with satellite, VOS-XBT (2) and moored buoys (3) observations; 2) the real time forecasting system (Fig. 1) assimilated all these observations and produced a 10 days forecast every week; 3) regional and shelf models were nested and calibrated within the MFS basin scale model; 4) biochemical flux models were calibrated and validated with data assimilation components for several open ocean and shelf areas in the Mediterranean.

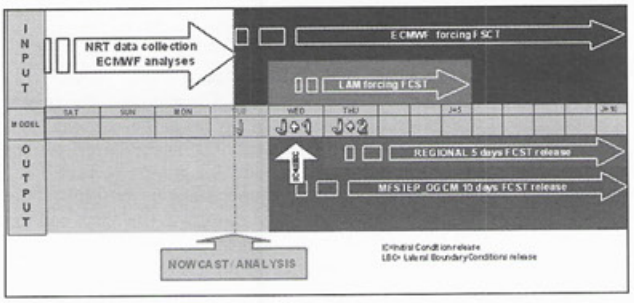


Fig. 1. The MFS weekly information flow for forecasting. The forecast starts every week at 12:00 fo Tuesday from an analysis/nowcast produced from data collected in the previous week. The basin scale forecast is done with ECMWF forcing and on Wednesday the initial and lateral boundary conditions are given to limited areas models, nested within the MFS OGCM.

The main goal of MFSTEP, that it is funded to run from March 1, 2003 for three years, is to advance the present monitoring system, to demonstrate practical feasibility of regional and shelf predictions in several Mediterranean sub-regions (at 3 km resolution), to further develop the ecosystem modelling and to start the development of end-users interfaces for the exploitation of project results.

In particularly MFSTEP has six major scientific/technological objectives:

OBJ1. Improve and expand the existing Near Real Time large scale monitoring system;

OBJ2. Add new observing system components in terms of biochemical measurements and new automated technology;

OBJ3. Improve the 10 days basin scale ocean forecast system (6.5 km resolution) and demonstrate the feasibility of Near Real Time three days forecasts in different regional areas (3 km resolution);

OBJ4. Develop the asynchronous ocean-atmosphere coupling with high resolution atmospheric forcing over regional areas;

OBJ5. Implement the three dimensional ecosystem models coupled to the forecasting system for future predictions of biochemical fluxes and state variables;

OBJ6. Consolidate the dissemination of forecast products to a wide user community and develop applications with end-users

The Mediterranean Forecasting System is presently operational and its products are available on MFSTEP central website: www.bo.ingv.it/mfstep (Fig. 2)

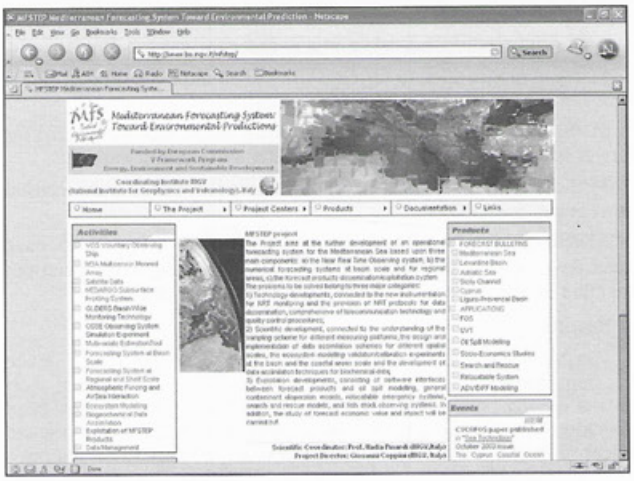


Fig. 2. MFSTEP central website.

References

1 - Pinardi N., Allen I., Demirov E., De Mey P., Korres G., Lascaratos A., Le Traon P.-Y., Maillard C., Manzella G., and Tziavos C., 2003. The Mediterranean ocean forecasting system: first phase of implementation (1998–2001). *Annales Geophysica*, 21, 1: 3-20.

2 - Manzella G. M. R., Scoccimarro E., Pinardi N., and Tonani M., 2003. Improved near real-time data management procedures for the Mediterranean ocean Forecasting System-Voluntary Observing Ship program. *Annales Geophysica*, 21, 1: 49-62.

3 - Nittis K., Tziavos C., Thanos I., Drakopoulos P., Cardin V., Gacic M., Petihakis G., and Basana R., 2003. The Mediterranean Moored Multi-sensor Array (M3A): system development and initial results. *Annales Geophysica*, 21: 1, 75-87.

CORIOLIS, A FRENCH PROJECT FOR IN SITU OPERATIONAL OCEANOGRAPHY.

S. Pouliquen [1], T. Carval1, Y. Desaubies [1], L. Petit de la Villéon [1], G. Loaec [1], L. Gourmelen [2]
(1) IFREMER, BP70, F29280 Plouzané - Sylvie.Pouliquen@ifremer.fr
(2) EPSHOM, BP426, F29275 Brest Cedex

Abstract
The seven French agencies concerned by ocean research are developing together a strong capability in operational oceanography based on a triad including satellite altimetry (JASON), numerical modelling with assimilation (MERCATOR), and in situ data (CORIOLIS).The CORIOLIS project aims to build a pre-operational structure to collect, valid and distribute ocean data (temperature/salinity profiles and current speeds) to the scientific community and modellers.

The seven French agencies concerned by ocean research are developing together a strong capability in operational oceanography based on a triad including satellite altimetry (JASON), numerical modelling with assimilation (MERCATOR), and in situ data (CORIOLIS).The CORIOLIS project aims to build a pre-operational structure to collect, valid and distribute ocean data (temperature/salinity profiles and current speeds) to the scientific community and modellers. CORIOLIS aims at four goals :

(1) To build up a data management centre, part of the ARGO network for the GODAE experiment, able to provide quality-controlled data in real time and delay modes.

(2) To contribute to ARGO floats deployment mainly in the Atlantic with about 250 floats during the 2001-2004 period.

(3) To develop and improve profiling ARGO floats. PROVOR is a self-ballasted float, able to drift at a user-defined parking depth and then to dive to 2000m before profiling up to the surface where data are transmitted using the Argos system. More than 100 cycles can be performed during its 3-year lifetime.

(4) To integrate into CORIOLIS all other data presently collected at sea by French agencies from surface drifting buoys, PIRATA anchored buoys, oceanographic research vessels (XBT, thermosalinograph and ADCP transmitted on a daily basis).

CORIOLIS has three phases:

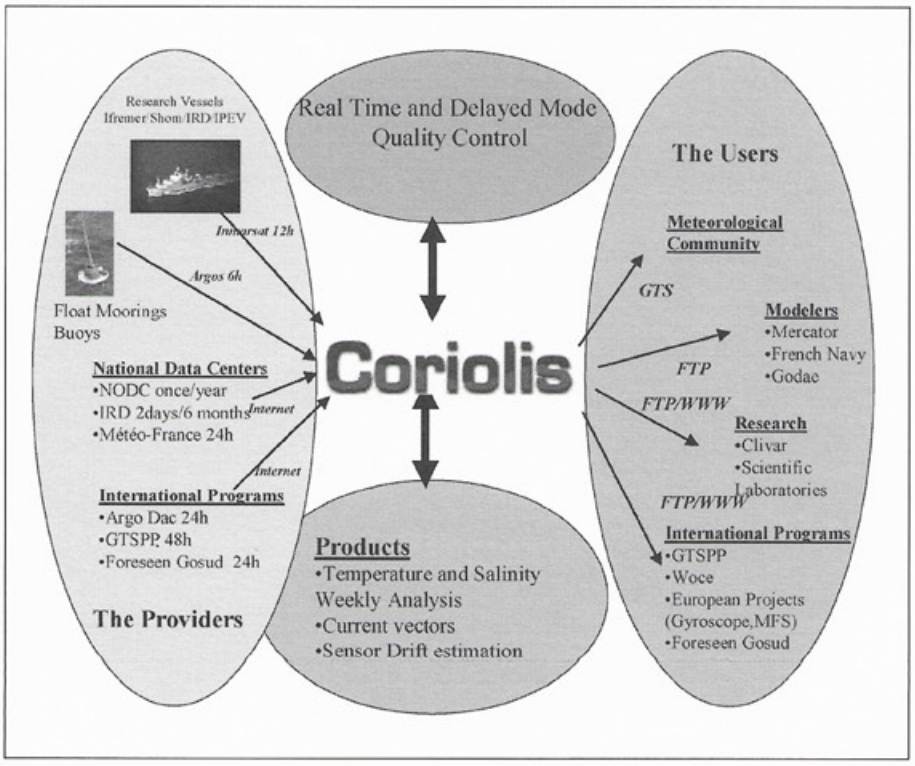
– Preparation phase (2000-2002) synchronised with MERCATOR demonstration phase, which sets up the system,

– Demonstration phase (2003-2005) during which CORIOLIS will operate in an operational mode,

– Lastly, an Evaluation Phase (2004-2005), which will provide recommendations starting from this experience, on what, should be a sustainable operational structure, in accordance with international plans that will follow the ARGO/GODAE expe

CORIOLIS data centre, already one of the two global data centres for ARGO, is the data centre for 5Prcd projects like Gyroscope and MFSTEP and is an important partner in projects within GMES et 6th PRCD calls like Mersea.

The CORIOLIS project implementation by the French agencies in charge of oceanography, will contribute to the ocean observing system, providing world coverage of the oceans in real time. CORIOLIS a multi-disciplinary pilot project is involved in new autonomous instruments development with up-to-date transmission capability, in float deployment in the Atlantic Ocean then world and in data collection, processing and distribution to users (public authorities, scientific community, industry sector,). It aims to be sustained when the world programs, to which it refer to, will have drawn their assessment for the coming years. One will then witness an evolution similar to the one observed in meteorology field twenty years ago: the deep-sea oceanography will go from science to operational for the benefit of the world population on a sustainable base. Nevertheless it will then be necessary to assume the recurring cost of such a program



Comité

Biogéochimie marine

Président : Nick Fisher

SEDIMENTARY ORGANIC MATTER LABILITY ALONG THE RIVER – SHELF TRANSITION ZONE IN A SEMI-ENCLOSED BAY (MALIAKOS BAY, AEGEAN SEA, GREECE).

Akoumianaki I. [1] * and Nikolaidou A. [2]

[1] University of Crete, Biology Department, Voutes, Iraklion, Crete, Greece - * akoum@edu.biology.uoc.gr
[2] University of Athens, Biology Department, Panepistimiopolis, Athens, Greece - anikol@uoa.gr

Abstract

Sedimentary organic matter lability was estimated along a river-shelf transition zone by measuring the concentrations of biolymeric compounds (proteins, carbohydrates, lipids) in a semi-enclosed bay in Eastern Mediterranean. Samples were taken in three stations, River, River Mouth and Shelf, in Winter 2000 and 2001. Biopolymeric concentrations displayed a seaward increase. Contribution of Labile Carbon to Total Organic Carbon ranged from about 15% (River) to about 35 % (River Mouth, Shelf). These results indicate the presence of a benthic trophic gradient along the transition zone with a seaward increase in nutritional quality of sedimenaty OM.

Keywords: biopolymers, lability, river-shelf transition zone

The sum of proteins (PRT), carbohydrates (CBH) and lipids (LIP), referred as biopolymers, is used as a measure of the amount of food potentially available for heterotrophic metabolism [1]. The contribution of Labile Carbon (LC) to Total Organic Carbon (TOC) was assessed along a transect in the mixing zone between Sperheios River and Maliakos Bay (Aegean Sea, Greece) in relation to the quality of suspended organic material (OM) in the water column. Samples were taken in three stations, River, River Mouth and Shelf, 1 mile apart, at 2.5, 4 and 22 m depth, respectively, in winter 2000 and 2001. Sediment samples were taken by Ponar grab, water column samples by Limnos bottles and salinity profiles by Aandera CTD. Biopolymer and sedimentary chloroplastic pigment concentrations were measured and converted to carbon equivalents as in [2] and [3] and to carbon content in the top 6 cm of sediment (g/m^2) assuming specific density of 2.6 g/cm^3.

LC content displays considerable spatial differences along the mixing zone, with definite seaward increase (Fig. 1), which coincides with an increase in silt-clay % from River (< 30%) to Shelf (>90%). Carbohydrate to Protein concentrations ratio, a measure of the relative contributions of phytodetrital and living material, ranged from 0.88 – 096 in River to less than 0.56 in River Mouth and Shelf stations. Contribution of sedimentary Chlorophyll *a* Carbon equivalent to LC was less than 10% with a peak in River Mouth in both sampling periods. Suspended Particulate Organic Material (SPOM) and Chloroplastic Pigment Equivalent (CPE) in water column did not exhibit consistent spatial trends (Fig. 2), with higher OM inputs in River in Winter 2000 and low phytodetrital inputs along the transition zone in Winter 2001. The temporal differences in CPE levels may be attributed to the fact that sampling in winter 2000 coincided with the phytoplankton bloom in the area. With respect to salinity, River station represents a fresh water environment whereas River Mouth and Shelf are virtually marine.

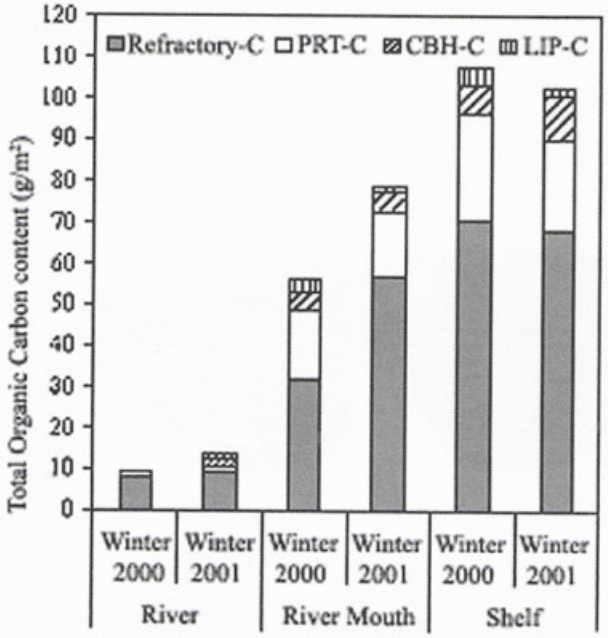


Fig. 1. Sedimentary Labile Carbon distribution to Total Organic Carbon.

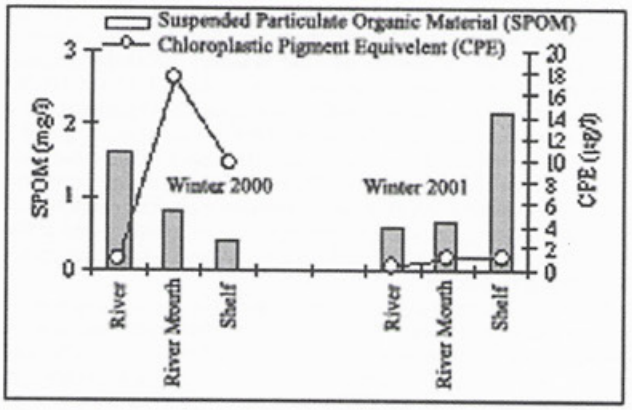


Fig. 2. Suspended Particulate Organic Material and Chloroplastic Pigment Equivalent along the river-shelf transition zone.

The results of the present study indicate that River sediments are mainly dominated by refractory material. River station corresponds to a high energy environment that does not allow the settling and accumulation of riverine OM while autochthonous primary production is negligible during winter. In contrast, water mixing in the estuaries and low hydrodynamic regime in Maliakos Bay favour the sedimentation of fine suspended material and the accumulation of OM in the sediments of the River Mouth and the Shelf stations. Although, primary OM production in water column is relatively high, especially during the bloom period, the low CBH:PRT ratio provides evidence that the labile fraction of sedimentary OM along the transect is mainly composed of living material or freshly derived detritus rather than old phytodetrital material. Provided that sedimentary chlorophyll *a* contributes a small amount to bioplymeric fraction it is assumed that the high percentage of proteins corresponds to heterotrophic microbial populations that take advantage of the high OM inputs in the topsets and the delta front. Concluding, there is a trophic gradient along the river – shelf transition zone in Maliakos Bay with low nutritional quality OM in the riverine end and high nutritional quality OM in the marine end. The consistency of this gradient during winter, despite temporal variation in the occurrence of phytoplankton bloom in the area, indicate that benthic processes are not solely coupled to water column productivity.

References

1 - Danovaro R. and Fabiano M., 1995. Seasonal and inter-annual variation of bacteria in a seagrass bed of the Mediterranean Sea: relationship with labile organic compounds and other environmental factors. *Aquat. Microb. Ecol.*, 9:17-26.

2 - Puscedu A., Sara G., Armeni M., Fabiano M. and Mazzola A., 1999. Seasonal and spatial changes in the sediment organic matter of a semi-enclosed marine system (W-Mediterranean Sea). *Hydrobiologia*, 397: 56-70.

3 - Akoumianaki I., 2003. Effects of riverine inputs to the benthic communities of a semi-enclosed bay (Maliakos Bay, Aegean Sea). PhD Dissertation, 300 p. University of Crete, (in Greek).

TRANSPORT OF PHOSPHORUS AND SUSPENDED MATTER ALONG THE COASTAL WATERS OF ALEXANDRIA (SE MEDITERRANEAN SEA)

Kh. A. Alam El-Din [1], M.A.R. Abdel-Moati [1] * and E. E. El-Hogaraty [2]

[1] Department of Oceanography, Faculty of Science, University of Alexandria, Moharem Bey 21511, Alexandria, Egypt
alam_eldin@lycos.com , * marabdelmoati@yahoo.com

[2] Arab Academy for Science and Technology, Alexandria, Egypt - eslamocean@yahoo.com

Abstract

A hydrodynamic and water quality model were applied to a coastal bay east of Alexandria City in the southeastern sector of the Mediterranean Sea subjected to industrial, agricultural and sewage water discharge, to determine the transport and dispersion of phosphorus and total suspended matter within the bay. The numerical simulation for the dispersion of phosphorus discharged into the bay, mainly in the particulate form, exerted a major effect on the marine environment as indicated by phytoplankton blooms in the area.

Keywords: Water quality model, phosphorus, suspended matter, Alexandria coast

Abu-Qir Bay, lying east of Alexandria City, is considered one of the hot spots in the southeastern Mediterranean Sea. The Bay is mostly affected by different sources of land drainage; industrial polluted water of El-Tabia outfall which receives daily about 1.5-2.0 x 10^9 m^3 of untreated sewage and industrial wastes, agricultural polluted water from Lake Edku discharged through El-Maadiya outlet at a rate of 3.3 x 10^6 m^3/day and fresh water from Rosetta branch of the River Nile (about 3.76 x 10^9 m^3/y). About 22 different factories mainly food processing and canning, paper industry, fertilizer industry, textile manufacturing and gas exhausting are located in the surrounding area of the Bay. These factories dump their wastes to the bay mainly through El-Tabia Pumping Station.

In view of the rapid increase in the population and development of Mediterranean cities like Alexandria, and consequent increase in industrialization, and accumulation of contaminants derived from terrestrial, industrial and domestic disposals to the coastal waters, the objective of the present work is to study the water circulation in Abu-Qir Bay and its effect on phosphorus (a limiting nutrient along the southern Mediterranean) and suspended matter transport using numerical modeling. By developing a hydro-dynamical model (POM) together with a water quality model (EIA), the study will discuss and explain both the water circulation and phosphorus transport to find out a predictable distribution which can be used in understanding the fate and impact of phosphorus on the marine biota and human life.

The water circulation in the Abu-Qir Bay is dynamic and is controlled by two factors: the velocity and frequency of the prevailing wind and the amount of drainage water discharged into the Bay. Five scenarios are proposed in Abu-Qir Bay. The **first** occur during summer when the drainage water discharged into the Lake increases and a weak Northerly or Northwesterly wind prevails. In this case, the spreading of large amount of lake water discharged into the Bay was limited by the weak prevailing wind. The **second** scenario occurs when a strong Northerly or Northwesterly wind prevails and small quantity of drainage water is discharged into the Lake. In this case the accumulated water in the southern part of the Bay penetrates into the Lake. The **third** scenario occurs when a strong Northerly or Northwesterly wind is acting on the Bay and large amount of drainage water reaches the Lake. In this case, the water accumulates from the Lake and the Bay at El-Maadia outlet, raising the sea level. The salinity gradient between the Lake and the Bay in this case is very high. The **fourth** scenario occurs under the influence of the Westerly wind where the surface water is directed to the east and turned with the coastline to the northeast direction to escape from the northeastern edge of the Bay causing an accumulation in the eastern part of the Bay. The **fifth** scenario appears when the Easterly wind pushed the fresh water coming from Rosetta mouth to spread in the Bay especially if there is a Northerly component.

According to their importance and availability of credited data, Total Suspended Matter (TSM) and Phosphorus (PTOT) data were used since a main part of this limiting nutrient is discharged to the bay through the particulate form rendering it non-bioavailable. Data and measurements had been taken in front of the main sources of land runoff. From numerical simulation, PTOT and TSM had two privileged flowing directions during **Winter**. The first is parallel to the coast along the northeastern region of the Bay while the most important direction was flowing south to the western edge of the central part of the Bay, which seems to be more often affected. Total Phosphorus (PTOT) was significantly distributed in the eastern coast of the Bay near Rosetta Mouth due to the maximum discharge of phosphorus from the River Nile during winter (11,371 kg/d) as well as the accumulation of PTOT at the western part near TPS (915 kg/d) and Lake Edku (300 kg/d) approaching the offshore area (Figure 1). The PTOT load derived from Rosetta Mouth is directed westwards covering most of the eastern part of the Bay. The flow extends seaward exceeding the open sea boundary. In the coastal zone, particularly in the area adjacent to the main outlets, PTOT levels reached maximum values causing high phytoplankton bloom as indicated from the elevated Chlorophyll a content of the surface water.

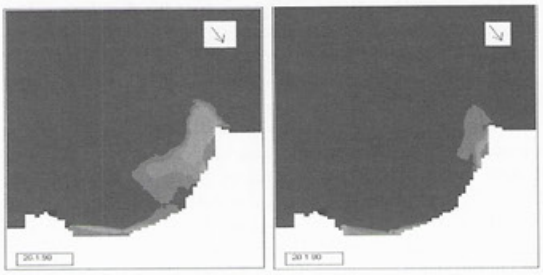


Fig. 1. PTOT and TSM in Abu-Qir bay during winter.

Generally, TPS and Lake Edku are considered the main sources affecting the distribution of PTOT and TSM among the Bay during **Spring** and **Autumn**, where the discharge of Rosetta Mouth is decreasing to its minimum levels. During spring, and under the effect of northeast winds, the targeted variables are piled at the area located between TPS and Lake Edku. High concentrations of TSM were recorded at the immediate vicinity of Lake Edku and TPS causing high turbidity in the water column, which is considered to contain high oxygen consuming material since most of the discharge from TPS is formed of cellulose derived from the paper industrial complex. Such oxygen demanding wastes will severely affect the marine biota in the Bay, creating unsuitable conditions for biological life, especially in front of these sources.

Under the influence of the north and northeasterly winds prevailing during **Summer**, PTOT and TSM derived with brackish water, were directed eastward. The area lying southwest of Abu-Qir Bay sustained high concentrations due to the maximum discharge from TPS during this season (Fig. 2).

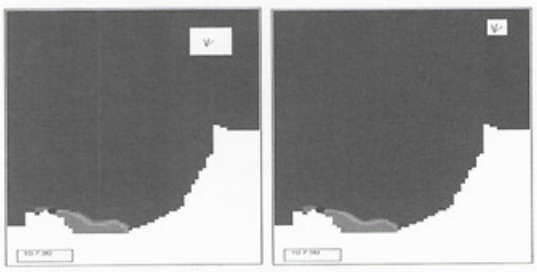


Fig. 2. PTOT and TSM in Abu Qir bay during summer.

Generally, PTOT normally peaked following the peak of sewage discharge. Although the increase of phosphorus is important for increasing plankton biomass and productivity, negative consequences ex: eutrophication sometimes take place in the bay.

PLUTONIUM AND POLONIUM CONCENTRATION LEVELS IN MUSSELS FROM THE SPANISH COAST

M.P. Antón [1] *, C. Gascó [1], J.M. Benedicto [2]

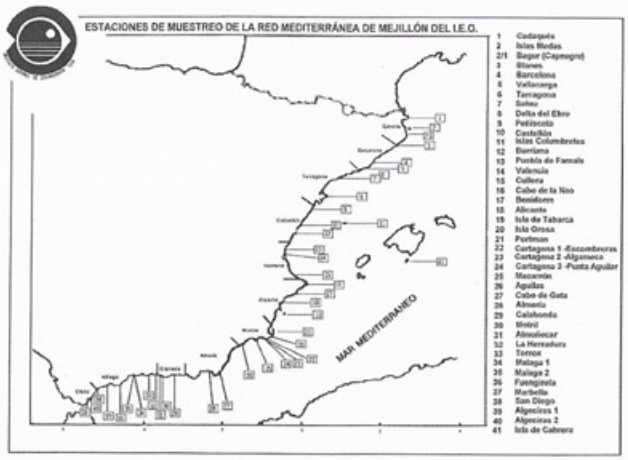
[1] CIEMAT. Avda Complutense 22, 28040 Madrid. Spain.
[2] IEO. C/ Varadero 1. San Pedro del Pinatar. 30740 Murcia. Spain.

Within the frame of the Mediterranean Mussel Watch Program some wild mussels Mytilus galloprovincialis samples were collected by the Instituto Español de Oceanografía, IEO in the late spring of 2002 in several locations of the Spanish Mediterranean coast. At CIEMAT laboratories these samples were pretreated and analyzed to measure the $^{239+240}$Pu, 210Po and ^{137}Cs content. Polonium values ranged from 48±2 to 60±2 Bq/kg. Plutonium concentrations were around 10 mBq/kg. Cesium concentrations were below the detection limit. Concentration activities obtained in samples taken from mussels farms located in Galicia (northwestern Spain) are also presented.

Keywords: mussels, Spanish Mediterranean coast, plutonium, polonium

The large capacity of mussels to accumulate pollutants has favoured their use as bioindicators of the contamination of the surrounding ecosystem, avoiding the analysis of other matrices which require more sophisticated and expensive techniques (water/sediments). Mussels are considered appropriate bioindicators due to their sedentary, filter-feeding habit, common abundance and ease of collection. Since 1991, biomonitoring of the Iberian Mediterranean coast has been performed by the Group "Studies on Marine Contamination" from the IEO located in Murcia. This Group examines the quality of surface coastal waters in 40 different stations, analysing heavy metals (mercury, cadmium, lead, zinc and copper) and organic compounds like PCBs, DDTs, HCB, etc. [1,2].

In 2002, CIEMAT got involved in the Mediterranean Mussel Watch Program, sponsored by CIESM, with the aim of determining the radionuclides content in *Mytilus galloprovincialis* from selected Mediterranean locations, namely Delta del Ebro (fishing region/marine farms), Cullera (medium populated area, 10000-100000 inhabitants) and Algeciras-Guadarranque (heavily populated zone, >100000 people/ industrilized area) [Fig. 1].



Mussel samples (about 200 units per station) were kindly taken by IEO between mid-May and mid-June 2002. Following collection, samples were cleaned with seawater, appropriately packaged and fast-mailed to CIEMAT laboratories, where they were measured, weighed (fresh weight), freeze-dried and weighed again (dry weight).

Polonium was analysed in 5 grams aliquots digested with concentrated HNO_3 and H_2O_2 . The internal tracer ^{209}Po was added to the solution so obtained, then it was evaporated to near dryness. The residue was dissolved with concentrated HCl and evaporated again. The residue was treated with concentrated HCl; hydroxylamine hydrochoride, bismuth and sodium citrate were also added. The samples were then filtered through a paper filter and the residue was rinsed with distilled water until reaching the appropriate volume for the autodeposition of polonium following Flynn´s method. Quantification was done by alpha-spectrometry.

For cesium measurements, the mussels flesh was ashed at 450ºC for 12 hours. Gamma determinations were performed with a hyperpure N-type germanium detector.

Plutonium analyses were carried out in stations Delta del Ebro and Algeciras in about 6 grams subsamples following calcination at 450ºC. Galicia sample was ashed at 550ºC; sample size was 2 grams. Briefly, the ashes were digested with hot HNO_3 8N (3x) and then filtered through a 0.45 µm glass fiber filter. Following the attacks, ^{242}Pu was added as an internal tracer to calculate chemical recoveries. Plutonium was purified using two ionic resins, namely AG 1x8 (20-50 mesh) to eliminate with HCl 10N most of the natural radionuclides such as thorium and uranium and AG 1x8 (50-100 mesh) to remove Th and U traces. Plutonium was eluted from the column with NH_4I/HCl, then electroplated following Talvitie´s method onto stainless steel discs. At last, it was quantified by alpha-spectrometry using PIPS detectors.

The results obtained are displayed in Table 1. As it can be observed, in the Mediterranean stations polonium values vary from 48±2 to 60±2 Bq/kg. The two studied stations present similar average values. Plutonium values were identical in both stations, namely 10±2.4 and 11±3.1 mBq/kg. Cesium values were below the detection limit, since the amounts of sample available for gamma measurements were not big enough.

STATION	DELTA DEL EBRO	CULLERA**	ALGECIRAS	GALICIA
Temperature (ºC)	17.5	----	16.8	----
Salinity (‰)	37.1	----	37.2	----
Average size mm ± SD	43±5	----	37±6	81±8
Condition Index*	13.7	----	9.4	20.8
Weight ratios	Ww/Dw=6.6 Dw/Aw=4.4	----	Ww/Dw=6.9 Dw/Aw=4.2	Ww/Dw=7.1 Dw/Aw=5.6
$^{239+240}$Pu mBq/kg±1s D.w.	11±3.1	----	10±2.4	58.9±9.2
^{210}Po Bq/kg±1s D.w.	49.40±1.81 59.97±2.37 53.04±2.12	----	57.71±2.24 48.40±2.00 ----	48.7±1.8 53.5±2.0 40.4±1.5
mean	**54.14±1.2**		**53.1±1.5**	**47.5±1.0**
^{137}Cs Bq/kg±1s	<0.21	----	<0.99	---

*Cl=(Mussel flesh wet weight/mussel shell wet weight)x100
Ww: Wet weight; Dw: Dry weight (freeze-dried); Aw: Ashed weight
**sample lost due to technical problems within Ciemat electrical system

Mussel samples from Galicia present Po values similar to those obtained in the Mediterranean stations. However, Pu results are close to 6 times higher.

References

1 - Rodríguez C., Guerrero J., Benedicto J.M. y Jornet A., 1995. Spatial distribution of heavy metals in Mediterranean mussel *Mytilus galloprovincialis* from Spanish Mediterranean coast. *Rapp. Comm. Int. Mer Médit.*, 34 : 145. ISSN 0373-434X.

2 - Benedicto J.M., Rodríguez C., Guerrero J., Jornet A. Y Gómis C., 1999. Niveles de metales traza en Reservas marinas y zonas de interés ecológico de la costa mediterránea peninsular, utilizando mejillón como bioindicador. Actas de la Jordanas Internacionales sobre Reservas marinas, pp. 283-291. Ministerio de Agricultura, Pesca y Alimentación. Secretaría General de Pesca Marítima. ISBN 84-491-0492-0.

ANTHROPOGENIC RADIONUCLIDES IN SURFACE SEDIMENTS OF THE TOULON-BAY AREA (FRENCH MEDITERRANEAN COAST).

Mireille Arnaud [1]*, Sabine Charmasson, Hervé Thebault, Frédérique Eyrolle, Evelyne Barker

[1]Institut de Radioprotection et de Sûreté Nucléaire, Base Ifremer, BP 330, 83 507 La Seyne sur mer, France - * mireille.arnaud@ifremer.fr

Abstract

In the frame of an integrated coastal area and river basin approach, an environmental assessment was carried out in the Toulon Bay area as defined by the Regional Water Master Plan. Part of this assessment concerns anthropogenic radionuclides within the sediment compartment. In surface sediments, ^{137}Cs is the only artificial radionuclide which was regularly detected by gamma spectrometry. ^{137}Cs and silts fraction (4-63 µm) are closely correlated, revealing that ^{137}Cs arise mainly from a diffusive source (i.e. atmospheric inputs).

Keywords: Surface sediment, radionuclides, Mediterranean sea, Toulon Bay contract

Introduction

In the Toulon area, a Regional Research Contract (Toulon Bay Contract) concerning Toulon harbor and its catchment basin was initiated in 1998 [1]. The main objective was to assess a balanced water resource management and to propose an integrated coastal management.

Since 1984, the site harbor has been sheltering six French Navy nuclear-powered submarines. The arrival of the *Charles de Gaulle,* a new nuclear-powered aircraft carrier, led us to carry out a study of anthropogenic radionuclide contents in surface sediments of this area.

Materials and methods

The study area

The area includes the harbor and the surrounding coastal area between the longitudes 5° 52.586 E and 6° 01.282 E, as defined in the Water Master Plan instituted by the French Water Act (1992). It represents a coastline of about 70 km for a marine water surface area of about 60 km^2 and a catchment area of 340 km^2 .

Sampling and analytical methods

51 stations regularly distributed on the study area were sampled in April 2000 (Fig. 1). Within this area 50 sediment samplings were realized in September 1997 in the Eastern part of the Bay which is affected by the releases of the Toulon sewage outfall (Fig. 2). Thus this last area represents a zoom within the area studied in 2000.

Samples were collected with grab corers (Shipeck and Orange Peel) and Eckman box corer depending on station depths. They were dried (80 °C) and measured by gamma spectrometry (N type hyper-pure Ge detector). Particle-size was measured using a Coulter LS 230 laser diffraction granulometer.

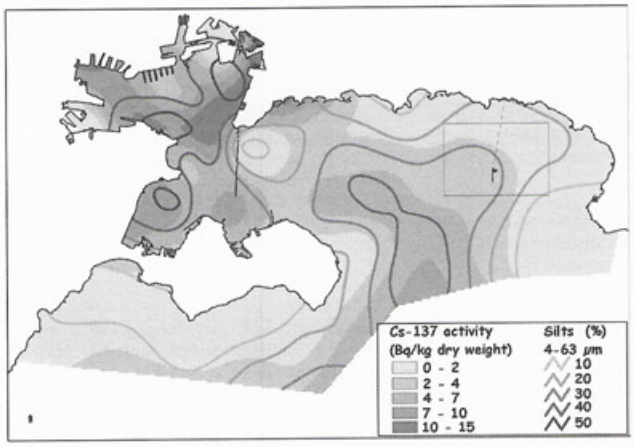


Fig. 1. Distribution of ^{137}Cs and silt fraction in surface sediments of the Toulon Bay obtained by numerical interpolation (Spline method, Arcview®).

Results and conclusions

^{137}Cs was the only artificial radionuclide systematically detected in the sediment samples. Indeed, due to is relatively long half life (30 years), it is the only radionuclide arising from atmospheric deposits (bomb fallout and Chernobyl) still detected by gamma spectrometry.

In 2000, ^{137}Cs levels in Toulon area atmosphere do not exceed 1µBq.m^{-3}. ^{137}Cs levels in sediment range between 0.28 (± 0.09) and 12.20 (± 0.90) Bq.kg^{-1} dry weight. In the literature it is generally reported that ^{137}Cs demonstrate high affinity for clay minerals [2], [3]. Indeed, spatial distributions obtained by numerical interpolation

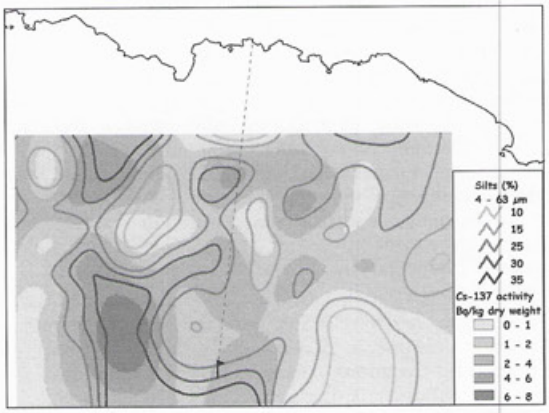


Fig. 2. Distribution of ^{137}Cs and silt fraction in surface sediments around the Toulon-East sewage outfall (———-),obtained by numerical interpolation (Spline method, Arcview ®)

methods (Figs. 1 and 2) highlight the positive correlation between ^{137}Cs contents and silt fractions (4-63 µm) and the negative correlation to raw sands (200-2000µm). The harbor area which is characterized by fine-grained sediments due to the low dynamic in the current conditions has the highest ^{137}Cs contents in relation to the high specific surface area of the smallest particles.

The scale of observation is of peculiar interest. As a matter of fact, in 2000 stations surrounding Toulon-East sewage outfall, exhibited relatively low ^{137}Cs concentrations (1,2 to 2,8 Bq.kg^{-1} dry weight) and silts fractions (20,1 to 32,7%). In 1997 a higher range of variation in both ^{137}Cs levels and silt contents were found in an area included between these stations (respectively 0,68 to 7,7 Bq.kg^{1} dry weight and 9,7 to 62,6%). If repeated this kind of study, should allow to resolve the fractal dimension of the distribution of these parameters in this area.

^{137}Cs levels found in the study area at both periods (1997 and 2000) are within the range reported for Mediterranean Sea coastal sediment only affected by atmospheric fallout i.e. 2 to 20 Bq.kg^{-1} dry weight [4], [5]. Radionuclides such as cobalt, silver, manganese were not detected demonstrating the lack of contamination by nuclear releases in that area

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References

1 - Henocque Y., 1999. Urban communities and environmental management in France : the Toulon Bay Contract example. International Workshop on Coastal Cities. China, Handgzhou, 27-30 septembre 1999, 10 p.

2 - Ancellin J., Guéguéniat P. et Germain P., 1979. Radioécologie marine. Etude du devenir des radionucléides rejetés en milieu marin et applications à la radioprotection. Ed. Eyrolles, Paris, 256 p.

3 - IAEA, 1985. Sediment Kds and concentration factors for radionuclides in the marine environment. Tech. Rep. Series n°247, Aiea, Vienne, 73 p.

4 - Delfanti R., Frignani M., Langone L., Papucci C. et Ravaioli M., 1997. Accumulation of radiocaesium in fine recent sediments of the northern Adriatic Sea. *Radioprotection*, vol. 32, C2: 251-256.

5 - Albrecht A. et Beer J., 1997. Assessment of radionuclide distribution in continental shelf sediments (Gulf of Taranto, Mediterranean Sea). *Radioprotection*, vol. 32, C2: 277-285.

DEEP MICROBIAL REMINERALIZATION IN THE ROSS SEA: EVIDENCE FOR POC SOURCE AS MAIN ORGANIC FUEL OF BIOLOGICAL PUMP.

Azzaro M.*, La Ferla R.

IAMC-CNR, section of Istituto Sperimentale Talassografico, Messina, Italy - *dedalus@ist.me.cnr.it

Abstract

Carbon dioxide production rates (CDPR) of micro-organisms were monitored through their electron transport system (ETS) activity in the deep Ross Sea. The depth-integrated CDPR amounted to 28,2 mg C $m^{-2}d^{-1}$ in the depth range 100-1000 m. Comparing CDPR determined in this study with that obtained by sediment traps in the Ross Sea resulted that about 63% of organic carbon remineralized by respiration derived from POC pool. Such evidence highlighted POC source as main organic fuel of biological pump in the Ross Sea.

Key-words: Ross Sea, Microplankton, Respiration

Introduction

Recent studies have demonstrated that dissolved organic carbon (DOC) is an important component of the biological pump that assumed in the deep waters a key role as main organic fuel of microbial respiration (1, 2). Such evidence seem overturned in the Southern Ocean, where Wiiebinga and De Baar (3), by estimates of apparent oxygen utilization and DOC, asserted that DOC pool accounted for < 10 % of the remineralization in deep waters. Another study demonstrated (4) that the euphotic zone of the Ross Sea yielded only a small portion of primary production as DOC (11%), so that DOC removal by deep convection could be not an important export term due to the small quantity of DOC that accumulates there. Furthermore other authors (5) also by sedimet trap studies suggested, that very little organic remineralization occurred between 250m and the bottom in the Ross Sea, which implies a rapid delivery and/or reduced bacterial remineralization.

The purpose of this study was to investigate the supply and utilization of organic carbon in the aphotic zone of Ross Sea by evaluation of microplankton respiratory activity and to compare the vertical carbon balance to different estimates of export production from the same area and other oceanic regions.

Material and methods

The oceanographic cruise, in the context of the BIOSESO II project, was carried out from 5 January to 27 February 2001, on board the R/V Italica (Fig. 1). Microbial respiratory activity (<200µm) was determined according to the ETS (Electron Transport System) assay and converted to carbon dioxide production rates (CDPR) using the factors described in Christensen *et al.* (1).

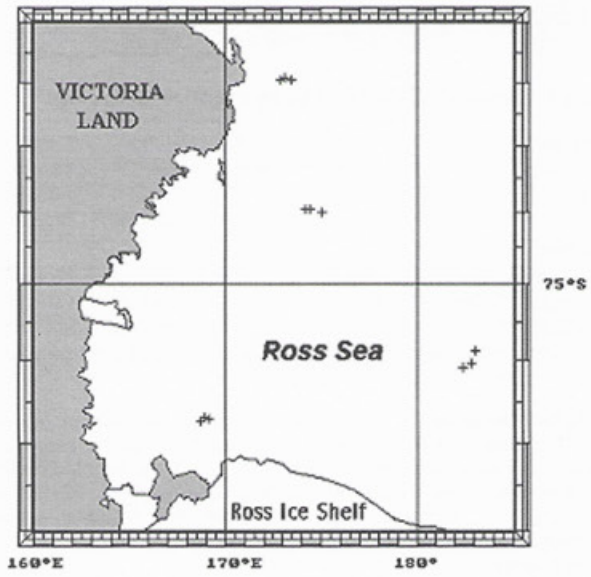

Fig. 1. Map of sampling locations.

Results and discussion

The ETS data points versus depth are shown in figure 2 together with the curves computed for Ross Sea and oceans. Microplankton ETS activity ranged from 0.012 to 0.139 µl O_2 $m^{-3}h^{-1}$ on a volume basis in the layer between 100 and 1000m.

ETS-based CDPR calculated in the Ross Sea, decreased with depth according to the power function:

$$CDPR\ (mg\ C\ m^{-3}d^{-1}) = 0.7207\ z^{-0.517},$$

where z is in meters, r^2=0.351 and n=73. The depth-integrated CDPR calculated by the above power function, amounted to 28,2 mg C $m^{-2}d^{-1}$ in the depth range 100-1000 m. Our CDPR later summer estimates were enclose in the range of ETS-derived $CDPR_{(200\text{-}1000m)}$ (21.8-105.6 mg C $m^{-2}d^{-1}$) determined in the Indian sector of Southern Ocean during early spring (6), but was 2,5 fold lower of their averaged CDPR.

In figure 2 the curve illustrating the above calculated function, is compared to those determined in the oceans (1). CDPR calculated in the Ross Sea were 3 and 7 fold lower than in the Atlantic and Pacific Oceans, respectively.

Finally comparing CDPR determined in this study with that obtained by sediment traps in the Ross Sea (5) resulted that about 63% of organic carbon remineralized by respiration derived from POC pool. Such enough large percentage should be too higher observing that daily sediment trap study was derived from an annual research while CDPR study regarded two months and neglected the remaining more poor months of year.

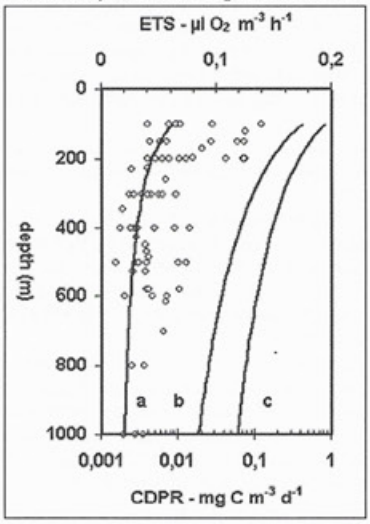

Fig. 2. ETS versus depth and comparison for the best-fit functions representing the depth dependence of CDPR in the Ross Sea (a), Atlantic Ocean (b) and Pacific Ocean (c).

Future studies on remineralization and the fate of organic matter of Ross Sea must primarly asses the amount of POC and DOC exported and oxidized in the deep sea and furthermore highlight the relationship between the very low flux of carbon through the DOC pool in the euphotic zone and the very high percentage of POC pool oxidized in the aphotic zone as registered in this study.

References

1- Christensen J.P., Packard T.T., Dortch F.Q., Minas H.J., Gascard J.C., Richez C., and Garfield P.C., 1989. Carbon oxidation in the deep Mediterranean sea: evidence for dissolved organic carbon source. *Global Biogeochemical Cycles*, 3: 315-335.

2- Lefèvre D., Denis M., Lambert C.E., and Miquel J.C., 1996. Is DOC the main source of organic matter remineralization in the ocean water column? *Journal Marine Systems*, 7: 281-291.

3- Wiebinga C.J., and de Baar H.J.W., 1998. Determination of the distribution of dissolved organic carbon in the Indian sector of the Southern Ocean. *Marine Chemistry*, 61: 185-201.

4- Carlson C.A., Hansell D.A., Peltezer E.T., and Smith W.O.Jr., 2000. Stocks and dynamics of dissolved and particulate organic matter in the Southern Ross Sea, Antartica. *Deep Sea Research II*, 47: 3201-3226.

5- Nelson D.M. DeMaster D.J., Dunbar R.B., and Smith W.O.Jr., 1996. Cycling of organic carbon and biogenic silica in the Southern Ocean: estimates of large-scale water column and sedimentary fluxes in the Ross Sea. *Journal Geophysical Research*, 101: 18519-18532.

6- Arìstegui J., Denis M., Almunia J., and Montero M.F., 2002. Water-column remineralization in the Indian sector of the Southern Ocean during early spring *Deep Sea Research II*, 49: 1707-1720.

RADIONUCLIDES IN MUSSELS FROM THE EASTERN ADRIATIC COAST, CROATIA – A CASE STUDY OF THE MEDITERRANEAN MUSSELWATCH PROGRAM

Delko Barišić [1]* and Goran Kniewald [2]

[1] * Laboratory for Radioecology, Center for Marine and Environmental Research, Rudjer Bošković Institute, Zagreb, Croatia - * dbarisic@rudjer.irb.hr

[2] Laboratory for Physical Trace Chemistry, Center for Marine and Environmental Research, Rudjer Bošković Institute, Zagreb, Croatia

Abstract

This communication reports first data from the monitoring of radionuclides in the mussel *Mytilus galloprovincialis* from croatian coastal waters, within the scope of the Mediterranean Mussel Watch program. Data from 2 sampling stations are given, from the Šibenik harbour in the Krka river estuary and from Kaštela bay near the city of Split, where elevated radionuclide activities were expected and found.

Keywords: Mediterranean Mussel Watch, radionuclides, Adriatic Sea

Introduction

In 2002 the Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée (CIESM) launched a program called the *Mediterranean Mussel Watch* (MMW), thereby designing a regional program for detecting radionuclides and trace contaminants in "sentinel" organisms (1).

Considering the growing public concern as well as the institutional enforcement over marine environmental quality, the main objective of the MMW is to identify spatial and temporal trends through long-term monitoring at the regional scale. The first phase of the project requires the identification of existing baseline levels of certain key radionuclides in Mediterranean coastal waters, measured by the total body burden of filetr feeder mollusks, preferably Mytilidae. A comprehensive technical scheme was formulated which focuses on monitoring strategy (indicator species, sampling sites, sampling frequencies, selection of calibrated individual organisms), sampling and treatment of samples, trace level radionuclide measurement, data management and reporting.

The chosen bio-indicator species is the mussel *Mytilus galloprovincialis*, with a geographic distribution recorded on all coasts of the Mediterranean basin.

The MMW has started with a limited number of sampling sites in each country. Existing information (and sources thereof) on previous investigation related to the monitoring of bivalves, other marine organisms and recent sediments on the eastern Adriatic Coast, Croatia, have been reported as background information to the project implementing agency – CIESM (2, 3).

Studies of radionuclides in marine bivalves from croatian waters have been comparatively few, and little data has been published in scientific literature. Some recent investigations, dealing with the distribution of radionuclides between mussels and associated sediments showed the following activities for some radionuclides in mussel tissue (wet weight) collected from several sites on Adriatic coast including the location where fly and bottom ash (residual after coal burning) was deposited: ^{40}K = 94-105 Bq/kg, ^{232}Th = 0.9-2.3 Bq/kg, ^{137}Cs = bdl - 1.2 Bq/kg, ^{238}U = 3-20 Bq/kg (unpublished internal data of Laboratory for radioecology).

Sampling sites



For specific purposes of radionuclide monitoring in the mussel *Mytilus galloprovincialis* on the Croatian coast, two sampling stations were established where the identification of possibly elevated radionuclide concentrations due to specific activities might be expected. Station 1 (Fig. 1) is in the harbour of the city of Šibenik in the Krka river estuary. Station 2 (Fig. 1) is in Kaštela bay, north-east of the city of Split. Samples were taken in April 2003.

Results

Table 1. gives data on mussels and the sampling environment. Radionuclide activities are given in Table 2.

Table 1. a. Data on mussels and the sampling environment (Station 1 – Sibenik with sublocations). b. Data on mussels and the sampling environment (Station 2 – Split with sublocations)

a)

Description/location	Sv. Nikola	Šibenik bri.	Mandalina	Šibenik h.
Fresh sample weight (g)	2134	2662	2760	2035
Shell weight (g)	1057	1202	1331	1015
Fresh sample/shell ratio	**2.022**	**2.215**	**2.074**	**2.005**
Tissue and water (g)	745	828	1085	606
Lost sea-water (g)	332	632	244	414
Weight before drying (g)	701.3	788.3	1025.4	566.6
Dry weight (g)	188.0	94.8	206.5	61.6
Concentration factor	**3.730**	**8.315**	**4.967**	**9.198**
Salinity (o/oo)	29	26	19	18
Water temp.(°C)	13.4	13.0	13.6	13.1
Coastal zone	Limestone	Limestone	Limestone	Limestone

b)

Description	Vranjic	Adriavinil	Marina	Stobre_
Fresh sample weight (g)	3384	3453	4759	Not sampled
Shell weight (g)	1520	1544	1709	
Fresh sample/shell ratio	**2.2263**	**2.2364**	**2.7847**	
Tissue and water (g)	1062	742	1287	
Lost sea-water (g)	802	1165	1763	
Weight before drying (g)	1014.8	690.7	1235.6	
Dry weight (g)	141.1	97.4	220.0	
Concentration factor	**7.192**	**7.091**	**5.616**	
Salinity (o/oo)	25	35	39	
Water temp.(°C)	15.7	15.8	13.0	
Coastal zone	Flysch margin	Limestone	Limestone	

Table 2. Radionuclide activity (Bq/kg dry weight) in shells tissue

Location	^{40}K	^{232}Th	^{137}Cs	^{226}Ra	^{238}U
Adriavinil	266.6 ± 12.2	1.27 ± 0.65	0.49 ± 0.19	8.06 ± 0.87	9.68 ± 3.62
Marina	239.5 ± 10.8	1.02 ± 0.55	0	1.48 ± 0.62	5.94 ± 2.85
Vranjic	251.1 ± 11.0	1.51 ± 0.62	0.26 ± 0.17	2.35 ± 0.64	3.67 ± 2.77
Stobreč	Not sampled				
Mandalina	330.1 ± 11.0	1.92 ± 0.6	0	3.84 ± 0.66	7.24 ± 3.06
Sv. Nikola	182.7 ± 8.4	0.63 ± 0.42	0	3.78 ± 0.54	5.33 ± 2.39
Šibenik h.	329.0 ± 15.9	1.11 ± 0.84	0	5.94 ± 1.09	13.39 ± 4.79
Šibenik br.	215.1 ± 10.4	0.85 ± 0.53	0	2.25 ± 0.64	2.65 ± 2.60

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References

1 - CIESM, 2002. Mediterranean Mussel Watch – designing a regional program for detecting radionuclides and trace-contaminants. Briand, F. (ed.) *CIESM Workshop Series No. 15, 136 pages, Monaco.*

2 - Kniewald, G., and Barišić, D., 2002. Investigations related to the monitoring of bivalves and other marine organisms on the Eastern Adriatic Coast (Croatia). *Pp. 77-78. In:* Briand, F. (ed.) *CIESM Workshop Series No. 15, 136 pages, Monaco.*

3 - Barišić, D., Vertačnik, A., Lulić, S., Mihelčić, G., Sondi, I, Juračić, M., Prohić, E. and Crmarić, R., 1998. Natural radionuclides in recent marine sediments of the Adriatic Sea. *Rapp. Comm. int. Mer Médit. 35: 228-229.*

NITROGEN FLUXES IN FISH CAGE FARMINGS AT THE COAST OF WESTERN GREECE

Christos Belias, Manos Dassenakis, Michael Scoullos *

University of Athens, Department of Chemistry, Laboratory of Environmental Chemistry, Panepistimiopolis, 15771 Athens, Greece
* mio-ee-env@ath.forthnet.gr

Abstract

This study focuses on the nitrogen mass balance in a fish farm located near the Acheloos estuary. The nitrogen loss to the environment found to be 75% of the input. The nitrogen releases of dissolved and particulate forms were 51% and 24% respectively. 3% of the later was immediately deposed to the sediments under the cages while the remaining 21% resided in suspended mater recycled through the food chain and involved in more complex bio-geochemical processes. Furthermore a 6% to 45% from the deposited to the sediments nitrogen releases back to the water column, depending on the oxidation conditions.

Key words: Mass balance, nitrogen, aquaculture, Mediterranean, Greece

The purpose of this study was the estimation of how much of the nitrogen supplied with food and juveniles is recovered with the harvested fish and how much is lost to the environment in a typical Mediterranean fish farm of sea bream (*Sparus aurata*) and sea bass (*Dicentrarchus labrax*). Furthermore we wanted to determine the percentage of particulate and dissolved nitrogen distribution in the environmental loss; how much of the particulate form is accumulated in the sediment under the cages and how much remains in suspension or is engaged in biogeochemical outside the immediate vicinity of the cages. Finally, how much of the nitrogen accumulated in the sediments emanates in the dissolved form to the overlying water. To do so we calculated the annual mass balance making the assumption that the external nitrogen input to the farm, from the open Mediterranean Sea and the atmosphere was significantly smaller than the nitrogen originating from the fish farm.

The study took place during 2002 in collaboration with the Aquaculture Center of Acheloos, a research and development company working on aquaculture production in Western Greece under the Supervision of the General Secretariat of Research and Technology, Hellenic Ministry of Development.

Prototype sediment traps were constructed and employed to collect sinking particles under the cages and to measure the sedimentation releases.

A prototype benthic chamber was constructed to study the sediment / water exchange of nitrate, nitrite, ammonium and DON under four oxidation conditions: oxygen depletion (8.00 ppm to 1.55 ppm), hypoxia (1.60 ppm to 2.10 ppm), oxygenation (2.00 ppm to 7.40 ppm) and anoxia (rapid fall to 0.20 ppm).

Ammonium, nitrate, and nitrite were determined in water samples by standard spectrophotometric methods. Total Dissolved Nitrogen (TDN) in water samples was determined following the Valderrama persulfate oxidation method [1].

Dissolved Organic Nitrogen (DON) in water samples was calculated as the difference between TDN and the Total Inorganic Nitrogen (the sum of NO_3^-, NO_2^-, NH_4^+). Samples of fish food, fish and particulate matter were frieze dried and analysed following an effective oxidation method [2].

The nitrogen fluxes were calculated on the basis of data provided by the fish farm and the determination of the average water content in nitrogen and the nitrogen concentration of the various samples (fish food, juveniles, harvest, fish loss and the particulate matter in the sediment traps).

Benthic fluxes of nitrate, nitrite, ammonium and DON, were measured with the benthic chamber using sediment and overlying water from the fish farm. Maximum fluxes for all nitrogen compounds were observed under anoxic conditions. Ammonium fluxes were always the prevailing ones giving rise to significant ammonium concentrations in the overlying water. On the contrary nitrate fluxes were always low. During oxygenation, ammonium concentrations were significantly lower. Under all oxidant conditions the nitrite concentrations were the lowest. A decrease of DON concentration in the overlying water was observed only in hypoxia.

Concerning the nitrogen mass balance, almost the entire nitrogen input to the farm during the 2002 growing season was supplied by fish food (99.8%). The recovery in harvest was 25%. The nitrogen equivalent to fish loss was negligible (0.3%). The environmental loss is considerable amounting to 59 Kg N per tonne (t) of fish produced, corresponding to 75% of the total nitrogen input to the farm. The dissolved nitrogen release amounted to 68% of the environmental loss while the particulate release amounted to 32%. Suspended solids represent 87% of the particulate release (21% of the total nitrogen input to the farm). Direct sedimentation in the immediate vicinity, under the cages represents 3% of the total nitrogen input to the farm or 13% of the particulate release.

No other similar study in the Mediterranean region is known until now. Therefore comparison is made with studies from northern European countries which show that our environmental nitrogen loss is similar to that determined by Hall et al. (67% to 71%) [3], and by Phillips et al. (79%) [4]. It is worth mentioning that the amount of nitrogen per tonne (t) of fish produced found in this study is smaller than that of the above mentioned works (95 to 102Kg N t^{-1}) in [4] and (104Kg N t^{-1}) in [4].

This could be explained partly by the smaller nitrogen concentration of the fish food used in our case and partly by the higher fish growth rate in the Mediterranean Sea due to faster fish life cycle and higher water temperature.

Finally the dissolved nitrogen fraction dominates in the environmental loss representing in the Greek case 68%, which is slightly higher than (61%) reported by Hall *et al.* [3].

References

1 - Valderama J.C., 1981. The simultaneous analysis of total nitrogen and total phosphorus in natural waters. *Mar. Chem.,* 10: 109-122.

2 - Ladakis M., Belias C., Dassenakis M., Scoullos M., Salta F., 2003. An effective oxidation method for the simultaneous determination of nitrogen and phosphorus in marine sediments. 3rd International Conference IMA, 23-27 September 2003 Thesalloniki, Greece, pp. 381-384.

3 - Hall P.O.J., Holby O., Kollberg S. and Samuelsson M.O. 1992. Chemical fluxes and mass balances in a marine fish cage farm. IV.Nitrogen. *Mar. Ecol. Prog. Ser.,*89: 81-91.

4 - Phillips M.J., Beveridge M.C.M., Muir J.F., 1985. Waste output and environmental effects of rainbow trout cage culture. Comm. Meet. Int. Coun. Explor. Sea, C.M.-ICES/F: 21, Maricult. Comm., Sess. W.

TEMPORAL TRENDS OF TRACE METALS IN MUSSEL (*MYTILUS GALLOPROVINCIALIS*) FROM THE IBERIAN COAST (NORTHWESTERN MEDITERRANEAN), 1991-2002.

José Benedicto [1] *, Carmen Rodríguez [2], Concepción Martínez-Gomez [1], Juan Guerrero [1] Y Antonio Jornet [1]

[1] Instituto Español de Oceanografía. Centro Oceanográfico de Murcia. San Pedro del Pinatar. Spain - * benedicto@ieo.mu.es

[2] Centro Oceanográfico de Santander. Promontorio de San Martín s/n. 39004 Santander. Spain.

Abstract

Trace metal (Hg, Cd, Pb, Cu and Zn) trends at Catalonian and Valencian coast from 1991 through 2002 have been identified by the Oceanographic Center of Murcia using *Mytilus galloprovincialis* as bioindicator. The non-parametric Kendal-tau test was used to determine statistically significant correlations between trace metal concentration and year. The most common observation was that no trend was evident, but, when trends were noted, decreases greatly outnumbered increases. Lead, mercury, copper and zinc show significant downward trends in several sites, mainly located on Catalonian coast, while cadmium and copper are the only metals that show an upward trend.

Keywords: Trace metals, mussel watch, monitoring, temporal trends, coastal waters quality.

Introduction

In the last years, the use of marine organisms has become general to evaluate the environmental quality of coastal waters. Ever since Goldberg E. (1) proposed the application of the "Mussel Watch" concept, based on the suitability of mussels as bioindicators of contamination, most of the national (2,3,4) and international monitoring programs of marine pollution have adopted it. In Spain, Mussel Watch is being applied by the Spanish Institute of Oceanography (I.E.O.). The Mediterranean coast is cover by the Center of Murcia (5, 6) and the North-Atlantic coast by the Center of Vigo (7). The main objective of the IEO Mussel Watch Project is to determine the status and long-term trends of chemical contamination along the Spanish coast.

Material and methods

In order to minimise natural variability, sampling was made under standardized conditions, collecting native mussels from the same site and at the same time of the year (May-June, post-spawning period). At each site (Fig. 1), three subsamples of 50 individuals, size 3 to 4 cm, were collected by hand. Preparation of samples has been described elsewhere in detail (5). Measurements were performed by AAS (Perking-Elmer, mod 4.100). Hg was measured by cold vapour atomic absorption. Intercalibration mussel homogenate samples, from QUASIMEME, were used as a control for the analytical methods. The non-parametric Kendal-tau test (8) was used to determine temporal trends.



Fig. 1. Map of the study area with the sampling stations.

Results and discussion

Table I summarizes the increasing (I), decreasing (D) and no trends (NT) of trace metal concentrations in mussels from Catalonian and Valencian coast obtained for each metal, considering two levels of significance $p \leq 0.01$ (**) and $p \leq 0.05$ (*), applying one side test. The most remarkable results are the absence of statistically significant temporal trends (60 cases, 70.59 %) and the predominance of significant decrements (20 cases, 23.53 %), as opposed to the increases (5 cases, 5.88 %). Lead and mercury are decreasing at six sites, most of them located on the Catalonian coast. Zinc is decreasing at five and copper at three. Cadmium is the only metal that presents a significant upward trend. This behaviour pattern in metals has been observed in mussels from the Andalusian coast (6) as well as from the Spanish North-Atlantic coast (7).

Table 1. Increasing (I), Decreasing (D), No Trends (NT). Significant at level 0.01 (**) and 0.05 (*), one side test. Years (Y).

Main location	Specific location	Y	Hg	Cd	Pb	Cu	Zn
Cadaqués	Cucurucu sa Saboya	10	NT	NT	D*	NT	D**
Islas Medas	Pota del Llop Point	10	NT	I*	NT	NT	NT
Blanes	San Francisco Cove	10	NT	NT	D**	NT	D*
Barcelona	Harbour. Jetty	10	D**	I*	D**	NT	NT
Vallcarca	Morisca Cove	10	NT	NT	D*	NT	NT
Tarragona	Harbour. Jetty	10	D*	NT	NT	I*	NT
Salou	De las Animas Point	9	D**	NT	D**	NT	D*
Delta del Ebro	Tortosa Cape	12	D**	NT	NT	D*	D*
Peñíscola	NW Papa Luna C.	9	NT	NT	NT	NT	NT
Castellón	Harbour. Jetty	6	NT	NT	NT	NT	NT
Burriana	Harbour. Jetty	6	D*	NT	D*	D*	D*
Puebla de Farnals	Marina. Breakwater	7	D*	NT	NT	D*	NT
Valencia	Harbour. Jetty	10	NT	NT	NT	NT	NT
Cullera	Pedrera Vieja Point	11	NT	NT	NT	NT	NT
Cabo de la Nao	Ligthouse	10	NT	I*	NT	NT	NT
Alicante	Harbour. Jetty	7	NT	I*	NT	NT	NT
Isla de Tabarca	Buoy	6	NT	NT	NT	NT	NT

Conclusions

Data from Catalonian and Valencian coast show more decreases than increases in trace metal concentrations between 1991 and 2002. At most individual sites there are no strong correlations between concentration and year, but where correlations are found decreases outnumber increases. This tendency for contamination to decrease is occurring at the same time that our society is taking more and more steps to reduce the emissions of this type of contaminants, as much at atmospheric level as at level of industrial and urban water purification.

References

1 - Goldberg, E., 1986. The Mussel Watch Concept. *Environmental Monitoring and Assessment.*, 7: 91-103.

2 - O'Connors, T.P. and Beliaeff, B., 1995. Recent trends in Coastal Environmental Quality: Results from the Mussel Watch Project 1986-1993. National Status and Trends Programme. 40pp.

3 - O'Connors, T.P., 1996. Trends in chemical concentrations in mussels and oysters collected along the U.S. coast from 1986 to 1993. *Marine Environ. Re.s*, 41 (2): 183-200.

4 - RNO., 2000. Travaux du Réseau National d'Observation de la qualité du milieu marin. Tendances temporelles des teneurs en contaminants dans les mollusques du littoral Français. IFREMER, pp. 9-32.

5 - Rodríguez, C., Guerrero, J., Benedicto, J. , 1995. Spatial distribution of heavy metals in the Mediterranean mussel *Mytilus galloprovincialis* from the Spanish Mediterranean coast. *Rapp. Comm. int. Mar. Médit.*, 34: 145.

6 - Benedicto J., Rodríguez, C., Martínez-Gómez, C., 2002. Spatial distribution and temporal trends of heavy metals levels along the Andalusian coast using *Mytilus galloprovincialis* as bioindicator. *Abstracts of the XIth Iberian Seminar of Marine Benthos Study*, 34.

7 - Besada, V., Fumega, J. and Vaamonde, A., 2002. Temporal trends of Cd, Cu, Hg Pb and Zn in *Mytilus galloprovincialis* from the Spanish North-Atlantic coast 1991-1999. *Sci. Total Environ.*, 288: 239-253.

8 - Hollander M. and Wolf, D., 1999. *Non-parametric Statistical Methods*. John Wiley and Sons, Inc.

OPTICAL ABSORPTION OF CHROMOPHORIC DISSOLVED ORGANIC MATTER IN THE ESTUARY OF THE PO RIVER (NORTHERN ADRIATIC, ITALY)

D. Berto, V. Zangrando, F. Savelli, M. Giani *

Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare, Brondolo, 30015 Chioggia, Italy - *m.giani@icram.org

Abstract

Dissolved and particulate organic matter (DOC, POC), chlorophyll and salinity were analysed to evaluate the origin of chromophoric dissolved organic matter (CDOM) in an estuary of the Po. The absorption coefficient (aCDOM) at 280 and 355 nm were not positively correlated with temperature, salinity and DOC. The values of the slope coefficient of the exponential spectral, S, and the absorption coefficients $aCDOM_{280}$ and $aCDOM_{355}$ showed a marine origin of CDOM. To characterise the aCDOM the waters were extracted and the optical properties of extracts resulted comparable to those of the original waters.

Keywords: chromophoric dissolved organic matter, Po river, Northern Adriatic, optical absorption.

Chromophoric dissolved organic matter (CDOM) absorbs light strongly in UV, limiting the penetration of biologically damaging radiation into surface waters. In order to evaluate the variations and the origin of chromophoric dissolved organic matter in the estuary of Po river, analysis of dissolved and particulate organic matter (DOC, POC), chromophoric dissolved organic matter (CDOM), and chlorophyll and salinity were carried out (1). The sampling was performed in surface waters from February to May 2003 along an axis extending from the Po river towards the open sea.

Coastal DOC and POC values ranged from 70 to 263 µmol/L and from 66 to 580 µmol / L, respectively. DOC concentration increased from winter through spring (Fig. 1) mainly as a seasonal response to the increase of the phytoplankton production and thermohaline stratification. The aCDOM at 280 and 355 nm were not positively correlated with temperature and DOC, stressing the fact that the accumulation of DOC from winter to spring was mainly not chromophoric (Fig. 2).

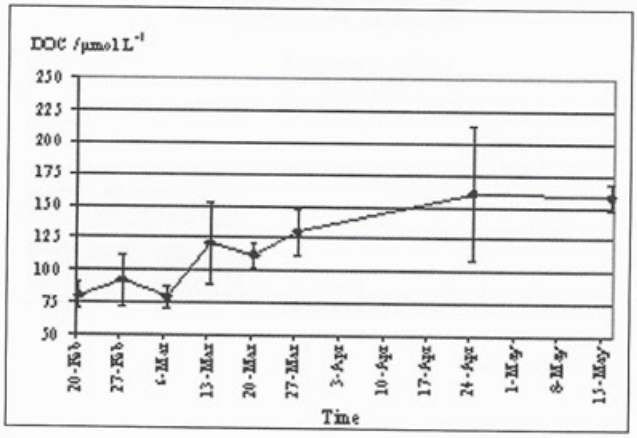

Fig. 1. Temporal variation of mean surface DOC concentration along the axis Po delta-seawards in winter–spring 2003. Error bars represent the standard deviation.

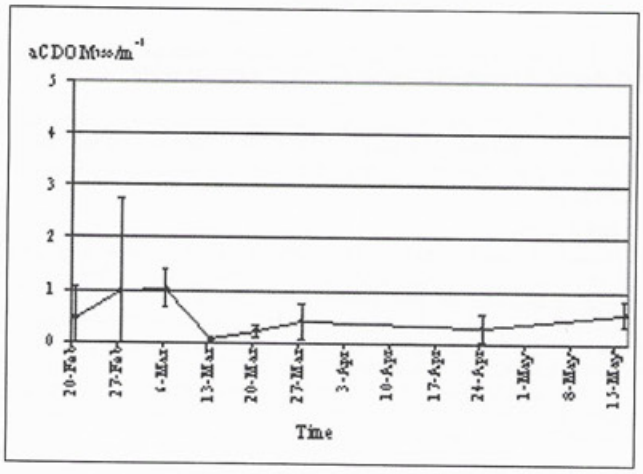

Fig. 2. Temporal variation of mean surface $aCDOM_{355}$ along the axis Po delta-seawards in winter–spring 2003.
Error bars represent the standard deviation.

High salinity in the coastal waters due to exceptionally low Po river discharge could explain the lack of linear correlation between chromophoric dissolved organic matter - and salinity as well as between DOC and salinity. Absorption coefficients at 280 nm, $aCDOM_{280}$, and 355 nm, $aCDOM_{355}$, ranged from 0.46 to 6.45 m^{-1} (average 1.79 m^{-1}) and from 0.05 to 2.38 m^{-1} (average 0.55 m^{-1}), respectively. The slope of absorption spectra, S, derived by exponential fitting, ranged from values typical of coastal waters influenced by rivers to offshore marine waters: 0.008 to 0.033 nm^{-1} (average 0.019 nm^{-1}).

High values of the exponential spectral slope coefficient, S, and low $aCDOM_{280}$ and $aCDOM_{355}$ values showed a low aromatic content and a marine origin of CDOM. To isolate and characterise the optical properties of humic and fulvic acids, seawaters samples were extracted through Amberlite XAD 2 resin column.

The optical properties of the extracted organic fractions were similar to those of the original water, as evidenced by the similar S values (2). The high values of S found in the extracts together with their solubility at pH 2 point out that this fraction is mainly constituted of fulvic acid.

References

1 - Ferrari M.G., 2000. The relationship between chromophoric dissolved organic matter and dissolved organic carbon in the European Atlantic coastal area and in the West Mediterranean Sea (Gulf of Lions). *Mar. Chem.*, 70: 339-357.

2 - Green S., and Blough N.V., 1994. Optical absorption and fluorescence properties of chromophoric dissolved organic matter in natural waters. *Limnol. Oceanogr.*, 39(8): 1903-1916.

THE MARINE ORIGIN OF MUCILAGINOUS AGGREGATES OF THE NORTHERN ADRIATIC

D. Berto, M. Giani *, V. Zangrando, S. Castelli

Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare, Brondolo, 30015 Chioggia, Italy - *m.giani@icram.org

Abstract

The chemical composition of mucilaginous aggregates sampled during summer 2000, 2001 and 2002 in the North Adriatic Sea was studied. The aggregates were mainly composed by organic matter and secondarily by inorganic elements. The C_{org}/N ratio of the aggregates changes with their morphology, dimension and age . To investigate nature of organic fraction of the aggregates the extraction of humic, fulvic and humin fractions substances was carried out. The origin of the humic compounds have been studied by UV-VIS and FT-IR spectroscopy. The 270/407 nm ratio have been used in order to differentiate the marine and terrestrial humic acids in the aggregates. In order to differentiate humic acids from fulvic acids the slope of absorption spectra, S, derived by exponential fitting, was measured and compared to terrigenous and marine sediments.

Keywords: Aggregates, humic acids, Northern Adriatic , UV-VIS spectra

The chemical composition of mucilaginous aggregates sampled during summer 2000, 2001 and 2002 in the North Adriatic Sea depends on the nature of organic matter during aggregation, on the environmental conditions of the site of formation and on the transformations during aging.

The aggregates sampled in the water column were mainly composed by organic matter and secondarily by inorganic elements. Elemental analysis indicates 12.5-32.2 % of organic carbon, 0-7.3 % of inorganic carbon and 1.0-3.7 % of nitrogen. The C_{org}/N ratios of most aggregates are between 7.5 and 12.6, values close to those found in the suspended matter, higher ratios were found in large size (>5 m) aggregates which were probably older.

The C_{org}/N ratio of aggregates changes with their morphology, dimension and age in the following sequence: ribbons ⇒ cob webs ⇒ false benthos ⇒ clouds ⇒ sedimented clouds.

The extraction of humic, fulvic and humin fractions by XAD 2 column allows the characterisation of organic substances constituting the aggregates. The humin (fraction insoluble in acid and basic media) was present in all mucilage samples pointing out the refractory nature of a part of the organic matter.

The humic acids were characterised by the presence in the UV-VIS spectra of a peak around 407 nm, not present in the terrestrial humic acids. The 407 nm peak could be due to covalent bond between humic acids and degradation pigments of chlorophyll, while in those of terrestrial humic acids the interaction is only adsorptive (1) .

The 270/407 nm ratio can be used in order to differentiate marine humic acids and terrestrial humic acids in the aggregates . Higher values of the ratio can be attributed to a terrestrial origin of the humic acids (1). Terrestrial samples had higher values (>3.4) than marine ones (<1.9) whereas the coastal humic acids had intermediate values ranging from 2.4 to 3.1 (Fig. 1). Most part of the Adriatic aggregates sampled showed a marine origin, in particular the clouds and the false benthos, while the surface aggregates evidenced a coastal origin due to higher contribution of organic substances of fluvial origin.

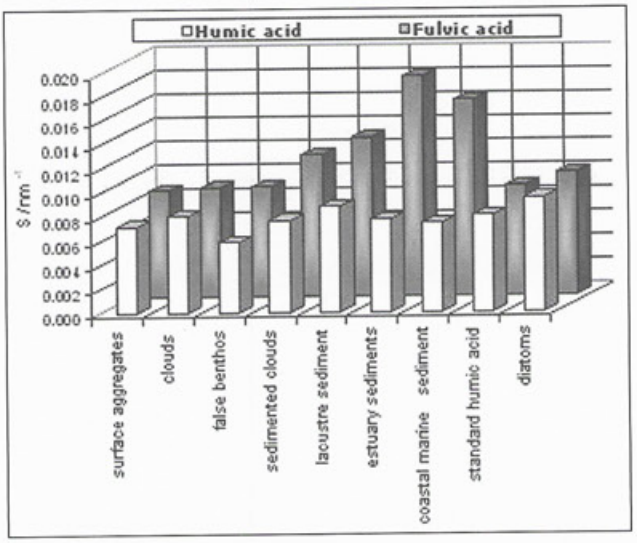

Fig. 1. Spectral slope of the absorption spectra for humic and fulvic acids of different origin.

In order to differentiate humic acids and fulvic acids found in the aggregates the slope of absorption spectra, S, derived by exponential fitting, was measured and compared to terrigenous and marine sediments (2). The S for the fulvic acid absorption spectra were nearly twice as large as those for humic acids (3) (Fig. 2).

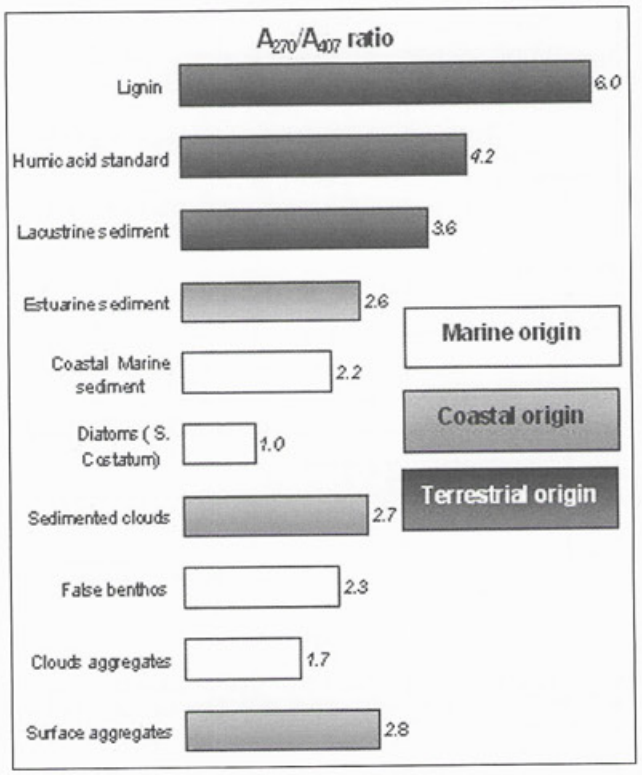

Fig. 2. Absorbance ratio A_{270}/A_{407} for humic fractions extracted by mucilaginous aggregates and sediments of different origin.

The FT-IR spectra of mucilage and humic fractions showed the absence of aromatic structures, typical of terrestrial humic acids (Bottura, pers. Comm.), confirming the marine origin of these aggregates .

References

1 - Fooken U. and Liebetzeit G , 2000. Distinction of marine and terrestrial origin of humic acids in North Sea surface sediments by adsorbtion spectroscopy. *Mar. Geology*, 164: 173-181

2 - Zepp R.G. and Sclotzhauer P.F., 1981. Comparison of photochemical behaviour of various humic substances in water. Spectroscopic properties of humic substances. *Chemosphere*, 5: 479-486.

3 - Carder K.L., Steward R.G., Harvey G.R., and Otner P.B., 1989. Marine humic and fulvic acids: their effects on remote sensing of ocean chlorophyll. *Limnol. Oceanogr.*, 34(1): 68-81.

THE EFFECT OF NUTRIENTS AND IRON ADDITIONS ON THE PHYTOPLANKTON DYNAMIC IN THE NORTHWESTERN MEDITERRANEAN SEA

Bonnet S. *, Guieu C., Chiaverini J., Ras J.

Laboratoire d'Océanographie de Villefranche-sur-mer, Villefranche-sur-mer, France - *sbonnet@obs-vlfr.fr

Abstract

The impact of atmospheric inputs on phytoplankton dynamic was investigated in the Northwestern Mediterranean Sea. Using microcosms incubation experiments performed with surface seawater collected during the stratified period, we studied the impact of macronutrients, iron and Saharan dust on the primary production and composition of the phytoplankton community. By using taxonomic pigments as size class markers of phototroph groups we show that different degree of limitation control pico-, nano- and microphytoplankton growth. Considering the whole community, the primary production was maximum both when adding macronutrients and simultaneously macronutrients and iron suggesting that iron was not a limiting factor.

Keywords : atmospheric inputs, phytoplankton dynamic, iron limitation, taxonomic pigments.

Studying the impact of atmospheric inputs in the water column is essential to understand the biogeochemical cycles in the ocean. The atmosphere is actually an important way for the nutrients to enter the ocean. Indeed, it is one of the major sources of iron in the ocean and probably the dominant one (1).

The impact of atmospheric inputs on phytoplankton dynamic was investigated in the Northwestern Mediterranean Sea. The cruise took place the 1st and 2nd August 2003 at the permanent time-series DYFAMED station (France-JGOFS) (43°25'N, 07°52'E) in the Ligurian Sea. This station, located at 28 nautic miles off Nice, France, is an open-sea site (2350m depth) protected from coastal inputs by the presence of the coastal Ligurian current. This date were chosen because this is the period characterized by a stratified water column and a low primary productivity: during this period, the surface mixed layer is isolated from deeper waters, and the atmosphere is the main source of nutrients such as iron and phosphorus to the surface waters (2).

Incubation experiments were performed with surface seawater collected at 10 meter depth with acid-cleaned polyethylene tubes using an Osmonics solid Teflon diaphragm pump. Unfiltered seawater was transferred to 4L polycarbonate microcosms under a laminar flow hood. The 44 microcosms were immediately amended with Fe, N, P, Si, Saharan dust with different combinations reported in Table 1. One unamended treatment served as control. Each fertilization were realized in duplicates.

Table 1. Different combinations of additions in the microcosms. The concentrations of nutrients added were those encountered in the winter season in the mixed layer at the DYFAMED site in order to obtain non limiting conditions.

Additions	*Concentrations added*
+ Fe	2.5nM
+ N/P/Si	3µM/0.18µM/2.7µM
+ Fe/N/P/Si	2.5nM/3µM/0.18µM/2.7µM
+ Fe/P	2.5nM/0.18µM
+ Saharan dust	0.25mg.L^{-1}

By using taxonomic pigments as size class markers of phototroph groups we show that different degree of limitation control pico-, nano- and microphytoplankton growth. Considering the whole community, chorophyll *a* and primary production were both maximum when adding macronutrients and simultaneously macronutrients and iron, suggesting that iron was not a limiting factor (Fig. 1, Fig. 2). Indeed, the concentration of dissolved iron before additions was surprisingly high (1nM) as only a very small Saharan event have been recorded since the beginning of the stratified period. We suspect a 'fertilization' of the water column by the smokes originating from the huge biomass burnings that occurred in South of France and in Corsica at this time. This hypothesis was tested by analysing the concentrations of total iron and labile iron (dissolution experiments) in aerosols collected in Corsica and in South of France during this summer.

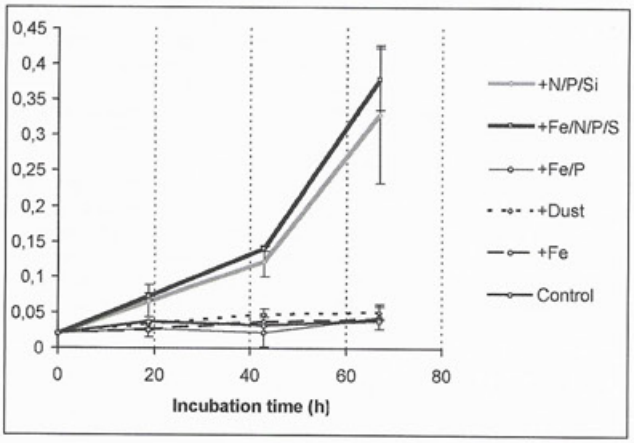

Fig. 1. Concentrations of Chlorophyll-a in the course of the incubation. The error bar represents the standard deviation from duplicates incubations.

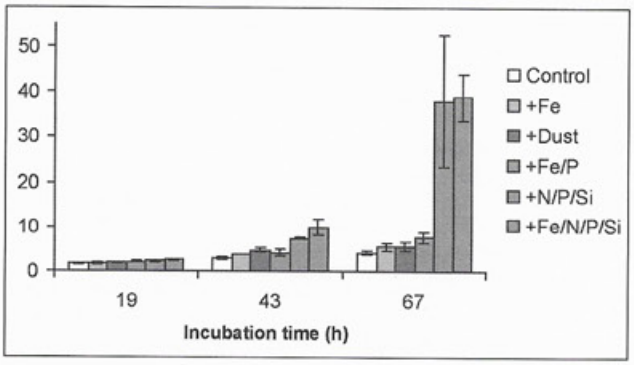

Fig. 2. Primary production along the time of incubation. The error bar represents the standard deviation from duplicates incubations.

References

1 - Duce, R., Liss, P. S., Merrill, J. T., Atlas, E. L., Buat-Ménard, P., Hicks, B. B., Miller, J. M., Prospero, J. M., Arimoto, R., Church, T. M., Ellis, W., Galloway, J. N., Hansen, L., Jickells, T. D., Knap, A. H., Reinhardt, K. H., Schneider, B., Soudine, A., Tokos, J. J., Tsunogai, S., Wollast, R. and Zhou, M., 1991. The atmospheric input of trace species to the world ocean. *Glob. Biogeochem. Cycles, 5:* 193-259.

2 - Migon, C., & V. Sandroni, 1999. Phosphorus in rainwater: partitioning, inputs and impact on the surface coastal ocean. *Limnol. Oceanogr.*, 44: 1160-1165.

LEAD AND CADMIUM TRANSFER FROM A POLLUTED STREAM TO THE MARINE ENVIRONMENT

F. Botsou, M. Dassenakis, E. Panou and M. Scoullos *

University of Athens, Department of Chemistry, Laboratory of Environmental Chemistry, Panepistimiopolis, 15771, Athens, Greece - * mio-ee-env@ath.forthnet.gr

Abstract

In the Mediterranean area and especially in Greece many, rather small polluted streams transfer their heavy metal load to the coastal environment. Asopos River is a typical pollution source for the coastal waters of South Euvoikos gulf. The chemical behaviour of lead and cadmium in this system and particularly in the intermixing zone between freshwater and the marine environment has some interesting features. It includes processes of precipitation, dilution and desorption, which could affect on their bioavailability and toxicity.

Keywords: Asopos; streams; lead; cadmium.

Introduction

Major international conferences (WSSD Johannesburg 2002, WWF Kyoto 2003) stress the need for Integrated Water Resources Management (IWRM) and suggest to address water management at the river basin level. In the Mediterranean, apart from few large riverine systems, there are hundreds of small and medium size rivers characterized by: a) high variation in river flow and discharge, b) high sediment discharge, mostly seasonal c) many scattered polluting activities in small catchment areas and d) lack of systematic environmental management of water. Little is known about the extent in which such small systems contribute to coastal pollution. This study aims at identifying the contribution and the geochemical behaviour of two priority hazardous substances, lead and cadmium in the estuary of Asopos River, which could be considered as a representative case of such systems. The drainage basin of Asopos is one of the most industrialized areas of Greece.

Study area

The drainage basin of Asopos river covers an area of approximately 450 km^2. During the dry season there is almost no physical flow and small pools and hypersaline microenvironments are formed. On the contrary, flash flood events are common during the wet season. The basin hosts more than 220 industries, including textile and dyes, metal finishing plants, chemicals, fertilizers etc. About 80 of these plants produce wastewaters, but only 36 of them are equipped with wastewater treatment facilities. The direct disposal of treated and untreated effluents into Asopos river and its branches is a usual practice [1]. The estuary of Asopos is located at the west coast of Southern Evoikos Gulf, which has relatively strong currents and some tides. The studied area was between 38°18'-38°20' North and 23°44-23°47' East.

Materials and methods

Four samplings were carried out in May, July (dry season), November 2001 (wet season) and July 2002 (after a flash flood event) at the riverine, estuarine and marine compartments of the system. Dissolved oxygen, temperature, conductivity, and pH were measured *in situ*. Water samples were filtered in succession through 8 and 0,45µm Millipore filters. The filters were treated with HNO_3 in PTFE beakers for the determination of particulate metals [2]. Dissolved metals were preconcentrated on "Chelex–100" resin columns [3]. Trace metals were determined by Graphite Furnace Atomic Absorption Spectrometry (Varian SpectrAA-640Z) and Flame AAS (Varian SpectrAA-200). Organic carbon was determined by a Shimanzu Carbon Analyzer 5000A.

Results and discussion

• The three "compartments" of the system were identified and they are characterized by three distinctive regimes: the riverine (salinity <2‰), the estuarine (mixing zone with salinity variations 2-40‰, turbidity maximum) and the marine (salinity >36‰).

• Due to the small depth the water column throughout the system was well oxygenated.

• pH ranges between 7.7-8,7 at the river and between 8.0-8.2 at the sea.

• Dissolved organic carbon distribution also corresponds to the aforementioned division, with the most elevated concentrations in the riverine part and lower concentrations in the estuarine and marine ones (mean values 19.4, 10.7, 4.7 ppm respectively).

• During the period of permanent flow of the river (11/01-7/02) the concentrations of particulate metals were reduced seawards. This pattern of distribution is clear for both expressions, w/v and w/w due to dilution and desorption respectively (Table 1).

	5/01						7/01					
	D		P v/w		P w/w		D		P v/w		P w/w	
	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb
Riv.	0,03	0,60	5,26	1,48	3,05	167	0,07	4,49	0,07	1,50	0,91	19,1
Est.	0,02	0,17	4,16	0,68	0,31	22,7	0,02	0,15	0,01	0,50	0,18	15,0
Mar.	0,04	0,32	0,52	0,41	0,46	49,9	0,03	0,41	0,02	0,29	2,70	43,7
	11/01						7/02					
	D		P v/w		P w/w		D		P v/w		P w/w	
	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb
Riv.	0,15	0,48	0,02	2,14	0,54	112	0,07	0,38	0,05	1,46	4,78	320
Est.	0,08	0,42	0,01	0,97	0,32	25,6	0,05	0,43	0,04	0,87	1,67	126
Mar.	0,07	0,38	0,01	0,69	0,34	28,4	0,06	0,55	0,01	0,18	0,20	31,3

• The concentrations of dissolved metals in the estuarine and marine parts are reduced compared to the river due to dilution of the riverine polluting load. However, the desorption of metals from particles entering the marine environment results occasionally to higher concentrations of dissolved metals in the marine compartment in comparison to the estuarine one.

• During the dry (no flow) period (5/01-7/01) the concentrations of both dissolved and particulate metals (expressed as w/w) were increased in seawater in comparison to the estuary. This may be attributed to coastal pollution sources, the contribution of which becomes more visible under reduced riverine inputs.

• The main form of lead is the particulate one whereas, in the case of cadmium the dissolved form, which is also more bioavailable, prevails.

Conclusion

The study of the Asopos River indicates that small and medium size rivers and streams play an important role in the pollution of coastal waters in their vicinity. However, their impact on the pollution of the offshore Mediterranean waters is likely to be very limited.

References

1 - Loizidou M., Spanos I., Lagoudi A, 1999. Planning of central industrial wastewater treatment plant of Asopos area. NTUA Technical report.

2 - Dassenakis M., Scoullos M., Gaitis A, 1997. Trace metals transport and behavior in the Mediterranean estuary of Acheloos river. *Marine Pollution Bulletin*, 34, 2: 103-111.

3 - Scoullos M. and Dassenakis M., 1984. Determination of dissolved trace metals in seawater: the use of Chelex –100 resin. First Hellenic Symposium on Oceanography and Fisheries. Abstr. Pp. 302-309.

COMPARISON OF ORGANIC CONTAMINANT LEVELS IN MUSSELS *MYTILUS GALLOPROVINCIALIS* FROM THE MEDITERRANEAN COAST OF SPAIN COLLECTED IN 1993 AND 2001.

Juan A. Campillo [1]*, Maria Franco [2], Fulgencio Martinez [1] And José Benedicto [1]

[1] Instituto Español de Oceanografía, Centro Oceanográfico de Murcia, Varadero 1, 30740 San Pedro del Pinatar, Murcia, Spain.
[2] Centro Oceanográfico de Vigo. Cabo Estay. Canido. 36390 Vigo, Spain.

Abstract

Organic contaminant concentrations in mussels collected from 15 sites along the Iberian Mediterranean coast, in 1993 and 2001, are compared applying the Sign test. Polychlorinated biphenyls (PCBs) concentrations showed a significant decrease between 1993 and 2001, since 14 of the 15 concentrations determined in year 1993 exceed the obtained ones in 2001. DDT and its metabolites showed a comparable decrease for ppDDD and as well as for the sum of ppDDT, ppDDE and ppDDD.

Keywords: PCB, DDT, Mytilus galloprovincialis

Introduction

Mussels have the ability to accumulate trace levels of certain organic pollutants. Owing to their sedentary characteristics, bivalves are considered ideal bioindicators for marine pollution monitoring. Among a large number of man-made chemicals, organochlorines, such as DDTs and PCBs, are of great concern due to their ubiquitous, persistent and highly bioaccumulative nature as well as toxic effects. Even though most of the countries have banned or restricted the production and usage of many of these organochlorines, they are still widely distributed in the marine environment (1). The objective of this study was to assess the trends of the levels of contamination of PCBs and DDTs in the Mediterranean coastal waters of Spain, through comparison of organic contaminants levels in mussels collected in 1993 and 2001.

Materials and Methods

In order to minimise natural variability, sampling was made under standardized conditions, collecting native mussels from the same site and at the same time of the year (May-June, post-spawning period). Ateach site (Fig. 1), three subsamples of 50 individuals, size 3 to 4 cm, were collected by hand. Preparation of samples has been described elsewhere in detail (2). The mussel homogenates were freeze-dried and soxhlet extracted. Lipids were removed by chromatography over alumina. The PCBs and DDTs purified fractions were obtained by chromatography on silica. Final extracts were analysed by capillary gas chromatography with a ^{63}Ni electron capture detector. Total PCB concentrations in samples was quantified as the sum of 7 congeners (nº 28, 52, 101, 118, 138, 153 and 180). Intercalibration mussel homogenate samples, from QUASIMEME, were used as a control for the analytical methods. The Sign test was used for comparing results obtained from 1993 and 2001.

Results and discussion.

ΣPCBs and DDTs concentrations in mussels are summarized in the Table 1. Of the 15 pairs of data per chemical, the 1993 concentrations were higher 14, 12, 12 times for ΣPCBs, ΣDDTs and ppDDD, respectively. Statistically, ΣPCBs results have less than a 0.1 % chance of being random, and for ΣDDT and ppDDD there are less than a 3 % chance that any of those tendencies toward higher values in 1993 are random. For ppDDE and ppDDT, the Sign test does not show any significant differences between 1993 and 2001 levels.

In 1993 and 2001, ΣPCBs mean concentration values were 68.9 and 59.8 ng/g dry wt., respectively. ΣPCBs concentration decreased a 13.2 % in 2001 with respect to 1993. In general, ΣPCBs concentrations decreased at all the locations studied, excepted at Delta del Ebro, where ΣPCBs concentration was 2.6 times higher in 2001 than in 1993. However, mussels collected in 2000 from this sampling point showed a similar result obtained in 1993. Although European countries have banned PCBs uses, releases of this compounds occur as leaks from sealed systems, accidental losses and spills, and emissions from PCB-containing materials and soils.

ΣDDTs mean values in 1993 and 2001 were 54.6 and 39.7 ng/g dry wt., respectively. ΣDDTs concentration decreased approximately a 27.3 %. ppDDE was the major compound founded in mussel. There is evidence, that DDT concentration in biota have generally decreased, whereas for related compounds no such conclusions can be drawn (3).

Conclusion

Comparison of organochlorine concentrations founded in mussel collected in 1993 and 2001, shows a general decreases of PCBs concentrations along the Spanish Mediterranean coast. The declining use and progressive elimination of PCBs have been reflected in these results. For DDT and its metabolites, banned in many countries including those in Western Europe, a similar decline has been observed.

Table 1. Concentrations of PCBs and DDTs (ng/g dry wt) in mussel from the Spanish Mediterranean Coast.

	2001				1993			
	ppDDT	ppDDE	ppDDD	ΣPCBs	ppDDT	ppDDE	ppDDD	ΣPCBs
Islas Medas	2.9	6.5	5.4	18.1	0.7	2.4	0.6	23.8
Barcelona	19.0	52.4	13.5	203.5	2.0	167.9	17.7	260.9
Vallcarca	12.4	61.7	8.1	214.3	21.0	232.5	15.8	232.0
Tarragona	3.4	11.5	3.6	53.8	4.6	55.1	4.6	78.9
D. del Ebro	96.8	125.9	66.0	196.2	20.9	44.3	25.8	74.0
Valencia	6.7	17.4	4.0	106.4	10.1	40.6	12.8	151.2
Cullera	2.7	18.4	6.4	35.9	4.9	30.1	8.6	46.6
Portman	1.9	7.1	2.2	10.9	5.4	5.2	2.9	20.6
Cartagena	1.8	2.6	1.7	33.4	2.3	5.0	2.8	45.3
Calahonda	0.6	4.6	1.1	2.4	2.6	31.6	2.2	16.0
Almuñecar	1.0	5.8	0.2	5.0	nd	5.0	nd	10.4
Herradura	1.3	5.3	0.2	2.8	2.3	2.8	4.1	9.6
Fuengirola	0.2	3.0	nd	4.9	nd	3.9	1.5	21.9
San Diego	0.7	3.9	0.1	3.4	1.8	4.0	2.2	11.2
Algeciras	1.4	3.7	0.8	6.2	1.6	6.5	1.4	31.7



Fig. 1. Map with sampling points.

References

1 - Chen W., Zhang L., Xu L., Wang X., Hong L., and Hong H.. Residues levels of HCHs, DDTs and PCBs in shellfish from coastal areas of east Xiamen Island and Minjiang Estuary, China. *Mar. Pollut. Bull.*, 45: 385-390.

2 - González-Quijano A., and Fumega J., 1996. Determinación de congéneres individuales de bifenilos policlorados en organismos marinos. Informes Técnicos del IEO, nº 160.

3 - OSPAR, 2000. Quality Status Report 2000: Region IV Bay of Biscay and Iberian Coast.

MODELING TRACE METAL ACCUMULATION IN THE MEDITERRANEAN MUSSEL, *MYTILUS GALLOPROVINCIALIS*

S. Casas [1] *, D. Cossa [2], J.L. Gonzalez [1], C. Bacher [3], B. Andral [1]

[1] IFREMER, Centre de Toulon, BP 330, Zone Portuaire du Brégaillon, F.83507 La Seyne-sur-Mer cedex, France
* Stellio.Casas@ifremer.fr
2 IFREMER, Centre de Nantes, BP 21311, F.44311 Nantes, France
3 IFREMER, CREMA, BP 5, F.17137 L'Houmeau, France

Abstract

Monitoring coastal contamination by trace metals pollution using mollusks bivalves as quantitative bioindicators is widely performed in many international biomonitoring programs. For this purpose, modeling metal dynamics in marine mussels is a reliable tool, allowing understanding the bioaccumulation process resulting from the interactions between biological, chemical and environmental factors. To calibrate such a model, kinetic experiments on uptake and elimination were conducted at three Mediterranean sites chosen on the basis of their different nutritive and chemical characteristics.

Keywords: Bioindicator, Mytilus galloprovincialis, bioaccumulation, heavy metals, growth.

Introduction

Many monitoring programs (the US Mussel Watch, the French RNO and RINBIO) are based on the concept of quantitative bioindicator, which uses the properties of marine bivalves (usually mussels) to concentrate and, under certain conditions, accumulate contaminants in their soft tissue, with a relationship with the ambient level. This technique allows technically simpler measurements of chemical contaminants than in water (1, 2, 3, 4).

National and international monitoring networks are designed to discern spatial and temporal patterns in contaminant concentrations in the environment. Some difficulties appear in the accomplishment of this objective: the data obtained give only information on the bioaccumulation level without taking into account the contaminants dynamic. There is still a lack of knowledge about the significance of the concentration at time "t"; does this concentration result from a change in environmental conditions, or from a change in the contamination level in the surrounding environment? Furthermore, comparing concentrations between different sites appears to be difficult because of the variations in environmental conditions, and subsequent variations in growth rate of the mussels among sites, may involve changes in the concentration level in the animals. Subsequently, modeling bioaccumulation of metals in mussels could be a pertinent tool to optimize the use of quantitative bioindicators.

The aim of this study is to couple growth and bioaccumulation models for the marine mussel, *Mytilus galloprovincialis*. Indeed, each fluctuating condition will interact and affect the concentration of metal in mussels. Hence, the reconstruction of ambient metal concentrations, based on metal body burden, will be only feasible when the effect of food density and/or temperature on the physiological condition of the mussel is known.

Interactions between environmental changes, growth and bioaccumulation

Interpretation of environmental monitoring data is improved by knowledge of the relationship between metal concentration in the environment and in tissues of the mussel. Most of the studies on the bioaccumulation process assume implicitly steady state conditions for the other physiological processes in the organism. These models do not consider the organism changes in its physiological conditions (i.e. size, energy reserves and reproductive cycle) and do not take into account the impact of these changes on the metal concentration in mussels.

In fact, many biotic and abiotic parameters are known to affect the metals body burden of *Mytilus sp.:* temperature, available food, reproductive cycle, size and weight (5, 6). This is the reason why the coupling of the growth and accumulation models is of utmost importance in understanding the metal bioaccumulation process within the mussel.

Metal kinetics in the mussel: accumulation model

Uptake and elimination kinetics of metals in the mussel *Mytilus galloprovincialis* can be described by a dynamic energy budget (DEB) model. A multi-compartment-pharmaco-kinetic model has been used to describe metal kinetics (7, 8). The contribution of physiologically determined variables, such as body size and tissue composition, on its influence on the pharmaco-kinetics of the metals has been evaluated. The metal uptake / elimination model has been designed to account for change in the physiological conditions of the organism. The uptake is considered to be carried out directly from the environment and/or *via* food and the elimination is *via* reproduction and/or directly to the environment.

Adjustment of parameters and field validation

In order to couple growth and metal accumulation, it is essential to have complementary data: (i) physico-chemical variables on the contaminant and the water, (ii) biological variables of the water, and (iii) biological variables of the mussel.

In this experiment, mussels originating from a same site have been transplanted for six months in two sites known for their contamination (Lazaret bay and Bages lagune). The two mussel sets were sampled fortnightly, and allometric parameters and contaminant concentrations in the mussel tissues were measured. In addition, water conditions were recorded: temperature, pH, salinity, suspended solids and dissolved and particulate metal concentrations. After these six months, mussels were transplanted to a clean site (Port-Cros island) in order to examine the decontamination kinetics during three months. All these data will be integrated into the DEB model to adjust parameters and validate it.

After calibrating the bioaccumulation model and after coupling the two models using dissolved and particulate metal concentrations in the environments, the model has been inverted in order to prove its functionality in assessing the real metal concentrations in water. By combining environmental and biological data, the model could constitute an optimized biomonitoring tool that can be applied to various coastal environments.

References

1 - Goldberg, E. D.,1975. The Mussel Watch. *Mar. Pollut. Bull.*, 6: 111-113.

2 - Kock de, W. C. and H. Van Het Groenewoud, 1985. Modelling bioaccumulation and elimination dynamics of some xenobiotic pollutants (Cd, Hg, PCB, HCB) based on "*in situ*" observations with *Mytilus edulis*. TNO report. The Hague: 68-79.

3 - Claisse, D., M. Joanny, *et al.*, 1992. The French marine pollution monitoring network (RNO). *Analusis* (Masson, Paris), 20(6): 19-22.

4 - Andral, B., J.Y. Stanisiere, *et al.*, 2001. Réseau Intégrateurs Biologiques. Rinbio. Evaluation de la contamination chimique des eaux basée sur l'utilisation de stations artificielles de moules en Méditerranée : résultats de la campagne 2000., Ifremer. R.INT.DEL/TL/01-03.

5 - van Haren, R.J.F., H.E. Schepers, *et al.*,1994. Dynamic energy budgets affect kinetics of xenobiotics in the marine mussel *Mytilus edulis*. *Chemosphère,* 29 (2): 163-189.

6 - Cossa, D., E. Bourget, *et al.*,1980. Geographical and seasonal variations in the relationship between trace metal content and body weight in *Mytilus edulis*. *Mar. Biol.,* 58: 7-14.

7 - Kooijman, S.A.L.M.,1988. The von Bertalanffy growth rate as a function of physiological parameters: a comparative analysis. In: T.G. Hallam, L.J. Gross and S.A. Levin (eds.), Mathematical Ecology. World Scientific, Singapore.

8 - Kooijman, S.A.L.M. and R.J.F. van Haren, 1990. Animal energy budgets affect the kinetics of xenobiotics. *Chemosphère,* 21: 681-693.

ABOUT ACCUMULATION FACTORS OF CD, CR, CU AND PB IN THE BLACK SEA COAST BIOTA

Elisabeta Chirila [1] *, Adrian Bavaru [2], Ionela Carazeanu [1]

[1] Department of Chemistry, University "Ovidius" of Constantza, 124, Mamaia Blvd., 900527, Constantza, Romania,
* echirila@univ-ovidius.ro

[2] Department of Biology, University "Ovidius" of Constantza, 124 Mamaia Blvd., 900527, Constantza, Romania

Abstract

This paper deals to report original results concerning four metal accumulation factors in the Romanian Black Seacoast biota. Cd, Cr, Cu and Pb were determined in brown and green algae, mussels, crustaceans, fishes and also in water using flame atomic absorption spectrometry.

Keywords: trace metals, Black seacoast biota, FAAS, concentration factors.

Introduction

The release of heavy metals into our environment is still large. In certain areas of the world it is even increasing. Cadmium, chromium, copper and lead play an important role in marine ecosystems as pollutants or essential elements. Their study has increased in the last decades, but biogeochemical cycles may be better explained in active areas. Bioaccumulation (defined as association of a metal with an organism) is a necessary first step before organisms can manifest a response to metals or influence metal geochemical cycling. Many studies published in recent years evaluate the rates and mechanisms of metal bioaccumulation in marine organisms (1-4).

This investigation was carried out in the Black Seacoast ecosystem. Original results of Cd, Cr, Cu and Pb accumulation in marine biota are reported.

Experimental

Samples were collected during the summer of 2002 from eight stations placed on the Romanian Black Seacoast between Midia and Vama Veche. Algae (*Ceramium sp., Cladophora sp., Enteromorpha sp., Polysiphonia sp., Ulva rigida*), mussels (*Mytilus sp., Scapharca sp.*), crustaceans (*Crangon crangon, Gammarus sp., Idotea sp., Palaemon sp., Pontogammarus sp., Sphaeroma sp.*) and fishes (*Apollonia melanostomus, Atherina sp., Blennius sanguinolentus, Mugil auratus, Ponticola cephalargoides*) samples were carefully washed with deionised water, hashed and dried. 0.1 – 0.9 grams of each dry sample was submitted to digestion with nitric acid and hydrogen peroxide at 170 ^{0}C in a Digesdahl device provided by Hach Company [5, 6]. For the determination of metal concentration an AA 6300 flame atomic absorption spectrometer provided by Shimadzu Company was used.

Results and discussion

The goal of this work was to study the accumulation of cadmium, chromium, copper and lead in the Romanian Black Seacoast biota.

Aquatic organisms may take up trace metals mainly from solution and from food. For example mussels, as filter feeders effectively filter particulate matter out of suspension and therefore this suspended matter may be a source of trace metals. Gagnon and Fischer demonstrate that the organic content of suspended particles may influence bioavailability of trace metals (7).

The concentration factor was calculated as the rapport between ppm metal in organism and ppm metal in water (8).

The table 1 summarizes the obtained results. There are presented mean values of concentration factors for brown and green algae, for two shells species (*Mytilus sp. –My* and *Scapharca sp.- Sc.*), for crustaceans and fishes. In the same time in the table are presented the interval of concentration factor's values for each category.

Table 1. Concentration factors of Cd, Cr, Cu and Pb in the Romanian Black Seacoast biota.

Biota		Cd	Cr	Cu	Pb
Algae	brown	12652	404	2252	339
	green	3225	215	1917	811
	Min-max.	1280 - 14881	22.6 –762.2	370 -5322	88.7 -1117
Shells	My	5564	197	3268	409
	Sc	6125	122	518	450
	Min-max.	390-21378	15.9-231.3	406.7-7021	28.6-1570
Crustaceans	mean	18259	357	9678	1341
	Min-max.	588-53658	125-843	598-36142	43.2-3947
Fishes	mean	18280	819	2639	1343
	Min-max.	746.9-50762	42.9-2891	24.2-14830	54.8-6668

It can be observed that brown algae have higher metal accumulation capacity than the green ones, excepting lead.

There is a large variation of concentration factors in each biota category. That may depend on the sample's collecting points, on the species but also on the physiologic behavior of organism.

Cadmium has the highest concentration factors in all biota species from Romanian Black seacoast.

As a conclusion, for all studied biota categories the concentration factors of trace metals increase as follows: Cr<Pb<Cu<Cd.

References

1 - Fisher N.S., Stupakoff I., Sanudo-Wilhelmy S.A., Wang W.-X., Teyssié J.-L., Fowler S.W., and Crusius J., 2000. Trace metals in marine copepods: a field test of a bioaccumulation model coupled to laboratory uptake kinetic data. *Mar. Ecol. Prog. Ser.*, 194: 211-218.

2 - Wang W.-X., and Fisher N.S., 1999a. Assimilation efficiencies of chemical contaminants in aquatic invertebrates: a synthesis. *Environ. Toxicol. Chem.*, 18: 2034-2045.

3 - Griscom S.B., Fisher N.S., and Luoma S.N. 2002. Kinetic modeling of Ag, Cd and Co bioaccumulation in the clam *Macoma balthica*; quantifying dietary and dissolved sources. *Mar. Ecol. Prog. Ser.*, 240: 127-141.

4 - Baines S.B., Fisher N.S., and Stewart R., 2002. Assimilation and retention of selenium and other trace elements from crustacean food by juvenile striped bass (*Morone saxatilis). Limnol. Oceanogr.*, 47: 646-655.

5 - Chirila E., Carazeanu I., Bavaru A. and Belc M.,2003. Cadmium occurrence in the Black Sea ecosystem. Proc. Int. Conf. Bramat 03, Brasov Romania, 4: 354-357.

6 - Chirila E., S. Birghila and P. Capota, 1999. Biogeochemical characterisation of an ecosystem using ICP-AES'. *S. Afr. J. Chem,*. 52: 154-156.

7 - Gagnon C. and N.S. Fisher, 1997. The bioavailability of sediment-bound Cd, Co and Ag to the mussel *Mytilus galloprovincialis. Can. J. Fish. Aquat. Sci.*, 54: 147-156.

8- Bowen H.J.M, 1966. Trace elements in Biochemistry. Academic Press, New York and London.

LONG-TERM INVESTIGATIONS IN MEROMICTIC SEAWATER LAKE (ROGOZNICA LAKE, EASTERN ADRIATIC COAST)

I. Ciglenečki [1] *, M. Carić [2], F. Kršinić [2], D. Viličić [3], B. Ćosović [1]

[1] Rudjer Boskovic Institute, Center for Marine and Environmental Research, Zagreb, Bijenicka 54, 10001 Zagreb, Croatia
* irena@rudjer.irb.hr

[2] Institute of Oceanography and Fisheries-Split, Laboratory of Plankton Ecology Dubrovnik, Kneza Damjana Jude 12, 20001 Dubrovnik, Croatia

[3] University of Zagreb, Faculty of Science, Division of Biology, Rooseveltov trg 6, 10001 Zagreb, Croatia

Abstract

Since 1994 seasonal variations of temperature, salinity and vertical distribution of dissolved oxygen, nutrients, dissolved organic carbon, surface-active substances, reduced sulfur species, phyto- and zooplankton have been investigated in water column of the Rogoznica Lake. During the thermohaline stratification (spring, summer) the surface water is well-oxygenated while anoxia is occurring in the bottom layer. As a result of autumn or winter mixing, bottom water enriched with nutrients is coming to the surface supporting new phytoplankton and oxygen productions. Turnover of Lake water layers in September 1997 occurred so quickly that it resulted in the appearance of total anoxia and sulfide presence throughout the water column. The aerobic flora and fauna died and added to the oxygen demand and production of nutrients. Special conditions leading to and following after the disastrous anoxia are illustrated and discussed.

Keywords: seawater lake, eutrophication, anoxia, reduced sulfur species, nutrients

Lakes are natural laboratories in which biogeochemical processes can be effectively studied. They are much quicker to respond to environmental pressures than ocean basins, and because of their smaller size of the reservoirs, the biogeochemical signals of such perturbations are amplified. In many lakes due to their topographic and hydrographic conditions anoxia could exist in the bottom layer seasonaly or permanently (1). Oxygen or the lack thereof is the driving force for many processes in lakes. It governs aqueous chemistry via oxidation and reduction processes, and it contributes to biological diversity and abundance by creating different habitats. Many lakes with anoxic hypolimnia are eutrophic.

Besides stratification in temperature and salinity many lakes with anoxic deep waters are chemically stratified. Meromixis is a condition of persistent chemical stratification with incomplete mixing over the course of a year: it usually results in anoxia and the accumulation of nutrients in permanently stagnant layer and reduced vertical mixing (2).

Rogoznica Lake is a typical example of meromictic saline lake. The lake is a small (15 m deep), naturally intensely eutrophicated and intermittently anoxic, karstic, seawater lake situated on the eastern coast of the Adriatic Sea, Croatia (43°32'N 15°58'E) (3, 4). During the thermohaline stratification the surface water is well oxygenated (oxygen saturation up to 300%), while hypoxia/anoxia occurs in the bottom layer (5, 6). Anoxic deep water (below 10 m) is characterized by high concentrations of reduced sulfur compounds (6), iodine species (5) and nutrients (7), as well as dissolved organic carbon (8) indicating the pronounced remineralization of organic matter in this water layer. The oxic-anoxic water layer boundary in Rogoznica Lake is characterized by a strong chemocline where usually up to 50 cm thick, pinky coloured water layer due to the presence of very dense populations of purple sulphur bacteria exist.

In September 1997 total anoxia occurred in the Rogoznica Lake, with hydrogen sulfide present in the entire water column, followed by massive death of planktonic and benthic organisms (7). Due to the decomposition of dead organisms, concentrations of nutritious salts tremendously increased along the entire water column and were maintained in the lake several months after disastrous anoxia, which points out to very complex and slow lake regeneration processes. Due to the extreme ecological conditions which prevail in this lake, phyto- and zooplankton populations are represented by a relatively small number of species, some of them, however in denser population from the surrounding sea. After the period of total anoxia, the number of species and their abundance were significantly reduced in comparison with the pre-anoxia values.

Since 1994 seasonal variations of temperature, salinity as well as vertical distribution of dissolved oxygen, nutrients, dissolved organic carbon, surface-active substances, reduced sulfur species, phytoplankton and zoo-plankton have been investigated in water column of the Rogoznica Lake. The aim of this paper is to present the importance of long-term investigations in studying eutrophication processes in the Rogoznica Lake. Special attention was paid to the conditions leading to and following after the disastrous anoxia.

References

1 - Nürnberg, G.K., 1995. Quantifying anoxia in lakes. *Limnol. Oceanogr.*, 40: 1100-1111.

2 - Romero, J.R., Melack, J.M., 1996. Sensitivity of vertical mixing in a large saline lake to variations in runoff. *Limnol. Oceanogr.*, 41: 955-965.

3 - Mihelčić, G., Šurija, B., Juračić, M., Branica, B., 1996. History of accumulation of trace metals in sediments of the Rogoznica lake (Croatia). *Sci. Total Environ.*, 182: 105-115.

4 - Ciglenečki, I., Kodba, Z., Ćosović, B., 1996. Sulfur species in Rogoznica lake. *Mar. Chem.*, 53: 101-111.

5 - Stipaničev, V., Branica, M., 1996. Iodine speciation in the water column of the Rogoznica Lake (Eastern Adriatic Coast). *Sci. Total Environ.*, 182: 1-9.

6 - Ciglenečki, I., Kodba, Z., Viličić, D., Ćosović, B., 1998. Seasonal variation of anoxic conditions in the Rogoznica Lake. *Croat. Chem. Acta*, 71: 217-232.

7 - Kršinić, F., Carić, M., Viličić, D., Ciglenečki, I., 2000. The calanoid copepod *Acartia italica* Steuer, phenomenon in the small saline Lake Rogoznica (Eastern Adriatic coast). *J. Plankton Res.*, 22: 1441-1464.

8 - Ćosović, B., Ciglenečki, I.,Viličić, D., Ahel, M., 2000. Distribution and seasonal variability of organic matter in a small eutrophicated salt lake. *Estuar. Coast. Shelf Sci.*, 51: 705-715.

MEDFLUX: RELATIONSHIPS AMONG BALLAST, PARTICULATE ORGANIC CARBON AND ^{234}TH ACTIVITIES AND FLUXES AT THE DYFAMED SITE, NORTHWESTERN MEDITERRANEAN

J. K. Cochran [1] *, J. C. Miquel [2], S. W. Fowler [2], B. Gasser [2], J. Szlosek [1], A. Rodriguez-y Baena [2], D. Hirschberg [1], G. Stewart [1] and P. Masqué [3]

[1] Marine Sciences Research Center, Stony Brook University, Stony Brook, New York 11794-5000 USA
* kcochran@notes.cc.sunysb.edu
[2] IAEA Marine Environment Laboratory, 4 Quai Antoine 1er, MC98000 Monaco
[3] Universitat Autonoma de Barcelona, Bellaterra, Spain

Abstract

Standard approaches for measuring the distribution and flux of ^{234}Th (in situ pumps, sediment trap) have been applied at the DYFAMED site, NW Mediterranean and complemented by analysis of samples from traps that collect and separate particles into fractions according to sinking velocity, and particles collected in a "net trap" and separated into sinking velocity using an elutriator on board the ship. The results show that >70% of the sinking flux of ^{234}Th is carried by particles sinking at velocities greater than ~100 m d^{-1}. Measurements of particulate organic carbon and elements corresponding to mineral ballast in the sinking particles will help to better understand the relationships among these parameters.

Sinking fluxes of particulate organic carbon (POC) in the oceanic water column are frequently measured using the disequilibrium between the natural radionuclide ^{234}Th and its parent ^{238}U. Such estimates require measurement of both the extent of disequilibrium and the POC/^{234}Th ratio on the sinking particles. The latter is commonly estimated through measurement of the POC/^{234}Th ratio in a large (>50 to 70 µm) filterable fraction or in sediment trap material. The relationship between the POC/Th in the filterable and sinking particles remains uncertain, however. As part of the MedFlux program, we used *in situ* pumps to measure the patterns of Th/U disequilibrium in the water column at the French JGOFS time-series DYFAMED site in the northwestern Mediterranean. In addition, IRS swimmer-exclusion sediment traps were deployed at 200 m to collect both a regular time series of particle flux and a composite sample with individual cups programmed to collect particles separated according to sinking velocity. A large sample of particles sinking through 200 m was collected by means of a newly-designed net trap deployed for 3 days, and subsequently separated into sinking velocity fractions using an elutriator.

Several water column profiles of particulate and dissolved ^{234}Th were collected over a one-week period in May 2003 (Fig. 1). The data show a pronounced minimum in total ^{234}Th (particulate + dissolved) centered on the depth of the chlorophyll maximum. Fluxes of ^{234}Th at 200 m (calculated applying a steady state model to the ^{234}Th deficit) were 2000 – 3000 dpm m^{-2} d^{-1}. These fluxes were in the range of those observed in a time-series sediment trap deployed at 200 m during the previous 60 days, although they more closely corresponded to trap fluxes measured early in the period (Fig. 2).

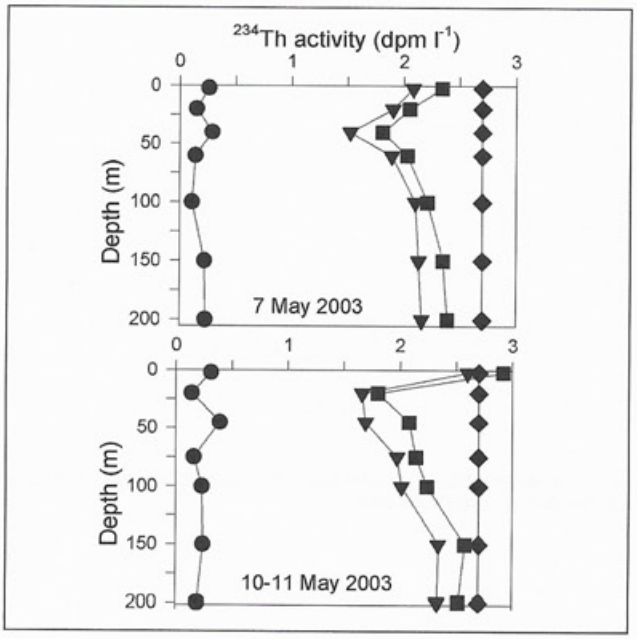

Fig. 1 Water column profiles of ^{234}Th (particulate:circles; dissolved:triangles and total:squares) and ^{238}U (diamonds).

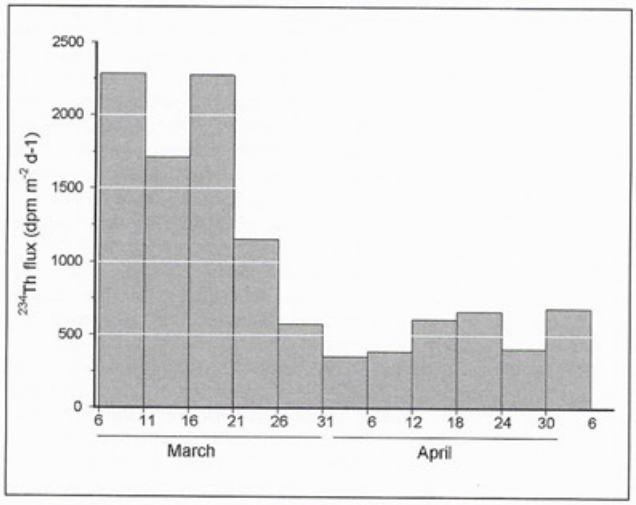

Fig. 2 Time series of ^{234}Th fluxes at 200 m.

Particles separated by sinking velocity using both the sediment trap and net trap/elutriator methods showed similar results. More than 50% of the ^{234}Th flux in the integrated sediment trap sample was carried in particles sinking faster than 196 m d^{-1} (Fig. 3). In the net trap sample collected May 6-8, more than 70% of the ^{234}Th collected was present on particles sinking at rates >100 m d^{-1}. The specific activity of ^{234}Th showed no clear relationship to sinking velocity. Future measurements of POC and ballast elements (Si, Ca, Al) will clarify the relationships between Th flux and particle composition.

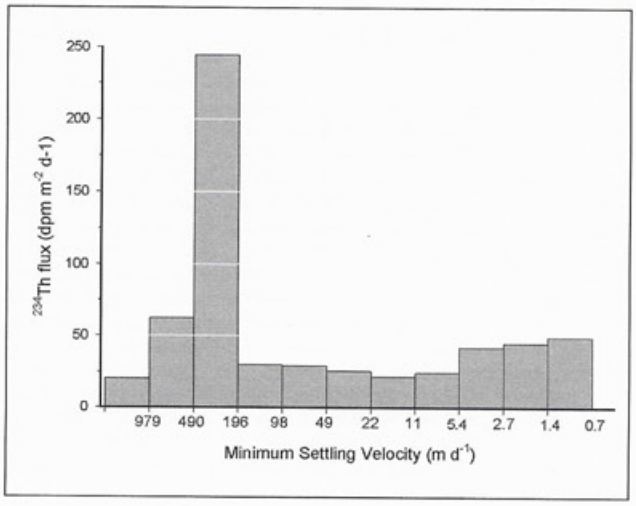

Fig. 3. Integrated ^{234}Th flux vs particle sinking velocity.

ENVIRONMENTAL CHARACTERISATION OF THE VENICE CANALS: FIRST RESULTS OF THE ICARO PROJECT

F. Collavini [1]*, E. Coraci [1], L. Zaggia [1], A. Zaupa [2], R. Zonta [1], A. Zuliani [1]

[1] National Research Council – Institute of Marine Sciences. San Polo, 1364, 30125 Venice, Italy - * f.collavini@ismar.cnr.it
[2] INSULA SpA. Dorsoduro, 2050, 30123 Venice, Italy

Abstract

Venice canals are a sink of particulate matter and associated pollutants deriving from sewage effluents and erosion of urban surfaces. Due to the progressive silting of the canals, restoring interventions are necessary to reduce the input of materials, improving water quality and hydrodynamic conditions in the network. To acquire the scientific knowledge which is necessary to evaluate the effectiveness of the policy actions, a project named ICARO started in 2002. First results are described, concerning the definition of circulation pattern and the study of transport mechanisms, as well as physico-chemical variations in a test canal system of the Venice historical centre.

Keywords: Venice canals, hydrodynamics, sediment transport, urban wastewater

Large amounts of particulate matter from untreated sewage effluents and the erosion of urban surfaces are delivered to the about 40 Km-long canals of the City of Venice, determining a progressive silting of the network. A comprehensive program of interventions aimed to the general improvement of the canals network has recently started, to obtain better water quality conditions, to restore and preserve the building foundations and to renew the urban utilities. The program activities include sediment dredging and the reduction of the amount of materials directly delivered in the network. Thanks to the collaboration between INSULA - the public limited company constituted by the Venice City Council in charge of the interventions on the City - and the Venice Institute (ISMAR) of the National Research Council, a project named ICARO was started on February 2002, to study the functioning of the canal network. The main objectives of the project are the description of the canals hydrodynamics and the study of transport and accumulation mechanisms governing the sediment and associated pollutants. The obtained results are expected to be useful to test the efficiency of the restoring interventions, and to address the planning of future activities to the maintenance of the canal network functionality. The investigation is initially focused on a test canals system corresponding to about 10% of the whole network. The definition of the water circulation and the study of the variability of physico-chemical parameters, as a function of both tidal exchanges and season, are the basic knowledge for the interpretation of the acquired data. These information are obtained from time series of hydrodynamic variables (tide level, current speed and direction) and physico-chemical parameters (salinity, temperature, dissolved oxygen, pH, redox potential and turbidity), recorded in few stations. These continuous acquisitions are integrated by a large number of point measurements performed in several sites, to investigate the variations occurring within the system. The hydrodynamic data are also used to calibrate a bidimensional model, that simulates the tide propagation in the canals, permitting to describe the water circulation and the sediment transport within the whole network. The water pollution is periodically monitored during dedicated field surveys: hourly samples are collected and analysed to determine the concentration of suspended particle matter (SPM), heavy metals and nutrients (nitrogen and phosphorus species). The amount of suspended material transported in the system is estimated by means of sediment traps; the collected materials is submitted to both the dimensional and chemical analyses. The trends of SPM concentration and turbidity in the water column highlights the important role of the boat traffic in determining the mobilisation of particulate matter in the canal network. The resuspension induced by tide circulation is, in fact, less effective than the whirling-up of sediment caused by boat traffic. As a consequence, the turbidity in the water column is mainly determined by the navigation, in function of the intensity of boat traffic, water level and tide conditions. The comparison between turbidity and the fluxes measured by sediment traps is useful in the evaluation of the solid transport processes. Figure 1 shows, for example, the clear correspondence between the trend of the sediment flux in a time interval of two weeks and the average value of the turbidity. Although the measured fluxes are an integrated signal on a given time interval, the periods characterised by a large sediment yield correspond to higher turbidity values.

Concerning the pollutants, the main focus of the project is to identify the species that are more useful in understanding the transport within the canals network, and the processes that determine quality variations in the water column. A good example is the trend of the dissolved nitrogen and phosphorus species (Fig. 2), in particular ammonia and orthophosphate, which are also strongly correlated. The concentrations of these compounds in the inner canals is essentially determined by both the discharge of urban effluents and the intensity of water exchange with the tide. The more the water stands within the network, the higher the concentration of ammonia and orthophosphate. Therefore, these species are a valid tracer of the quality variation in the water column, permitting to trace circulation patterns and to evaluate residence times in the system.

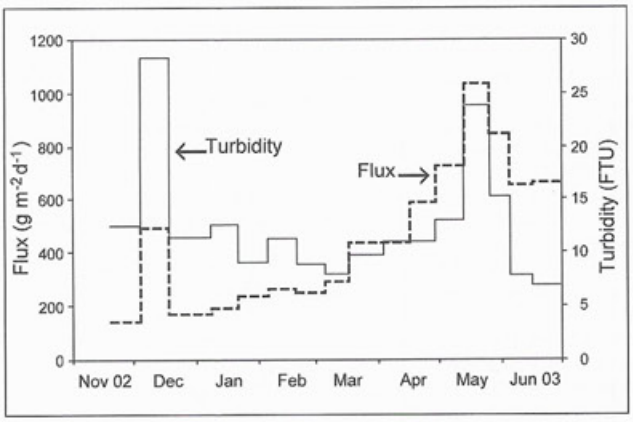

Fig. 1. Comparison between the trend of the sediment flux to the traps in a two-weeks interval and the average value of the turbidity.

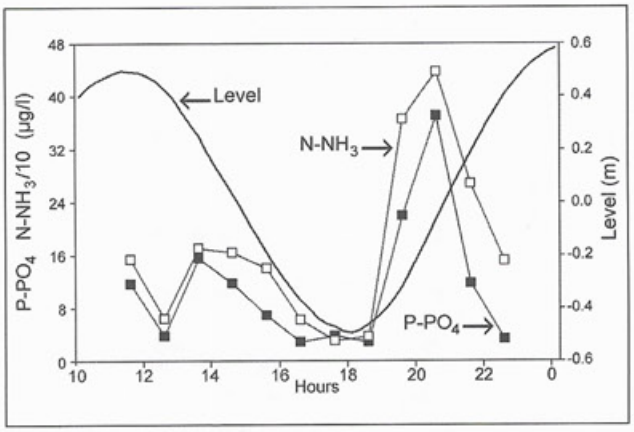

Fig. 2. Concentration of orthophosphate phosphorus and ammonia nitrogen during a tide excursion.

BIOCHEMICAL BIOMARKERS RESPONSES TO SUSPENDED AND RE-SUSPENDED PARTICLES *IN SITU*

Efthimia Cotou [1] *, Maria Koutsodimou [1] and Artemis Nikolaidou [2]

[1] Hellenic Centre for Marine Research (HCMR), 46.7 km, Athinon-Souniou Ave., P.O.Box 172, 190 13 Anavyssos – Greece
* ecotou@ncmr.gr

[2] Zoological laboratory, University of Athens, Panepistimiopolis, Athens 15771, Greece

Abstract

Three biomarkers [acetylcholinesterase (AChE), glutathione *S*-transferase (GST) and metallothioneins (MTs)] were measured in *Mytilus galloprovincialis* exposed to suspended and re-suspended particles *in situ*. Results provided not only temporal evidence that contaminants have been sorbed in suspended and re-suspended particles which were bioavailable, but also indicated significant difference of biomarkers responses between suspended and re-suspended particles.

Key-words: biomarker, AChE, GST, metallothionein, resuspension

Introduction

Contaminants that are present in marine environment are typically free or bound on suspended particles and sedimentary materials where they represent a source of chronic contamination and threat to pelagic and benthic organisms. Sedimentary material may periodically subjected to re-suspension processes resulting from natural events such as storm occurrences or bioturbation and human activities like dredging, shipping or trawling [1, 2]. The Mediterranean coastal zones experience such events either by near-bed current activity and breaking of internal waters or intense trawling operations resulting to significant re-suspension release of nutrients, pollutants or other toxic elements [3, 4]. Although these processes have been identified as being significant only little work has been devoted to their effects on biota [5]. The last decade biological effects are detected with tools that can provide early warning signals caused by the wide variety of contaminants present in the marine environment. Such tools are called biomarkers and are indicative of contaminant exposure and/or effect. The importance of measuring several biomarkers at the same time in the same organism may enables not only a pertinent approach to evaluating the effects of contaminants on individuals and the bioavailability of toxicants, but also the source of the exposure. This study was undertaken as a step in using biochemical biomarkers to determine responses caused by contaminants sorbed in suspended and re-suspended particles *in situ*.

Material and methods

A mooring device of a mud-hook, an auto-releaser and two bunches of nets with 50 mussels (*Mytilus galloprovincialis*) each, was placed in Thermaikos Gulf (northeastern Aegean Sea) and was exposed to suspended and re-suspended matter for 20 days during September and February 2001. The months correspond to periods of low and high re-suspension events occurred in the area. Net bunches were connected and suspended on a rope. One net was suspended at 10 m depth from the surface while the second 5 m above the sea-bottom level (50m). After collection, mussels were transferred to the lab and were stored at –80ºC till analysis. Three biochemical biomarkers were measured: acetylcholinesterase (AChE), glutathione *S*-transferase (GST) activities and metallothioneins (MTs) concentration. AChE as indicative for organophosphorous and carbamates since it is inhibited by their presence [6]. GST as indicative for organic compounds like organochlorine pesticides and PCBs as inhibited in their presence [7] and MTs concentration which increase in the presence of heavy metals. Determinations were carried out as have been previously described. AChE and GST were measured in the gills in the post-mitochondrial fraction (S9). AChE was measured according to [8] as modified by [9]. GST activity was determined according to [10]. MTs concentrations were determined in the digestive gland of mussels according to [11] and expressed as μg of MTs per gram tissue. AChE and GST activities were expressed as nmoles/min/mg of S9 protein (mg P). Protein concentration was determined according to [12].

Results and discussion

Results (average and standard deviation) of biomarkers responses measured in the gills and digestive gland of mussels are shown in Table 1. During the two periods (September, February), AChE activities and MTs concentration values for samples placed near to the surface level were slight decreased, and GST activities for similar samples were increased. These results were mainly related to the seasonal variation and to the different life cycle of the mussels which have also been reported by others [7, 9, 11]. It is however notable for samples placed near to the bottom level during February since biomarkers responses were significantly decreased compared to all the other samples. Decreases of approximately 37%, 25% and 7% were indicated for AChE, GST and MTs, respectively. It is clear from the data shown that biomarker responses provided not only temporal evidence that contaminants have been sorbed in suspended and re-suspended particles and were bioavailable but also indicated the source of the exposure (i.e. suspended and/or re-suspended particles).

Table 1. Biochemical biomarker responses of *Mytilus galloprovincialis* exposed to suspended and re-suspended particles *in situ*.

Source of exposure	Period of exposure	AChE (nmoles/min/mg P)	GST (nmoles/min/mg P)	MTs (_g/g tissue wt)
1. Suspended particles	Sept.r	52.77 ± 9.28	157.99 ± 8.31	81.16 ± 2.67
2. Re-suspended particles		52.98 ± 13.56	84.81 ± 11.56	80.17 ± 2.17
3. Suspended particles	February	42.50 ± 10.59	226.14 ± 26.29(2)	61.24 ± 1.17 (1,2,4)
4. Re-suspended particles		26.72 ± 12.71(1,2,3)	168.96 ± 23.99(2)	56.97 ± 0.99(1,2,3)

* Number in parenthesis indicate significant differences at $P<0.05$ level.

References

1 - Campbell P.G.C., Lewis A.G., Chapman P.M., Crowder A.A., Fletcher W.K., Imber B., Luoma S.N., Stokes P.M., Winfrey M., 1988. Biologically available metals in sediments. National Research Council of Canada, Publ. No. NRCC 27694, Ottawa, Ontario, Canada.

2 - Smart M.M., Rada R.G., Nielsen D.N., Claflin T.O., 1985. The effect of commercial and recreational traffic on the resuspension of sediment in Navigation Pool 9 of the upper Mississippi River. *Hydrobiologia,* 126: 263-274.

3 - Puig P., Palanques A., 1998. Nepheloid structure and hydrographic control on the Barcelona continental margin, northwestern Mediterranean. *Marine Geology,* 149: 39-54.

4 - Chronis G., Lykousis V., Georgopoulos D., Zervakis V., Stavrakakis S., Poulos S., 2000. Suspended particulate matter and nepheloid layers over the southern margin of the Cretan Sea (N.E. Mediterranean): seasonal distribution and dynamics. *Prog. Oceanog.,* 46: 163-185.

5 - Fichet D., Radenac G., Miramand P., 1998. Experimental studies of impacts of harbour sediments resuspension to marine invertebrates larvae: bioavailability of Cd, Cu, Pb and Zn and toxicity. *Mar. Poll. Bull.,* 36: 509-518.

6 - Galgani F., Bocquene G., 1989. A method for routine detection of organophosphates and carbamates in sea water. *Environ. Technol. Lett.*, 10: 311-322.

7 - Fitzpatrick P.J., O'Halloran J., Sheeham D., Walsh A.R., 1997. Assessment of glutathione S-transferase and related proteins in the gill and digestive gland of *Mytilus edulis* (L) as potential organic pollution biomarkers. *Biomarkers,* 2: 51-56.

8 - Ellman G.L., Courtney K.D., Andreas V., Featherstone R.M., 1961. A new and rapid colorimetric determination of AChE activity. *Biochem. Pharmacol.*, 7: 88-95.

9 - Galgani F., Bocquene G., 1991. Semi-automated colorimetric and enzymatic assays for aquatic organisms using microplate readers. *Water Res.*, 25: 147-150.

10 - Habig W.H., Pabst M.J., Jakobi W.B., 1974. Glutathione S-transferases: the first enzymatic step in mercapturic acid formation. *J. Biol. Chem.*, 249: 7130-7139.

11 - Viarengo A., Ponzano E., Dondero F., Fabbri R., 1997. A simple spectrophotometric method for metallothionein evaluation in marine organisms: an application to Mediterranean and Antarctic mollusks. *Mar. Environ. Research,* 44: 69-84.

12 - Bradford M., 1979. A rapid and sensitive method for the quantification of microgram quantities of protein utilizing the principle of protein-dye binding. *Anal. Biochem.*, 72: 248-254.

A COMBINED APPROACH TO STUDY INTERANNUAL VARIABILITY OF PIGMENTS IN THE FIRST OPTICAL LENGTH IN MEDITERRANEAN SEA

Alessandro Crise*, Guido Crispi, Valentina Mosetti

Department of Oceanography, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Borgo Grotta Gigante 42/c, 34010 Sgonico (TS), Italy .

Abstract

The aim of this work is to provide evidence of the interannual variability of the pigments in the upper ocean up to the first optical length. The approach is twofold: a 3D eco-hydrodynamical model describing the nitrogen cycle in the Mediterranean Sea has been integrated for the period 1980-86 to obtain estimates of monthly mean chlorophyll concentrations. Seasonal cycles are computed both from model results and CZCS monthly means obtained from JRC. The analysis of normalized relative anomalies show that in both cases the seasonal signal usually accounts for more than 80% of the energy of total signal.

Keywords: nitrogen cycle, interannual variability, chlorophyll content, CZCS.

Introduction

The interannual-to-decadal variability of circulation of upper and intermediate layer over the Mediterranean Sea has been appraised by many authors. Variability studies of the pelagic biogeochemical cycles on multiannual scales is instead hampered by the scarcity of the data sets. These studies are mainly located in selected areas such as the NW Mediterranean [1]. Here a coupled eco-hydrodynamical model is used to capture a basin-wide multiannual variability in the Mediterranean Sea. An estimate of relative importance of interannual variability versus seasonal cycle for the chorophyll content in the first optical length in Mediterranean area. Independently, the same estimates are obtained from the analysis of pigments concentration as derived by CZCS images. The comparison of satellite images with the model diagnosed chlorophyll fields demonstrates the robustness of the estimates.

Materials and methods: model experiments and remotely sensed chlorophyll concentration field processing.

Here the model protocol is firstly presented, and then the analysis of chorophyll concentration as derived from CZCS optical sensor.

The model is composed by two modules: a 1/4 degreee 31 level MOM 1.0 OGCM plus Nitrogen-Phytoplankton-Detritus-Chlorophyll (NPD-Chl) nitrogen cycle described through a set of advection-diffusion-reaction non-linear equations. Details on the functional forms of the equations, parametrization, numerics and forcings of the coupled model are provided in [2,3].

The model is in this case forced with NMC/NCEP annually varying monthly means along the period 1980-86. Chlorophyll-a was diagnostically computed from model outputs using an empirical non-linear model [4].The pheopigments concentration (ugChl/dm^3) in the first optical length was detected by CZCS sensor in the period 1979-1985. The original data set used here, reanalyzed by EU Joint Research Center of Ispra, was converted and regridded to a 2kmx2km resolution. A bathymetric mask was applied to regions shallower than 200m to wipe out coastal signals from the pelagic region both in model outputs and images.

Results

To obtain a synthetic estimate of the relative importance of interannual variability, the Hovmoller diagram of meridionally integrated (between 30.5N and 45N) chlorophyll fields are computed from both model and images. In this way, the well known zonal trophic gradient (presentet also in chlorophyll concentration), is preserved.

Both model and images show that the response of the basin is locked to the seasonal cycle all over the Mediterranean except for Alboran Sea which seems instead controlled by permanent upwelling conditions combined with baroclinic dynamics. The clear west-to-east negative gradient in chlorophyll concentration indicates the averaged increasing oligotrophy of the surface waters. Permanent maxima are connected to subbasin scale circulation, more evident in the western areas. Weaker signals are evident in the Eastern Mediterranean where the fertilization effects of Rhodes Gyre are barely visible at surface. Chlorophyll content shows energetic maxima in 1981 and 1983 years in Western Mediterranean. The model exibits stronger relative variability in the Eastern Mediterranean where winter maxima appear overestimated. Seasonal anomalies found in the Western Mediterranean during Autumn 1981 and 1982 are present both in images and model outputs (but not 1982 winter anomaly) as well as the 1983 winter peak (more spread in the CZCS). Summer deep chlorophyll maxima (in particular in the eastern basin) are too deep to be capture by satellite images but are well represented by the model.

The explanation of the normalized variance of the signal integrated over the East and West Mediterranean Sea is shown in Fig. 1: the seasonal cycle explains about 80% of the variance, except for January where the model only predicts slightly higher variability. Interestingly, similar figures were obtained in East Mediterranean from an EOF analysis of SST diagnosed from AVHRR radiometer [5].

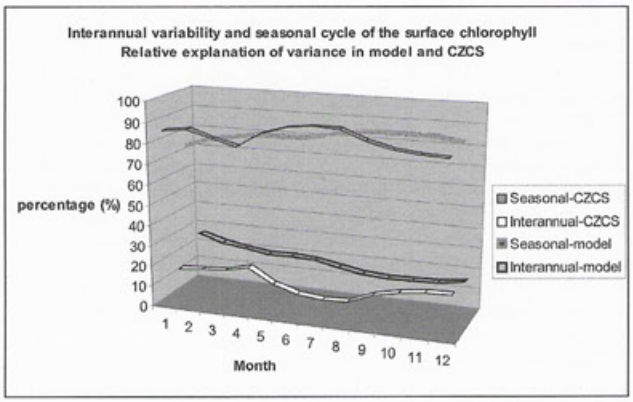

Fig.1. Breakdown of normalized chlorophyll variance expressed in terms of seasonal and interannual variability along the climatological year calculated in the period 1980-86. CZCS results are shaded while model outputs are plotted with thicker lines.

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References

1 - Marty J.-C. (ed.) 2002. Studies at the DYFAMED (French-JGOFS) Time-Series Station, N.W. Mediterranean Sea. *Deep-Sea Res. II*, 49: 11, 1963-2192.

2 - Crise A. , Crispi G. and Mauri E., 1998. A seasonal three-dimensional study of the nitrogen cycle in the Mediterranean Sea. Part I. Model implementation and numerical results, *J. Mar. Systems.*, 18, 1-3: 287-312.

3 - Crispi G., Crise A. and Mauri E., 1999. A seasonal three-dimensional study of the nitrogen cycle in the Mediterranean Sea. Part II. Verification of the energy constrained trophic model. *J. Mar. Systems.*, 20, 1-4: 357-380.

4 - Cloern J.E., Grenz C. and Vidergar-Lucas L., 1995. An empirical model of the phytoplankton chlorophyll:carbon ratio – the conversion factor between productivity and growth rate. *Limnol. Oceanogr.*, 40, 7: 1313-1321.

5 - Marullo, S., R. Santoleri, P. Malanotte-Rizzoli and Bergamasco A., 1999. The sea surface temperature field in the Eastern Mediterranean from advanced very high resolution radiometer [AVHRR] data Part II. Interannual variability, *J. Mar. Systems*, 20: 83-112.

SOLUBILITY OF Fe(III)-GLYCINE-NTA COMPLEXES IN AQUATIC SYSTEMS

Vlado Cuculić* and Marko Branica

Center for marine and environmental research, Rudjer Bošković Institute, Bijenička 54, 10001 Zagreb, Croatia
*cuculic@rudjer.irb.hr, branica@rudjer.irb.hr

Abstract

Solubility of iron(III)-glycine-NTA mixed complex in aquatic solution was measured by cathodic voltammetry with static mercury drop electrode. Experimental determined Fe(III) retention time in soluble phase at pH = 8.1 in 0.1 mol L^{-1} $NaClO_4$ was found to be more than 18 hours. It was achieved by addition of NTA to the iron(III)-glycine water solution. Under these conditions, iron(III) hydrolysis was sufficiently suppressed.

Keywords: aquatic system, iron(III), mixed complex, glycine, nitrilotriacetate, voltammetry.

Introduction

Iron is one of the most abundant metal on the earth's crust with a great biogeochemical importance in natural aquatic systems. It is an essential element whose key chemical and biological functions involve oxidation/reduction processes and interactions with oxygen (1). However, its strong tendency toward hydrolysis and precipitation is limiting factor for iron occurrence in soluble phase in natural aquatic systems (2). Soluble form of Fe(III) is necessary for phytoplankton growth. Iron is thought to be an element that regulates ecosystem structure and rate of primary production in large areas of the ocean (3). Dissolved iron concentrations in the surface waters of the Pacific area are < 0.1 nM, so rate of input of bioavailable iron must exert a strong influence on ocean productivity in these systems (3,4). The major source of iron in the ocean is deposition of atmospheric dust particles. However, iron oxyhydroxide particles and iron colloids are not directly available to phytoplankton due to their insolubility (4). Ionic iron must be in soluble form during sufficient period of time in order to be available to the phytoplankton. It is mainly achieved by organic complexation of iron(III) (1).

Methods and materials

μAUTOLAB analyzer (ECO Chemie, Utrecht, NL) and an electroanalytical quartz cell (20 ml) were used in experiments. The working electrode was a standing mercury drop electrode (SMDE), Ag/AgCl as reference electrode and counter electrode was platinum wire. The stock solutions of 10^{-2} mol L^{-1} of $Fe(NO_3)_3x9H_20$ (p.a., Kemika, Croatia), 10^{-2} mol L^{-1} of disodium nitrilotriacetate (Na_2NTA) (Sigma-Aldrich Chemie, Germany), 1 mol L^{-1} of glycine and 7.13mol L^{-1} of the $NaClO_4$ (p.a., Fluka Chemie, Switzerland) with bidistilled, Milli-Q water were prepared.

Results and discussion

The electrochemical measurements were performed in a 0.1 mol L^{-1} $NaClO_4$ water solution at pH = 8.1. Figure 1 shows differential pulse Fe(III) reduction peak current dependence on the time of the experiment. In figure 1, curve 1 shows reduction currents of the Fe(III) - glycine complex without NTA added. Advanced hydrolysis after only few minutes since Fe(III) addition is observed. This complex is very unstable5 at pH = 8.1 (natural seawater pH) and hydrolysis prevails over formation of Fe(III)-glycine complex. In figure 1, curve 2 shows Fe(III) reduction where NTA was added about 50 minutes after preequilibration of iron(III) and glycine. Before the addition of NTA, Fe(III)-glycine complex was formed, which has very strong tendency toward hydrolysis (5). After NTA addition, gradually formation of mixed Fe(III)-glycine-NTA complex takes place. After about 8 hours, mixed complex peak current achieves constant values. It is clear that presence of the both ligands, glycine and NTA, stabilizes iron(III) in soluble phase because peak current (Fig. 1, curve 2) was constant over 18 hours. When NTA was added into glycine water solution prior to addition of iron(III) ions, Fe(III) mixed complex was formed instantaneously (Fig. 1, curve 3). So, addition of NTA in Fe(III)-glycine water solution results in formation of the highly stabilized Fe(III)-glycine-NTA mixed complex that keeps iron(III) in soluble phase more than 18 hours.

Figure 2 shows d.c. polarogram of the Fe(III)-glycine-NTA reduction and logarithmic dependence of the reduction currents on potential (insert). Logarithmic analysis of the polarogram gives us a slope value 58.8±0.04 mV. Number of electrons in reaction depends on slope as follows: **slope = 0.059V / n**, for reversible electrode reaction. That clearly shows that oxidation/reduction reaction of the Fe(III)-glycine-NTA mixed complex is one-electron, reversible electrode reaction.

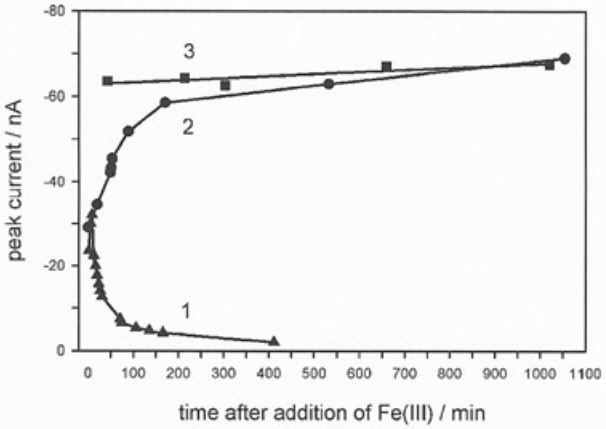

Fig. 1. DP reduction peak current dependence on the time of the experiment. 1: Fe(III)-glycine reduction; 2: Fe(III)-glycine-NTA reduction, NTA added after 50 min.; 3: Fe(III)-glycine-NTA reduction; $c(Fe^{3+})$ = $2.5x10^{-5}$ mol L^{-1}; 0.2 mol L^{-1} glycine; $5x10^{-4}$ mol L^{-1} NTA; 0.1 mol L^{-1} $NaClO_4$; pH = 8.1; DE = 2 mV; a = 25 mV; t_{pulse} = 0.05 s; Δt_{pulse} = 0.2 s.

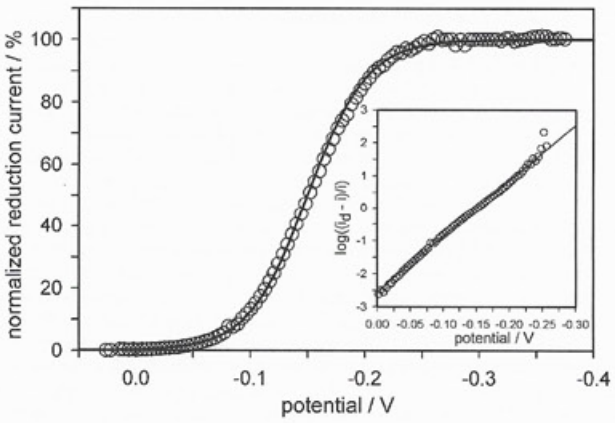

Fig. 2. D.C. polarogram of the Fe(III)-glycine-NTA reduction and logarithmic dependence of the reduction current on potential (insert). $c(Fe^{3+})$ = $2x10^{-4}$ mol L^{-1}; 0.02 mol L^{-1} glycine; $5x10^{-4}$ mol L^{-1} NTA; 0.1 mol L^{-1} $NaClO_4$; pH = 8.1; drop time = 0.5 s; ΔE = 2 mV.

References

1 - Sunda, W.G., Huntsman, S.A., 1995. Iron uptake and growth limitation in oceanic and coastal phytoplankton. *Mar. Chem.*, 50: 189-206.

2 - Crumbliss, A.L., Garrison, J.M., 1988. A comparison of some aspects of the aqueous coordination chemistry of aluminum(III) and iron(III). *Comments Inorg. Chem.*, 8: 1-26.

3 - Martin, J.H., Fitzwater, S.E., 1988. Iron deficiency limits phytoplankton growth in the north-east Pacific subarctic. *Nature*, 331: 341-343.

4 - Liu, X., Millero, F.J., 2002. The solubility of iron in seawater. *Mar. Chem.*, 77: 43-54.

5 - Cuculić, V., , 2003. Electrochemical reactions of iron ions and complexes in water solutions. Doctoral Thesis, University of Zagreb.

DISTRIBUTION AND ORIGIN OF HYDROCARBONS IN SURFICIAL SEDIMENTS FROM IZMIR BAY (TURKEY)

E. Darilmaz and F. Kucuksezgin *

Institute of Marine Sciences and Technology, Inciralti, 35340-Izmir, Turkey - * filiz.ksezgin@deu.edu.tr

Abstract

Hydrocarbons were studied in sediments collected from the bay. Total hydrocarbon concentrations ranged from 762-8502 while total aliphatic and aromatic hydrocarbons varied between 448-4427 and 223-6461 ngg^{-1}, respectively. High levels of aliphatics were observed in the inner bay due to domestic and industrial activities. Molecular indices were used to indicate the most probable source of contamination. Pri/Phy ratios of all stations were found >1 indicating the biogenic sources. All samples are characterized Phenanthrene/Anthracene ratio values <10 and most of samples are grouped by Fluoranthene/Pyrene ratios >1, which is characteristic of strong pyrolytic input.

Key words: sediment, aliphatic hydrocarbon, aromatic hydrocarbon, Izmir Bay

Introduction

Izmir Bay is one of the great natural bays of the Mediterranean. Industrial activities cover a large range of industries including food processing, tanneries, paint, chemicals, textile and petroleum refining. A large number of studies have been carried out on the physical, chemical and biological oceanography of Izmir Bay, but no published data are available on petroleum hydrocarbon concentrations. Aksu *et al.* (1) have only investigated congeners of polycyclic aromatic hydrocarbon (PAH) in surface sediments from the inner bay. This is the first time that the complete set of such data has been collected and evaluated in the bay.

Materials and methods

Surface sediments were collected at 16 locations in November 2000. Samples were collected using with a Van-Veen grab sampler and extracted in a soxhlet apparatus, using n-hexane and dichlorometane, according to UNEP (2). Extracts were separated into two fractions, using a column chromatography on silica and alumina. The first group has saturated aliphatic, the second group has unsaturated and aromatic hydrocarbons. High-resolution gas chromatography was conducted on a CHROMPACK gas chromatograph, equipped with a split/splitless capillary injection system, flame ionization detector. The detection limits range between 0.15-2.9 (ng g^{-1}).

Results and discussion

Aromatic Petroleum Hydrocarbons

The relatively high concentrations observed for the inner bay and the port is linked to the greater industrialisation and urbanisation at this part compared to the other sites (Table 1). In contrast, PAH concentrations in most of the sediments in the outer bay are low, and are typical of locations distant from extensive anthropogenic activities. Anthracene and indeno[1,2,3-c,d] pyrene are measured at all stations while naphthalene and benzo[g,h,i]perylene are only found in the middle bay. Total PAH ranges from 223-646 ngg^{-1} dry wt. and concentrations in the bay are comparable to relatively unpolluted locations in the Mediterranean and are lower than levels reported for polluted NW Mediterranean (3). The fingerprints of PAHs from pyrolytic or petrogenic origin may be used to differentiate these two origins by using molecular indices based on ratios of selected PAHs. Equivalent values for the phenanthrene/anthracene(Phe/Ant), fluoranthene/pyrene(Flt/Pyr) are presented in Table 1. All samples are characterized Phe/Ant ratio values <10 and most of samples are grouped by Flt/Pyr ratios >1, which is characteristic of strong pyrolytic input. Low values indicate petrogenic origin of the compounds. It is mainly linked to the shipping activity. The various possible PAH sources were estimated by calculating correlation coefficients between total and individual PAHs. All coefficients were generally found to be high (R^2 = 0.70-0.90). These high correlation levels for most PAHs indicate that sediment contamination was produced by the same sources and the fate of these contaminants was similar.

Aliphatic Petroleum Hydrocarbons

n-C14, n-C17 ranged between 0.12-829, 33-414 ngg^{-1} in the study area, respectively. C14-C18 was found throughout study area in which C18 (196-1068 ngg^{-1}) was the most abundant. High levels of aliphatics were observed in the inner bay due to anthropogenic sources. It is suggested that the presents of aliphatics due not only to anthropogenic activity but also result of marine phytoplankton and terrestrial vegetation (4). This is indicated by the presence of phytane and pristane at all stations. Pristane and phytane are often considered as good indicators of petroleum contamination. Pri/Phy ratios were >1 indicating the biogenic source in the bay. Increased ratios are also found at the estuary of Gediz River. The Pri/Phy ratio was low in the inner bay, indicating low contribution from biogenic hydrocarbons. Total aliphatic hydrocarbons ranged from 448-4427 ngg^{-1}. Total aliphatic hydrocarbon concentrations were higher than Eastern Mediterranean by Gogou *et al.*(5), similar in coastline-Black Sea by Readman *et al.*(6). Total extractable organic matter (EOM) ranged between 1-6.9 mgg^{-1} in the outer bay, 1.7-11 mgg^{-1} in the middle-inner bays, 84 mgg^{-1} in the harbor. The linear regressions between total PAHs, aliphatic, hydrocarbon and the % of organic matter show significant correlation coefficients.

Table 1. The concentration of total aliphatic (T.Ali), total aromatic (T.Aro), total hydrocarbons (T.Hc), organic matter, extractable organic matter (EOM) and selected ratios

Sta No	T.Ali ng/g	T.Aro ng/g	T.Hc ng/g	Phe /Ant	Flt /Pyr	Pri /Phy	nC$_{\frac{9}{}}$ /Pri	EOM mg/g	Org. mat.%
1	455	307	762	0.06	1.4	2.7	2.0	6.9	2.8
2	448	1009	1457	0.02	0.70	5.5	1.7	0.99	2.8
3	953	223	1176	0.01	1.9	30	1.2	2.2	1.9
4	561	1604	2165	0.13	1.9	13	0.90	1.8	3.4
5	579	1208	1787	0.05	479	7.1	1.1	3.4	3.4
6	721	428	1149	0.02	214	3.9	1.3	7.1	1.7
7	702	1141	1843	0.44	100	2.1	1.0	2.4	3.5
8	656	766	1422	0.06	1.0	1.8	1.9	2.4	3.6
9	668	858	1526	0.12	2.3	2.0	1.5	1.9	3.8
10	725	227	953	0.05	1.5	2.9	0.89	1.0	5.5
11	957	2389	3346	0.02	1.2	3.1	1.2	5.1	3.6
12	724	295	1019	0.03	1.5	3.6	0.70	2.2	4.0
13	823	818	1641	0.07	0.69	4.1	0.77	11	4.6
14	1961	1840	3801	0.13	0.81	1.0	1.2	2.4	6.7
15	2041	6461	8502	0.13	0.99	1.2	0.74	1.7	8.0
16	4427	711	5138	0.45	0.38	1.4	0.07	84	15

Conclusions

Two main source of PAHs in Izmir Bay sediments studied here have been found; pyrolytic and petrogenic, but the pyrolytic one is predominant. An important change in the sediments characterization can be observed according to the industrial activities along the Gediz River estuary. Relative to other urbanized coastal areas worldwide, the measured total hydrocarbons content of the bay can be considered low to moderately contaminate.

References

1 - Aksu A. E., Yasar D., and Uslu O., 1998. Assessment of marine pollution in Izmir Bay: Heavy metal and organic compound concentrations in surfical sediments. *Turkish Journal of Engineering and Environmental Science*, 22: 387-415.

2 - UNEP, 1991. Determinations of petroleum hydrocarbons in sediments. Reference Methods for Marine Pollution Studies, No:20, 97p.

3 - Benlahcen K.T., Chaoui A., Budzinski H., Bellocq J., and Garrigues P.H., 1997. Distribution and sources of polycyclic aromatic hydrocarbons in some Mediterranean coastal sediments. *Marine Pollution Bulletin*, 34: 298–305.

4 - Kennicutt M.C., Schroeder W.W., and Brooks J.M., 1995. Temporal and spatial variations in sediment characteristics on the Mississippi-Alabama continental shelf. *Continental Shelf Research*, 15: 1–18.

5 - Gogou A., Bouloubassi I., and Stephanou E.G., 2000. Marine organic geochemistry of the Eastern Mediterranean: 1. Aliphatic and polyaromatic hydrocarbons in Cretan Sea surficial sediments. *Marine Chemistry*, 68: 265–282.

6 - Readman J.W., Fillman G., Tolosa I., Bartocci J., Villeneuve J.P., Catinni C., and Mee L.D., 2002. Petroleum and PAH contamination of the Black Sea, *Marine Pollution Bulletin*, 44: 48-62.

CHEMICAL OCEANOGRAPHIC DATA FOR THE MEDITERRANEAN: EXISTING DATABASES - PROPOSAL FOR A DIFFERENT APPROACH

M. Dassenakis *, M. Ladakis, S. Triantafyllaki, V. Paraskevopoulou, T. Kastritis, H. Andrianos,
Laboratory of Environmental Chemistry, University of Athens, Panepistimioupoli Zografou, 15771, Athens, Greece
* edasenak@cc.uoa.gr

Abstract
This paper presents: (a) the results from a search in the World Wide Web for information portals and databases containing chemical oceanographic data about the Mediterranean, (b) a new approach for the dissemination and publication of such data in a proposed database.

Keywords : Database, chemical oceanographic data

The search in the World Wide Web produced the following list of main oceanographic portals and databases for chemical marine data and metadata.

Portals: OceanPortal (http://www.oceanportal.org), The eSeFDee Marine Sciences Portal (http://www.dvz.be/Portal/): directories with links to ocean data and information related web sites.

Metadata websites: Sea Search (http://www.sea-search.net/), European Directory of Marine Environmental Datasets (EDMED) (www.bodc.ac.uk/services/edmed), Marine Environmental Data Information Referral Catalogue (MEDI) (http://ioc.unesco.org/medi/), NASA's Global Change Master Directory (GCMD) (http://gcmd.nasa.gov/) are websites with metadata products/directories, i.e. information about datasets and centres or researchers that can provide them.

Datasets

- The European Environment Agency holds online environmental data from EU member states in the EEA Data Service (http://dataservice.eea.eu.int/dataservice/) and metadata for each dataset. No chemical oceanographic data for the Mediterranean were found.

- The World Ocean Database (http://www.nodc.noaa.gov/OC5/SELECT/dbsearch/dbsearch.html) allows a specified search of the World Ocean Database 2001, through the WODselect retrieval system. The datasets retrieved are subsequently e-mailed to the user.

- PANGAEA (http://www.pangaea.de/) is an online data library providing geo-coded environmental, marine and geological data/metadata.

-International Council for the Exploration of the Sea (ICES) (http://www.ices.dk). The Oceanography section contains datasets from oceanographic cruises for the Western Mediterranean Basin.

- UNEP (United Nations Environmental Programme) Resources: Unep.net (http://www.unep.net/,) provides oceanographic graphs, charts and reports from processed data, but no chemical oceanographic results were found about the Mediterranean. UNEP/MAP (Mediterranean Action Plan) (http://www.unepmap.org) provides all the technical reports of UNEP/MAP in pdf format, which contain processed data and conclusions.

- POSEIDON (http://www.poseidon.ncmr.gr/) is a monitoring, forecasting and information system for the Greek seas. A network of observation buoys and an operational centre will provide, when the system is in full functionality, physical, biological and chemical parameters. The website currently offers access to recent data from the Aegean Sea.

Limited datasets in websites with complete presentation on CD-ROMs:

- Mediterranean Targeted Project II-MATER (1996-1999) (Mass Transfer and Ecosystem Response) (http://www.ifremer.fr/sismer/program/mater/).

- Medar/Medatlas II (Mediterranean and Black Sea Database/1999-2001) (http://www.ifremer.fr/medar/).

Databases with other types of data, useful for the interpretation of marine chemical data:

- The Clean Seas and Coasts online (http://www.thalassa.gr/2002/index.html) website contains information on the bathing water quality in Greece.

- EMWIS (http://www.emwis.org/), (http://kronos.minenv.gr/emwis/), National Data Bank of Hydrological and Meteorological Information (http://ndbhmi.chi.civil.ntua.gr/), MED-HYCOS (Mediterranean Hydrological Cycle Observing System) (http://medhycos.mpl.ird.fr/) contain hydrological-meteorological information for rivers.

- MFSTEP (Mediterranean Forecasting System Toward Environmental Predictions) (http://www.bo.ingv.it/mfstep/), CERSAT (http://www.ifremer.fr/cersat/en/welcome.htm) contain satellite observation data.

Conclusion

We found that there is little information on chemical oceanography in contrast to the physical and biological disciplines. The available data are mostly about basic chemical oceanographic parameters (pH, salinity, dissolved oxygen, etc) and nutrients but not main pollutants (i.e. trace elements, organic compounds). Therefore a new database is needed, focused on chemical oceanography and at the same time interlinked with databases of physical, geological or biological data.

Aim of the database: to record chemical oceanographic-marine pollution data for the Mediterranean region.

Characteristics of the database:

-free access to every user interested in such data (academics, decision-makers, NGOs, general public),

-possibility for continuous contribution of new datasets by researchers,

-two choices of presentation format according to the end-user (data tables or graphs-conclusions for users not interested on raw data)

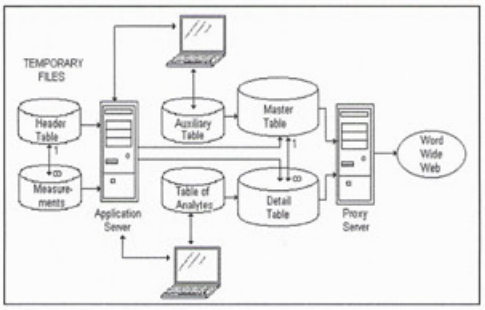

Figure 1 schematically presents the structure of the proposed database. The database will be built in the principles of master-detail tables.

Evaluation of the data: Data must follow the guidelines of IUPAC about minimum requirements for reporing analytical data for environmental samples [1]. The DB administrator will determine the format of the contributed data.

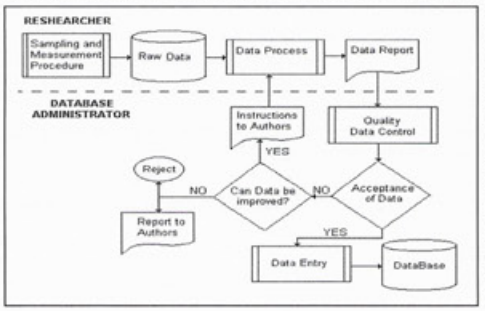

Figure 2 presents the operation flow chart for the proposed database. We believe that a database with chemical oceanographic data should be created under the auspices of an international organisation with long expertise on data processing and management. It should also have sufficient funding since the original database design/programming, the interconnection with other existing databases and the maintenance/constant expansion of the database require the permanent employment of adequate, specialised personnel.

References

1 - Egli H., Dassenakis M., Garelick H., Van Grieken R., Peijnenburg W.J.G.M., Klasinc L., Kördel W., Priest N., Tavares T., 2003. Minimum requirements for reporting analytical data for environmental samples (IUPAC Technical Report). *Pure Appl. Chem.*, 75: 8: 1097-1106.

ORGANOCHLORINE PESTICIDES AND PAHS COMPOUNDS OCCURRENCE IN MUSSEL AND FISH LIVER FROM BLACK SEA

Simona Dobrinas [1] *, Valentina Coatu [2], Elisabeta Chirila [1]

[1] Department of Chemistry, University "Ovidius" of Constantza, 124, Mamaia Blvd., 700, Constantza, Romania,
* sdobrinas@univ-ovidius.ro

[2] National Institute of Marine Researches and Development "Grigore Antipa", Bd Mamaia 300, 700, Constantza, Romania

Abstract

A method has been studied for the analysis of 9 POPs and 15 PAHs in mussel and fish liver from the Black Sea. The method was based on liquid-liquid extraction using n-hexane. The extracts were fractionated and cleaned up with a Florisil, respectively aluminium oxide and silica gel column. The concentrations of analytes were determined by gas chromatography with electron capture detection (GC-ECD), respectively by gas chromatography with mass spectrometer detector (GC–MS).

Keywords: POPs, PAHs, GC-ECD, GC-MS

Introduction

Many persistent, bioaccumulated POPs have been extensively used in many countries, but nowadays their use has been prohibited. Compounds such as DDT and diendrin have become globally enriched in food chains (1-3).

PAHs are widespread environmental contaminants and represent a very important group of chemical carcinogens (4). So, these pollutants pose a threat to human beings and aquatic organisms (5).

This study aims to evaluate the ocurrence of important organic contaminants, such as POPs and PAHs in biota (mussle and fish) collected from the Black Sea.

Sampling

Mussels' species samples (*Mytilus sp.*-M and *Scapharca sp.*-S) were collected from two different locations on the Romanian Black Sea coast (Midia -Mid and Vama Veche -VV). Fish species samples (*Apollonia melanostomus* -AM, *Ponticola cephalargoides* -PC, *Blennius sanguinolentus* -BS) were collected from three different locations in the Black Sea (Midia -Mid, Eforie Nord- EN and Agigea -Agi). All samples were collected in 2002. The samples were wrapped in polyetylene bags and frozen at 4°C.

A 5-10 g amount of fish and mussel liver was homogenized with anhydrous Na_2SO_4 and extracted with n-hexane in a Soxhlet device.

Extraction

The extracts were filtered and concentrated by rotary evaporator. In order to separate the PAHs, an aliquot of the extract was applied to 5 g of activated aluminium oxide and silica-gel column, respectively 5 g of activated Florisil column for POPs, topped with 1 cm of anhydrous sodium sulfate, which was pre-washed with n-hexane. The columns were eluted with n-hexane-dichlormethane (3:1). Each fraction was concentrate to 1 mL using the Kuderna – Danish concentrator. The concentrated aliquot was blown down with nitrogen, the internal standards (9,10 dihidroanthracene and trichlorobiphenyl) were added, and the final volume was injected.

Instrumental analysis

A HP 5890 gas chromatograph equipped with an electron capture detector (ECD) was used for POPs analysis. The separation was performed on a fused–silica capillary column HP–5, 30m×0.32mm×0.25µm film thickness.

PAHs analyses were performed using a HP5890 gas chromatograph interfaced to a HP5972 mass selective detector (6). The analyses were operated in SIM mode. Identification was made on the basis of matching the mass spectrum and the retention time of the compound to that of a known standard.

Results and discussion

Concentrations of POPs and PAHs measured in mussel and fish liver from Black Sea are given in Table 1 and Table 2. It can be observed that PAHs are the main contaminants in all samples. Aldrin was found at high levels, while HCB and heptachlor concentrations were low.

For fishes collected from the same location (Eforie Nord) it could be seen that AM contained higher amount of pollutants.

These analyses indicate that levels of HCB are much lower than concentrations measured in fishes from Danube Delta (7) and DDT was not detected comparatively with samples from Sea of Japan (8).

Table 1. Concentrations of PAHs and some POPs in the Black Sea biota.

Compound (ng/g)	Site	∑PAH	HCB	∑DDT	Heptachlor
M	VV	486.09	nd	nd	nd
S	Mid	49.63	nd	nd	nd
AM	EN	37.16	nd	nd	102.20
	Mid	262.57	nd	nd	89.11
BS	Agi	0.42	5.88	nd	nd
PC	Agi	168.82	8.28	nd	nd
	EN	57.85	nd	nd	nd

Table 2. Concentrations of some POPs in the Black Sea biota.

Compound	Site	Lindan	Aldrin	Endrin	Dieldrin
M	VV	430.43	787.52	286.52	nd
S	Mid	nd	660.61	nd	nd
AM	EN	65.34	1231.92	126.99	nd
	Mid	nd	287.20	118.49	nd
BS	Agi	nd	nd	nd	nd
PC	Agi	nd	nd	nd	nd
	EN	nd	nd	nd	nd

References

1 - Duke T.W., 1977. Pesticides in aquatic environments and overview. Plenum Press, New York, 257 p.

2 - Connor L., Johnson M.S., Copplestone D., Leah R.T., 2001. Recent trends in organochlorine residues in mussles (*Mytilus edulis*) from the Mersey Estuary. *Mar. Environ. Res.*, 52: 397-411.

3 - Garcia L.M., Porte C., albaiges J., 2000. Organochlorine pollutants and xenobiotic metabolizing enzymes in W. mediteranean mesopelagic fish. *Mar. Poll. Bulletin*, 40:764-768.

4 - Cooke M., Dennis A.J., 1986. Polynuclear aromatic hydrocarbons: chemistry, characterisation and carcinogenisis. Battle Press, Columbus, Ohio.

5 - Adamo R.D., Pelosi S., Trotta P., Sansone G., 1997. Bioaccumulation and biomagnification of polycyclic aromatic hydrocarbons in aquatic organisms. *Mar. Chem.*, 56: 45-49.

6 - Dobrinas S., Coatu V., Chitimiea S.C., 2002. Gas chromatography utilization for the pesticides determination in marine water. *Rev.Chim (Bucharest)*, 53: 630-633.

7 - Covaci A., Gheorghe A., Hulea O., Schepens P., 2002. Levels of organohalogenated pollutants in biota from the Danube Delta, Romania. *Organohalogen Compounds*, 59: 11.

8 - Syasina I.G., 2003. POPs in fish and mollusks from the lower reaches of the Tumen River and the adjacent areas of Peter the Great Bay, the Sea of Japan. *Biologya Morya*, 29: 34-40.

THE INFLUENCE OF THE BIOMETRIC PARAMETERS ON METAL AND METALLOTHIONEIN CONTENT IN THE CYTOSOL OF THE WHOLE SOFT TISSUE OF TRANSPLANTED MUSSELS

Zrinka Dragun*, Biserka Raspor, Marijana Erk, Dušica Ivanković and Jasenka Pavičić
Rudjer Bošković Institute, Center for Marine and Environmental Research, POBox 180, 10002 Zagreb, Croatia
* zdragun@rudjer.irb.hr

Abstract

The influence of two biometric parameters on metallothionein (MT) level in the cytosol of mussel's whole soft tissue was studied over the period of one year, as well as the correlation between the cytosolic levels of five metals (Cd, Zn, Cu, Mn and Fe) and MTs. MT level in the cytosol significantly depends on the mussel's physiological changes, but also positively correlates with Cd and Mn content. The correlation with Cd reflects the known Cd affinity for binding to MTs, while correlation of MTs with Mn is probably the reflection of the strong influence of soft tissue condition index on both parameters.

Key words: Mytilus galloprovincialis; trace metals; metallothionein; biometric parameters

Introduction

Metallothioneins (MTs) can function as storage proteins for essential metals, or as chelating agents to bind toxic metals, and essential metals when they are present in excess [1]. Although the synthesis of MTs depends on metal uptake in organism, other factors can influence it, as food availability or the reproductive cycle. Thus, the aim of our study was to define the connection between biometric parameters, MTs and metal content in mussels caged over one year.

Experimental

In September 1997, mussels Mytilus galloprovincialis of defined length (5.1±0.2 cm) and age (12±1 months) were implanted for one year in Kaštela Bay, and sampled monthly and bimonthly, from October 1997 to September 1998. As biometric parameters, soft tissue condition index (dry mass of whole soft tissue x 100 / shell mass), which varies during the reproductive cycle and with the food abundance [2], and the shell mass which reflects the aging process of mussels [3], were determined. Both MTs and metals were analyzed in the heat treated cytosolic fraction (S30) of the whole soft mussel tissue, and expressed as cytosolic tissue burden (mg and µg respectively). MTs were analyzed by electrochemical technique [4], and metals by flame atomic absorption spectrometry.

Results and discussion

The cytosolic tissue burdens of metals were ranked as follows: Zn>Fe>Cu>Mn>Cd. MT cytosolic tissue burden was comparable to the level of Cu.

Multiple regression analysis, explaining the influence of biometric parameters on the contents of all analyzed metals and MTs (Table 1), showed that the variability of Fe, Zn and Cd contents could only be slightly explained by biometry, and mostly as a consequence of mussel's age, while the changes of Cu content could not be attributed to the changes of neither of biometric parameters.

The strongest impact of biometric parameters was observed in the case of MTs and Mn. MT content could be related both to the aging process of mussels and to the changes of the soft tissue condition index. Although MT is a cellular ligand involved in homeostasis and detoxification of metals, it is also a protein, and it may be assumed that any factor which affects general protein metabolism may also affect MT level. For example, the higher food availability in the environment, which enhances somatic growth and, thereby, also the synthesis of total proteins, would be expected to affect the quantity of MTs, too [2]. Unlike MTs, Mn reflects only the changes in condition index of mussel's whole soft tissue. Strong, positive correlation between Mn and condition index ($r=0.75$; $p<0.00001$), indicates that this metal precisely follows the changes in tissue mass and makes an excellent indicator of mussel's physiological changes. Thus, it is not surprising that Mn positively, statistically significantly correlates with MTs (Fig. 1). Both parameters probably have important role in the physiological functions of mussel's tissues, which causes them to vary in accordance with the changes of the whole soft tissue mass. Frias-Espericueta *et al.* [5] suggested that Mn and protein content are influenced by reproductive cycle, and both increase with the gonadal maturation.

The fact that MT content increases with mussel's age, too, explains its positive correlation with Cd content (Fig. 1), which also shows increasing trend over the year. Since the accumulation of Cd takes place simultaneously with the enhanced synthesis of MTs, it is possible that Cd accumulation is a consequence of the age-induced MT synthesis, as it is known that metal uptake can be enhanced by the synthesis of metal-binding proteins, like MTs [6].

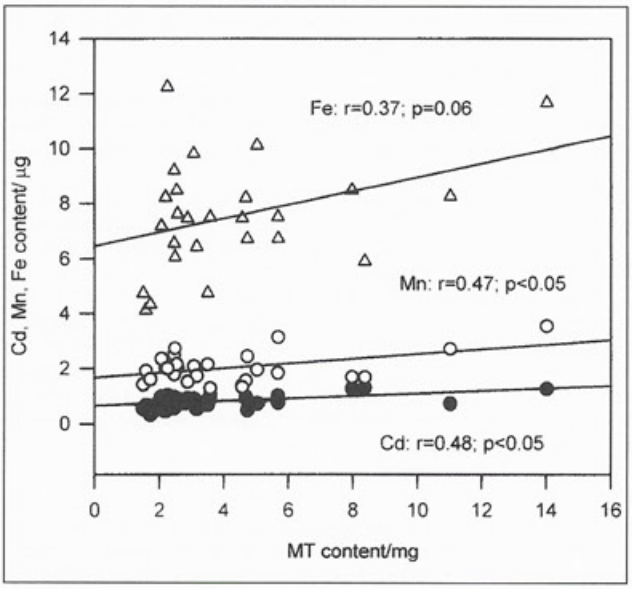

Fig. 1. Linear regression graphs: (MTs vs. Cd, and I MTs vs. Mn.

Table 1. Multiple linear regression analysis explaining the influence of biometric parameters on metal and MT content: p values for each biometric parameter and R^2 values for combination of two biometric parameters.

	Mn/ µg	Fe/ µg	Cd/ µg	Zn/ µg	Cu/ µg	MT/ mg
Shell mass/g p-value	0.037	0.007	0.029	0.081	0.704	<0.001
Soft tissue condition index/% p-value	<0.001	0.103	0.934	0.765	0.861	<0.001
R^2	0.61	0.23	0.14	0.06	0	0.59

References

1 - Carpene E., 1993. Metallothionein in marine molluscs. Pp. 55-72. *In*: Dallinger R., and Rainbow P.S. (eds.), Ecotoxicology of metals in invertebrates. Lewis Publishers, Boca Raton.

2 - Mourgaud Y., Martinez E., Geffard A., Andral B., Stanisiere J.Y., and Amiard J.C., 2002. Metallothionein concentration in the mussel *Mytilus galloprovincialis* as a biomarker of response to metal contamination: validation in the field. *Biomarkers*, 7: 479-90.

3 - Fischer H., 1983. Shell weight as an independent variable in relation to cadmium content of molluscs. *Mar. Ecol. Prog. Ser.*, 12: 59-75.

4 - Raspor B., Paić M., and Erk M., and Erk M., 2001. Analysis of metallothioneins by the modified Brdička procedure. *Talanta*, 55: 109-15.

5 - Frias-Espericueta M.G., Osuna-Lopez J.I., and Paez-Osuna F., 1999. Gonadal maturation and trace metals in the mangrove oyster *Crassostrea corteziensis*: seasonal variation. *Sci. Total Environ.*, 231: 115-23.

6 - Langston W.J., Bebianno M.J., and Burt G.R., 1998. Metal handling strategies in molluscs. Pp. 219-284. *In*: Langston W.J., and Bebianno M.J. (eds.), Metabolism of trace metals in aquatic organisms. Chapman & Hall, New York.

AFRICAN DUST DEPOSITION AND OCEAN COLOUR IN THE EASTERN MEDITERRANEAN

François Dulac *, Cyril Moulin, Hélène Planquette, Michael Schulz, Michael Tartar

Laboratoire des Sciences du Climat et de l'Environnement - CEA-Saclay 709, F-91191 Gif-Sur-Yvette Cedex, France - * fdulac@cea.fr

Abstract

We study the impact of Saharan dust deposition on chlorophyll concentrations in the Mediterranean using ocean colour products and simulated dust deposition fluxes. Chlorophyll increases follow most dust deposition events but dust fertilization and wind-related effects cannot be disentangled.

Keywords: Surface water fertilization, Dust deposition, Chlorophyll, SeaWiFS, LMDz-INCA.

Introduction

African dust deposition significantly contributes to soluble phosphorus inputs to Mediterranean surface waters (1), where it is the limiting nutrient, and probably sustains the marine productivity *(2)*. This work aims at investigating this possible fertilization of low productive Mediterranean waters.

Data and method

SeaWiFS daily level-3 maps (~9 x 9 km^2) of chlorophyll concentration ([Chl]) were obtained from NASA (3) for 1998 2000. Only part of the basin is observed every day because of clouds and orbital characteristics.

The atmospheric dust cycle was simulated at a resolution of 1.84° x 2.25°with LMDz-INCA, a 3-D AGCM coupled with chemistry and aerosols *(4)*. We extracted daily integrated dry and wet dust deposition fluxes ($F = F_d + F_w$).

We averaged [Chl] within the model grid (~600 pixels/cell) and selected four grid cells across eastern Mediterranean: Southern Central (SC: 18°E, 33.06°N), Eastern Central (EC: 22.5°E, 34.90°N), South-western Levantine (SL: 24.75°E, 33.06°N), and Northern Levantine (NL: 29.25°E, 34.90°N). We rejected days with ≤25% of pixels per grid cell. This left 50-60% of days and we filled gaps using a 7-day moving average.

Results and discussion

Maximum (resp. minimum) surface [Chl] at a given site varies between 0.20 and 0.34 (0.04 and 0.06) mg m^3. The seasonal cycle shows a winter maximum of 0.20±0.05 mg m^3 in January-February, with another, occasionally absolute, maximum in March (Fig. 1). [Chl] drops down in spring and remains low (0.05-0.10 mg m^3) from May to September. From October, [Chl] slowly increases to its winter maximum.

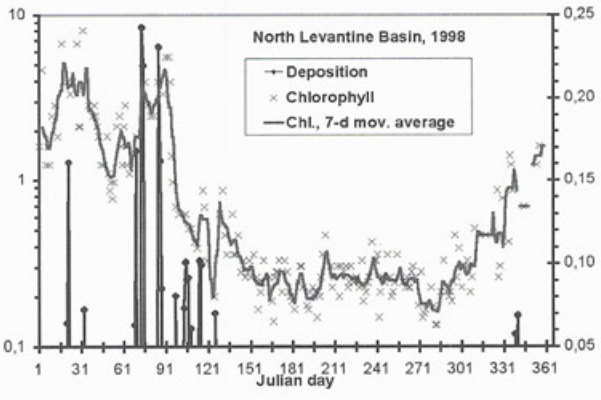

Fig. 1. Daily dust deposition, daily and 7d averaged chlorophyll at NL in 1998.

A dust outbreak generally causes high deposition at most sites. Overall range in F is 8.938.7 g m^2 yr^1, with a factor 2-3 of interannual variability at a given site, and no clear trend from one year or one site to the other. The fallout is controlled by a few wet deposition events ($F_w/F>93\%$). Maximum F_w of 15.7 g m^2 yr^1 is simulated at SC and $F_w>1$ g m^2 d is reached up to 9 d yr^1. F_d exceeds 0.1 g m^2 yr^1 for only 910 d yr^1, with a maximum of 1.24 g m^2 yr^1 at SL. Most of highest deposition events and annual deposition occur during March-May. Summer fallout never exceeds 0.25 g m^2 d^1. The simulated seasonal cycle is consistent with observations *(5,6)*.

Laboratory experiments support an increase of 8 mg Chl m^2 (or 0.08 mg Chl m^3 in a surface mixed layer of 100 m) per g m^2 of dust deposition *(7)* with a lag time of ~48 hours (8). For a summer dust deposition of 0.1 g m^2 in a mixed layer of 20 m, the expected increase is 0.04 mg Chl m^3. Our data set shows in accordance 0.020.16 mg m^3 increases in [Chl] shortly following dust fallout, and thus supports a dust fertilization of Mediterranean waters.

However, we also find a good correspondence between high surface winds and [Chl] peaks, and dust events are generally associated with wind peaks (Fig. 2). Surface wind controls the mixing between surface waters and deeper ones, richer in nutrients. Observed [Chl] increases can thus be contributed by both dust deposition and wind. Coupled biogeochemical-circulation model and appropriate in situ measurements are necessary to unravel both effects.

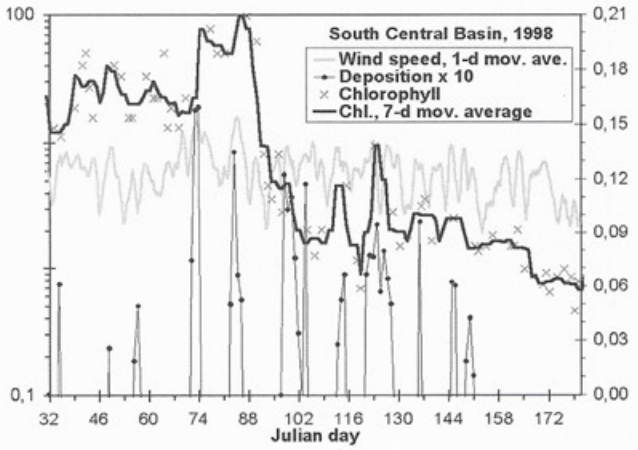

Fig. 2. Daily dust deposition, daily and 7d averaged chlorophyll, and wind speed at SC, between February 1 and June 30, 1998.

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References

1 - Bergametti G., et al., 1992. Source, transport and deposition of atmospheric phosphorus over the northwestern Mediterranean. *J. Atmos. Chem.*, 14: 501-513.

2 - Ridame C., and Guieu C., 2002. Saharan input of phosphate to the oligotrophic water of the open western Mediterranean Sea. *Limnol. Oceanog.*, 47: 856-869.

3 - http://seawifs.gsfc.nasa.gov/SEAWIFS.html

4 - Bauer S.E., *et al.*, in press. Global modelling of heterogeneous chemistry on mineral aerosol surfaces: The influence on tropospheric ozone chemistry and comparison to observations. *J. Geophys. Res.*

5 - Nihlén T., *et al.*, 1995. Monitoring Saharan dust fallout on Crete and its contribution to soil formation. *Tellus*, 47B: 365-374.

6 - Kubilay N., *et al.*, 2000. An illustration of the transport and deposition of mineral dust onto the eastern Mediterranean. *Atmos. Environ.*, 34: 1293-1303.

7 - Ridame C., and Guieu C., 2002. Saharan input of phosphate to the oligotrophic water of the open western Mediterranean Sea. *Limnol. Oceanog.*, 47: 856-869.

8 - Ridame C., 2001. Rôle des apports atmosphériques d'origine continentale dans la biogéochimie marine: Impact des apports sahariens sur la production primaire en Méditerranée. PhD diss., Univ. Paris-6.

SPATIAL AND TEMPORAL DISTRIBUTION OF HEAVY METALS IN DOWNWARD PARTICULATE MATTER FROM THE NORTHWESTERN ALBORÁN SEA

Mohamed El Khatab *, Albert Palanques, Pere Puig

Institut de Ciències del Mar (CSIC), Passeig Marítim de la Barceloneta, 37-49, 08003 Barcelona, Spain - * elkhatab@icm.csic.es

Abstract

Metal concentrations in settling particles within and around the Guadiaro submarine canyon were analysed to study spatial and temporal distribution of metals in the northwestern Alborán Sea. Ni, Cr, Al and Fe were associated to lithogenic components, whereas the Zn and Pb were related to the biogenic components. The heavy metals content decreases down-canyon and an important transfer towards the Western adjacent slope at the channel depth occurs, probably due to the alimentation from other canyons.

Keywords: particulate metal fluxes, Guadiaro submarine canyon.

Introduction

The FLUXALB project was conducted in the Guadiaro canyon and its adjacent continental slope. The main objective was to determine the vertical fluxes of particulate matter on the northwestern Alboran Sea, their composition, their spatial and temporal variability and the main processes controlling their variability. Previous studies have provided information of dissolved and particulate heavy metals (1), however, the seasonal variability of metal fluxes and contents in the settling particulate matter had not been studied before.

Sampling area and Methodology

Downward particulate matter was collected by means of five Technicap PPS3 sequential sediment traps (2) installed in three mooring sites. One of the moorings was deployed inside the Guadiaro canyon, at 592 m depth, with one sediment trap installed 25 m above the seafloor (5°10.135´W, 36°11.595´N). A second mooring was deployed at 717 m depth, in the Guadiaro channel (5°11.61'W, 36°09.30'N), equipped with three sediment traps located at 135, 500 and 692 m depth respectively. A third mooring site was located at the open slope westward from the Guadiaro canyon (5°11.61' W, 36°08.39'N) at 720 m water depth with a sediment trap 25 m above bottom. The total sampling period comprised of 348 days.

The total sample was divided following the method described by (2). To analyse the heavy metal content, particulate matter samples were totally digested according to (3). MESS-3 was used as a Certified Reference Material (National Research Council Canada). Two major elements (Al and Fe) were analysed by inductively coupled plasma atomic emission spectrometry (ICP-AES), whereas four trace elements (Cr, Ni, Zn and Pb) were determined by inductively coupled plasma mass spectrometry (ICP-MS).

Results and discussion

Mean heavy metal contents in the downward particulate matter of the Guadiaro canyon and its western adjacent slope are shown in Table 1. During the autumn-winter period, the concentration of Al, Fe, showed an increasing trend. During this period there were two Guadiaro river avenues that produced significant increases of total mass fluxes. In the first event (late December) there was not a significant metal increase, but in the second (early February) there was an important increase of Ni and Cr contents (around twice) and also a slight increase of Fe and Al. This second avenue coincided with a storm, suggesting that the increases of Ni and Cr were produced by resuspension of shelf sediments that have high contents of these metals. The more general Al and Fe increases are more related to the increase of lithogenic inputs produced by the stronger wave climate during the winter season. During the spring-summer period, the Al and Fe contents decrease indicating a reduction of terrigenous input as a consequence of lower river discharge and the absence of storms in this season. This decrease is more evident in the settling particulate matter of the most superficial level (135 m depth) at the channel site.

Table 1. Mean contents of trace metals in particulate matter recollected by sediment traps in the study area

		Cr (µg/g)	Ni (µg/g)	Zn (µg/g)	Pb (µg/g)	Al (%)	Fe (%)
Canyon trap near bottom (592 m)	Spring-summer	142.4	103.6	144.3	44.5	7.9	4.1
Channel trap near surface (135 m)	Autumn-winter	125.5	70.1	155.3	44.6	7.4	4.2
	Spring-summer	112.5	74.5	202.6	50.1	5.8	3.2
Channel trap mid depth (500 m)	Autumn-winter	137.7	77.6	160.0	50.7	5.9	4.2
	Spring-summer	123.9	76.5	179.9	50.8	7	3.8
Channel trap near bottom (692 m)	Autumn-winter	126.2	68.1	140.4	49	7.8	4.1
	Spring-summer	110.2	66.4	179.5	56.9	6.6	3.5
Open slope trap near bottom (720 m)	Autumn-winter	131.1	83.7	157.3	36.4	8	4.3

During summer, a maximum of Zn content was recorded (end of August of 1998). This increase of Zn concentration was not associated to any river avenue, storm or mass flux increase. The positive correlation of Zn and Pb with OC and biogenic silica, and the negative correlation of Zn with Al, indicate that Zn and Pb are mainly associated to biological components.

Near the bottom along the canyon axis, the mean Cr, Ni, Fe and Al contents tend to decrease with depth between the canyon and the channel sites, whereas, the Zn and Pb contents increase as well as organic matter and biogenic silica content. This indicates the decrease of the influence of the terrigenous components versus biogenic components down canyon.

Near the bottom, at the open slope, the mean heavy metal contents were slightly higher than those of the Guadiaro channel at the same depth during autumn-winter, which could be related to particulate matter inputs from the western adjacent submarine canyon (La Línea canyon).

Conclusion

In the study zone, Ni, Cr, Al and Fe were clearly associated to terrigenous components, whereas Zn and Pb to the biogenic components. The storm-river avenue episodes produce increases in terrigenous metals like Cr and Ni. Zn increases were associated to biological productivity blooms that occurred during spring and summer.

References

1 - Van Geen A., Boyle E. A., 1990. Variability of trace metal fluxes through the Strait of Gibraltar: *Paleogeo. Paleocli. Paleoeco.*, 89: 423-426.

2 - Heussner S., Ratti C. and Carbonne J., 1990. The PPS 3 time-series sediment trap and the trap sample processing techniques used during the ECOMARGE experiment. *Cont. She. Res.*, 10: 943-958.

3 - Puig P., Palanques A., Sánchez-Cabeza J.A., and Masqué P., 1998. Heavy metals in particulate matter and sediments in the southern Barcelona sedimentation system. *Mar. Chem.*, 63: 311-329.

DOWNWARD PARTICLE FLUXES IN A SUBMARINE CANYON OF THE NORTHWESTERN ALBORÁN SEA: THE GUADIARO SUBMARINE CANYON.

Mohamed El Khatab *, Albert Palanques, Pere Puig, Enrique Isla

Institut de Ciències del Mar (CSIC), Passeig Marítim de la Barceloneta, 37-49, 08003 Barcelona, Spain - * elkhatab@icm.csic.es

Abstract

Total mass flux (TMF) within the Guadiaro canyon and its western adjacent slope showed an important seasonal variability, ranging more than two orders of magnitude. Two peaks of downward mass fluxes occurred in winter coinciding with events of increasing Guadiaro River discharge. Particle fluxes in the open slope showed a similar variability and were slightly higher than fluxes measured at the same depth within the Guadiaro channel, indicating common sediment transfer processes within and outside the channel. During the autumn-winter period, the lithogenic content was high and relatively constant while during the spring-summer period the opal and organic carbon content increased both in magnitude and variability. Peaks of biogenic constituents were associated to biological blooms.

Keywords: Downward particles fluxes, Guadiaro canyon.

Introduction

Spatial and temporal studies of downward particle fluxes have been carried out in several continental margins of the world. The main objective of these studies has been the understanding of the continent-ocean sediment transfer and its role in the marine biogeochemical cycles, especially that of carbon. Direct observations of the temporal variation of the organic carbon fluxes in the Alborán Sea are scarce, despite the important role that this area has in the Mediterranean Sea.

Material and method

Five Technicap P.P.S/3 sediment traps (1) were deployed in three mooring lines inside and outside a submarine canyon system of the north-west Alborán continental margin, in the framework of the FLUXALB Project (Fig. 1): The Guadiaro canyon and open slope moorings were deployed at 592 and 720 m depth respectively and were equipped with one sediment trap each one installed 25 m above bottom. The Guadiaro channel mooring was deployed at 692 m depth and included three sediment traps installed at 135, 500 and 667 m depth respectively. The overall duration of the deployment was 12 months (from November 1997 to October 1998).

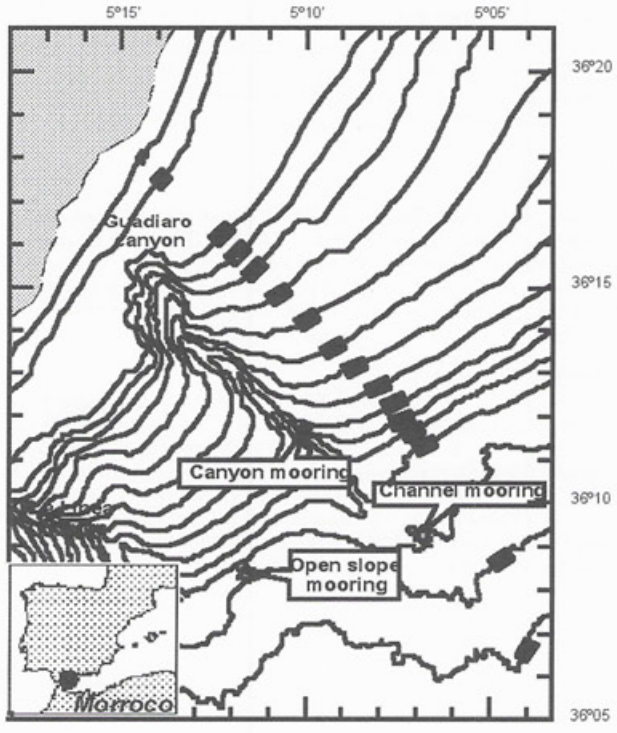


Fig. 1. Map of sampling locations.

Subsampling and TMF were estimated according to the method described in (1). The total carbon (TC) and nitrogen were determined by a LECO CN 2000 analyser. The inorganic carbon (IC) was obtained by acid digestion (HCL 6M) in a LECO CC-100. The difference between the (TC) and (IC) is defined as the organic carbon (OC). Biogenic silica (opal) content was obtained using a wet-alkaline extraction with sodium carbonate (2).

Result and discussion

TMF showed an important variability ranging more than two orders of magnitude (from 101,3 mg m^{-2} d^{-1} to 27397.7 mg m^{-2} d^{-1}). The OC content ranged from 1.38 % (in mid May, 1998) near the bottom in the canyon site to 8.11 % (May, 1998) near the surface at the channel site. The temporal evolution of OC content and TMF revealed an opposite trend. The higher OC content were measured during spring and summer, when the TMF was lower. The lowest opal content (1.77 %) corresponded to late December 1997 in the slope site, whereas the high opal content (12.93 %) to late June 1998 at mid depth at the channel site. The opal content increased in spring and summer, showing the maximum values between June and August, except near the bottom, where it increased mainly in August.

In the water column, particle fluxes in the Guadiaro canyon system showed an increasing trend with depth. Near the bottom, the downward particle fluxes decreased drastically from the canyon site to the channel site indicating either sedimentation of particulate matter within the canyon or along-slope particle dispersion outside the canyon before reaching the channel area. Near the bottom and at mid depth, the main TMF increases were related with increases of the river discharge. Storms events alone were not related with TMF increases. During May-June 1998, high fluxes (27.4 g $m^{-2}d^{-1}$) were recorded in the canyon site, which appear to be associated with resuspension processes caused by internal waves (3). The high near-bottom fluxes recorded in the western adjacent open slope are related either with inputs overflowed from the Guadiaro channel and/or from the adjacent submarine canyons besides those transported along slope directly from the shelf.

The downward particle fluxes reflected clear seasonal variation with maximum values in winter and minimum in summer and autumn. TMF variability is very similar near the bottom and intermediate depth, indicating near-bottom lateral particle transport and suspended particles detachments along the canyon. Near the surface (135 m) the flux variability differs from the other studied levels and there are only simultaneous high particle fluxes in November and December coinciding with the flood and stormy season.

The temporal distribution of the constituents had also a clear seasonal character. During the autumn-winter, the lithogenic content and the total mass fluxes were high and relatively constant at all the studied levels (near-bottom, intermediate and near-surface depths) as a consequence of the lateral transport and particulate matter detachments from the continental shelf and slope.

During spring and summer the content of biogenic constituents increased due to phytoplancton blooms and lower inputs of terrigenous constituents. Higher content of biogenic constituents corresponded to low TMF. However, whereas the higher OC contents were recorded near the surface, the higher opal contents were found in near-surface, intermediate and near-bottom waters indicating perhaps a better preservation of biogenic silica during settling in the water column.

References

1 - Heussner S., Ratti C., and Carbonne J., 1990. The PPS 3 time-series sediment trap and the trap sample processing techniques used during the ECOMARGE experiment. *Cont. She. Res.*, 10: 943-958.

2 - Mortlock R.A., and Froelich P.N., 1989. A simple method for the rapid determination of biogenic opal in pelagic sediments. *Deep-Sea Res.*, 36 (9): 1415-1426.

3 - Puig P., Palanques A., Guillén J., El Khatab M. 2002. The Role of Internal Waves in the Generation of Intermediate and Bottom Nepheloid Layers Within and Around the Guadiaro Submarine Canyon. Eos Transactions AGU, 83 (47), Fall Meeting Supplement, Abstract OS11C-0244. San Francisco, California.

POTENTIAL TOXICITY OF SEAWATER ALONG ADRIATIC COAST, CROATIA

Maja Fafandel *, Nevenka Bihari, Milena Micic, Renato Batel

Center for Marine Research, Rudjer Boškovic Institute, G. Paliaga 5, HR-52210 Rovinj, Croatia - * maja@cim.irb.hr

Abstract

The potential toxicity of organic extracts from 12 seawater samples per 24 sampling sites, collected during 1999-2001 period along Adriatic coast, Croatia, was analyzed by Microtox[7] bioassay. Discrimination between sampling sites according to their potential seawater toxicity was achieved by cluster analysis. The water quality of selected sites could be described as excellent at one sampling site (mean EC50 > 625), good at 15 sampling sites (375 < mean EC50 < 625) and fair at 8 sampling sites (EC50 < 375).

Keywords: Adriatic Sea, Microtox[7], seawater toxicity

Introduction

The Adriatic sea, as a semienclosed part of the Mediterranean Sea is of special interest for an evaluation of environmental pollution. We hypothesized that by assesing the potential toxicity of seawater collected at 24 sites along Adriatic coast (Croatia) four times per year for 3 years, one could get a better insight into the general seawater quality at each sampling site. Physical-chemical properties of the Split region waters showed to be the most polluted along the Croatian Adriatic coast (1). The levels of PCBs from the Adriatic Sea sediment samples (1976-1992) were significantly lower compared to samples from areas of the south coast of France, west coast of Italy and east coast of Greece (2).The aim of the study was to determine the potential toxicity load of the main "hot spots" along the Adriatic coast, Croatia. Cluster analysing was introduced for discrimination between groups according to their toxicity load.

Materials and methods

The investigated sites were along Adriatic coast, Croatia, in the vicinity of urban and industrial areas (Rijeka, Zadar, Šibenik, Split, Dubrovnik) under the influence of human activities. For potential toxicity testing, seawater was collected at: mariculture (site 1), protected (sites 2, 3), urban (sites 8, 9, 10, 11, 13, 14, 15, 18), industrial (sites 16,17), harbour (sites 4, 5, 6, 7, 12, 19, 24) and brackish (sites 20, 21, 22, 23). Surface seawater was collected at 0.5 m depth at each sampling site in March, June, August and October from 1999 - 2001. Non-polar compounds were extracted (3), dissolved in DMSO (300 µl) and stored at -20 °C. Decline in luminescence of marine bacterium Vibrio fischeri NRRL B-11177 (DIN EN ISO 11348-3) was measured in the Microtox[7] bioassay. Maximal tested amount corresponded to 1250 ml of seawater.The results were expressed as ml of seawater causing a 50% reduction of bioluminescence after 15 minutes (EC50). To detect groupings in EC50 data (minimum, maximum, mean and median) a cluster analysis (complete linkeage method, Euclidean distances) was applied. To verify the groupings K-means clustering was performed.

Results and discussion

Microtox[7] bioassay provides a response to a single toxicant or a combined effect of many toxicants when their concentration exeeds treshold limit. It was succesfully applied for detection of sediment and seawater toxicity (4, 5, 6) as well as for accidental toxic events (7).We observed broad range and high variation of EC50 values at each investigated site. Due to the high standard deviations at each sampling site, Kruskal-Wallis test showed no statistical differences between sampling sites. Therefore, the cluster analysis as a multivariate procedure for detecting natural grouping of data was performed. Hierarchical tree sorted samling sites in clusters in such a way that sites with similar toxicity data appear in the same cluster while sites with dissimilar toxicity data in different clusters (Fig. 1). Three-group K-means method produced partitioned clusters identical to 3 clusters (each case $p<0,05$) separated at 60% similarity in the joining tree. First cluster comprise sampling site 21 with mean EC > 625 ml (Fig. 2), second cluster 15 sampling sites (2, 3, 6, 7, 8, 9, 10, 12, 13, 16, 18, 19, 22, 23, 24) with 375 < mean EC50 < 625 and third cluster comprised 8 sampling sites (1, 4, 5, 11, 14, 15, 17, 20) with mean EC50 < 375. Our investigation based on determination of potential toxicity of seawater organic extracts mirrored the present status of seawater quality and background levels of potential toxicity at 24 selected sites along Adriatic coast, Croatia.

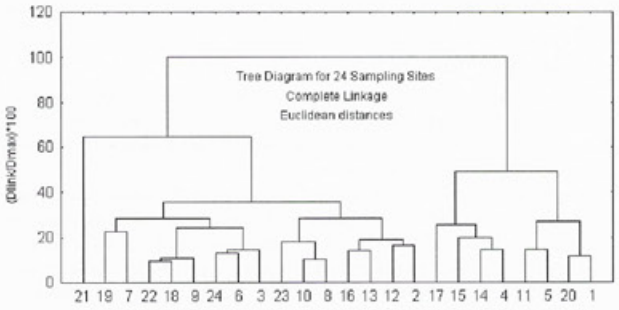


Fig. 1. Cluster analysis tree diagram of toxicity data (EC50) obtained from 12 samplings at 24 investigated sites along Adriatic coast, Croatia.

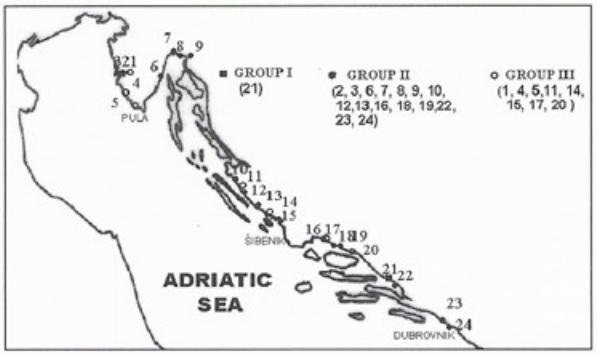


Fig. 2. Classification of 24 sampling sites along Adriatic coast, Croatia according to seawater toxicity: group I - mean EC50 > 625, group II - 375 < EC50 < 625, group III - EC50 < 375.

References

1 - Vukadin I., Stojanovski L.1998. Proceedings: Present water quality of Kastela Bay (Adriatic Sea) and some proposal for its protection and improvement. Kastela kolijevka Hrvatske, Matica Hrvatska, Kastela. ISBN 963-6370-10-7.

2 - Picer M., Picer N. 1997. DDT and PCBs levels and long-term trends in sediments collected from the eastern coastal and open waters of the Adriatic Sea. *Organohal. Comp.,* 32: 198-203.

3 - Hamer B., Bihari N., Reifferscheid G., Zahn R.K., Muller W.E.G., Batel R. 2000. Evaluation of the SOS/umu-test post-treatment assay for the detection of genotoxic activities of pure compounds and complex environmental mixtures. *Mutat. Res. Gem. Tox. En.*, 406(2):161- 171.

4 - Quinou F., Judas A., Lesquerande E. 1997.Assesment of potential toxicityin estuary water and sediments in the Bay of Brest using two types of bioassay. *Ann. Inst. Oceanogr.,* 73:35-48.

5 - Passarini F., Rampazzo G., Ghirardini A.V., Sperni L., Salizzato M., Pavoni B. 2000. Extraction, identification and quantification of heavy metals in Venice Lagoon sediments using toxicity tests with microorganisms. *Ann. Chim.,* 90: 91-101.

6 - Boluda R., Quinanilla J.F., Bonilla J.A., Saez E., Gamon M. 2002. Application of the Microtox test and pollution indeces to the study of toxicity in the Albufera Natural Park, Valencia, Spain. *Chemosphere* , 46: 355-369.

7 - Bihari N., Najdek M., Floris R., Batel R., Zahn R.K. Sediment toxicity assesment using bacterial bioluminescence: effect of an unusual phytoplankton bloom. *Mar. Ecol. Prog. Ser.,* 37: 307-310.

INFLUENCE OF ORGANIC AND METALLIC POLLUTION ON ANTIOXIDANT ENZYME LEVELS OF THE MEDITERRANEAN MUSSEL *MYTILUS GALLOPROVINCIALIS*

Fernandez B., Benedicto J. and Campillo J.A. *

Instituto Español de Oceanografía. IEO. 30740. San Pedro del Pinatar. Murcia. Spain - bea.fernandez@mu.ieo.es

Abstract

The aim of this study was to evaluate the usefulness of antioxidant enzyme levels as a biomarker of exposure to environmental pollutants in Mediterranean mussel, *Mytilus galloprovincialis*. The relation of antioxidant enzymes with contaminant body burden (PAHs, PCBs, DDTs and heavy metals) were determined. The examined biological responses included the activities glutatione reductase (GRx), selenium-dependent glutathione peroxidase (Se-GPx), non-selenium-dependent glutathione peroxidase (total-GPx), catalase (CAT), superoxide dismutase (SOD) and DT-diaphorase (DTD).

Keywords: Mediterranean Sea, Mytilus galloprovincialis, antioxidant enzymes

Introduction

Bivalve molluscs, and in particular mussel, are widely used as sentinels for pollution monitoring in coastal environments. These filter-feeding sedentary species are known to accumulate high levels of contaminants in their tissues.

Several studies have been carried out to identify alterations which could represent useful diagnostic biomarkers of exposure to contaminants or toxicity induced by selected classes of toxicants. In this context, the accumulation of contaminants in mussels tissues could enhance the levels of reactive oxygen species. Specific antioxidant enzymes such as CAT, SOD or DTD function to prevent the formation of oxyradicals, thus protecting the organisms from oxidative stress. This work examines the effects of environmental levels of organic and metallic pollutants on antioxidant enzymes in *Mytilus galloprovincialis*, to support the use of this biochemical responses as biomarkers of exposure in monitoring pollution studies.

Material and methods

Mussels, *Mytilus galloprovincialis* (3-4 cm) were sampled in May-June 2001 from fifteen sites of the Iberian Mediterranean Coast (Fig. 1). Animals were collected and their digestive glands dissected out for biochemical analysis and frozen in liquid nitrogen.



Fig. 1. Map of study area and sampling sites.

Enzyme measurements were carried out on cytosolic fractions prepared by differential centrifugation (1), on five pools constituted by the organs of eight individuals. CAT, SOD, GRx, Se-GPx and total-Se-GPx activities were measured essentially as described by Regoli and Principato (2); DTD activity was assayed as reported by Benson *et al.* (3).

The chemical data (PCBs, PAHs and heavy metals) used for correlation studies were determined in whole mussel tissues and belong to the chemical monitoring study made by IEO.

Results and discussion

The results of the correlation analysis showed a significant positive correlation between the different enzymatic activities studied (Fig. 2). GRx activity correlated with antioxidant activities SOD, DTD and CAT, while Se-GPx activity showed an important correlation with total-GPx activity. These correlations indicate a similar induction pattern in the different mussel populations.

Comparisons between the chemical and biochemical data were made in order to establish the influence of PAHs, PCBs and metals concentrations on the enzymatic responses (Fig. 2). Zinc was positively correlated to CAT, SOD and GRx activities, while cadmium levels were correlated to SOD activity. However, no significant relationship was observed between Cu and the biochemical responses. By the contrary, several studies with transplanted and Cu-exposed mussels showed a decrease of antioxidant activities in digestive gland (2). This finding suggests that the induction of the antioxidant activities is an adaptation mechanisms in mussels chronically exposed to Zn and Cd.

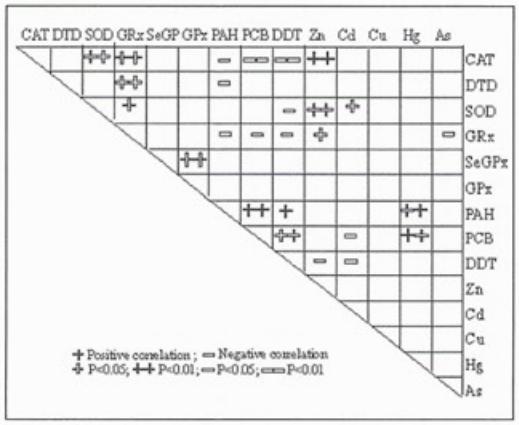


Fig. 2. Correlation matrix of enzymatic activities, organic contaminants and metals.

These activities were also markedly influenced by environmental levels of organic pollutants. GRx and CAT activities displayed a negative correlation with PAHs, PCBs and DDTs concentrations, while DTD and SOD activities showed a similar negative correlation with PAHs and DDTs, respectively. These results agree with the decrease on antioxidant enzymes detected in transplanted mussels to areas contaminated by PAHs, PCBs and DDT (4).

Conclusion

This study shows an important relationship between antioxidant enzymes and exposure to organic contaminants and heavy metals. Whereas Cu and Zn exposure increased some of these enzymatic activities, the accumulation of organic contaminants depressed the antioxidant defences. This general decrease of the antioxidant parameters may reveal a toxic effect on these organisms. Thus, this results support the use of antioxidant enzymes as biomarkers of the biological effects of pollutants in marine environment.

References

1 - Stegeman J.J., 1985. Benzo(a)pyrene oxidation and microsomal enzyme activity in the mussel (*Mytilus edulis*) and other bivalve mollusc species from the Western North Atlantic. *Mar. Biol.*, 89:21-30.

2 - Regoli F. and Principato G., 1995. Glutathione, glutathione-dependent and antioxidant enzymes in mussel, *Mytilus galloprovincialis*, exposed to metals under field and laboratory conditions: Implications for the use of biochemical biomarkers. *Aquat.Toxicol.*, 31:143-164.

3 - Benson A.M., Hunkeler M.J. and Talalay P., 1980. Increases of NAD(P)H: quinone reductase by dietary antioxidants. Possible role in protection against carcinogenesis and toxicity. *Proc. Natl Acad. Sci.*, 77: 5216-5220.

4 - Cossu C., Doyotte A., Babut M., Exinger A. and Vasseur P., 2000. Antioxidant biomarkers in freshwater bivalves, *Unio tumidus*, in response to different contamination profiles of aquatic sediments. *Ecotoxicol. Environ Saf.*, 455:106-121

MERCURY AND RADIONUCLIDES IN SEDIMENTS OF THE KASTELA BAY (CROATIA) : EVALUATION OF THE SEDIMENT POLLUTION HISTORY.

D. Foucher [1], S. Niessen [2], J-C. Fischer [2], Z. Kwokal [3], D. Barisic [3] and N. Mikac [3] *

[1] Department of chemistry, University of Trent, 1600 West Bank Dr., Peterborough, Ontario, K9J 7B8, Canada
[2] Laboratory for Analytical and Marine Chemistry, UMR 8013 CNRS, University of Science and Technology of Lille, Villeneuve d'ascq, France
[3] Center for Marine and Environmental Research, Rudjer Boskovic Institute, Zagreb, Croatia

Abstract

Mercury and radionuclides (^{226}Ra, ^{238}U and ^{137}Cs) were measured in sediments of the Kastela bay (Eastern Adriatic Coast), polluted with mercury by the chlor-alkali plant. From depth distributions of ^{238}U, ^{226}Ra and Hg it was revealed that sediment represents a mixture of natural sediment (rich in Hg) and ash (poor in Hg and rich in radionuclides) from coal used in the factory power plant. Distribution of ^{137}Cs showed that sediment up to a depth of 50 cm was younger than 1986, meaning that dumping of the coal ash to the sea took place after this year.

Keywords: mercury, radionuclides, Kastela bay, pollution history

Introduction

Kastela bay is a semi-enclosed bay, situated in the central part of the Eastern Adriatic coast, which is heavily polluted with mercury by 40-years activity (1949-1989) of the chlor-alkali plant. High concentrations of total and methyl mercury were demonstrated in sediment and marine organisms of this area (1). Although the factory is closed already for more than 10 years, mercury buried in sediment still represents an important source of this metal for the whole ecosystem (2). In order to elucidate the fate of mercury deposited in sediment and to evaluate pollution history of the area, sediment cores sampled in front of the chlor-alkali plant were analyzed for mercury and radionuclides content.

Sampling and methods

Sediment cores were sampled in June 2000, February and October 2001 at a distance of 100 m from the chlor-alkali plant. Cores, 20 to 50 cm long, were sliced onto 2 to 5 cm thick layers. A portion of each sediment slice was dried at room temperature for Hg analysis and another one at 106 °C for radionuclide analysis. After wet digestion of sediment with concentrated HNO_3, mercury was determined by CVAFS (cold-vapor atomic fluorescence spectrometry). For radionuclides a HPGe detector connected to a 4096 channel analyzer was used. Spectra were recorded for 80000 s and analyzed on PC using GENIE 2000 software.

Results and discussion

Mercury distribution in sediments sampled in front of the chlor-alkali plant demonstrated anomalous behavior – an absence of correlation with organic carbon (C_{org}), a strong positive correlation with inorganic carbon (C_{inorg}) and very irregular depth distribution. Results of radionuclides analyses (Table 1) revealed that this sediment was highly contaminated with ^{226}Ra and ^{238}U, in comparison with the Adriatic Sea sediments (3), and that a negative correlation existed between Hg and radionuclides. Typical sediment depth profiles of Hg and radionuclides (Fig. 1) illustrated opposite depth distributions of Hg and ^{226}Ra or ^{238}U. On the basis of all data obtained from 4 different sediment cores, it was reconstructed that the ash from the coal used in the factory power plant was dumped to the sea and that analyzed sediments represented a mixture of such artificial material and natural sediment. Obtained negative correlations between Hg, C_{inorg} and ^{226}Ra or ^{238}U were a consequence of mixing coal ash, which was low in Hg and C_{inorg} and high in radionuclides, with natural sediment, which was high in Hg and C_{inorg} and low in natural radionuclides content (Table 1). It was estimated that sediment contained between 15 and 80 % of the coal ash and analyzed sediment cores demonstrated that sediment and ash were mixed in very irregular manner, regarding both spatial and depth distributions.

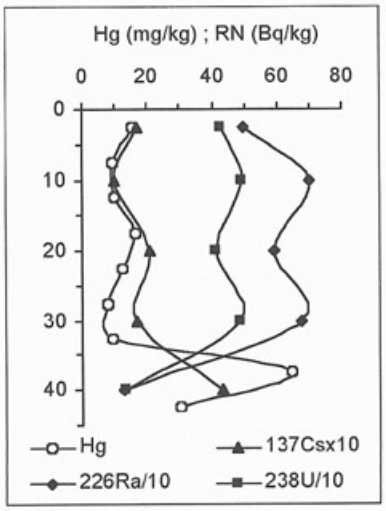


Fig. 1. Depth distributions of Hg and radionuclides in sediment core sampled in February 2001.

Table 1. Average concentrations of some parameters in coal ash, sediments from the Kastela bay and, for comparison, in sediments from the Adriatic Sea (KB - Kastela bay; AS – Adriatic sea).

Sample type	Hg (mg/kg)	C_{inorg} (g/kg)	C_{org} (g/kg)	^{226}Ra (Bq/kg)	^{238}U (Bq/kg)	^{137}Cs (Bq/kg)
Coal ash	1.9 ± 0.2	14 ± 2	38 ± 2	1350 ± 80	832 ± 36	0.9 ± 0.1
KB sediment	28 ± 14	26 ± 12	54 ± 6	460 ± 145	345 ± 110	2.4 ± 1.2
AS sediment	0.1 – 0.4	45 – 90	10 – 20	10 – 30	10 – 40	1 – 15

Data on ^{137}Cs content (Table 1, Fig. 1) showed that sediment was characterized with relatively large range of ^{137}Cs activity (0.5 – 5.0 Bq/kg) and that ^{137}Cs was positively correlated with Hg. Very similar depth profiles of ^{137}Cs and Hg obtained in analyzed sediment cores (Fig. 1) illustrate this correlation. The obtained positive correlation confirm the a consequence of mixing the coal ash with low ^{137}Cs content with sediment that contained much higher ^{137}Cs concentrations (Table 1). Sediment containing low percentage of ash at the bottom of the sediment core (Fig. 1) had high ^{137}Cs concentration (about 5.0 Bq/kg) which was typical for sediments deposited after the Chernobyl accident. Accordingly, it was concluded that dumping of the coal ash to the sea took place after 1986.

These results did not allowed a more precise dating of the mercury pollution history of the area due to artificial nature of the investigated sediments. For this purpose longer sediment cores at various distance from the factory should be analyzed. However, obtained results explained well recent pollution history of the investigated sediment and for the first time demonstrated that the Kastela bay is heavily polluted not only with mercury, but also with radionuclides.

References

1 - Mikac, N., Picer, M., Stegnar, P. and Tusek-Znidaric, M., 1985. Mercury distribution in polluted marine area, ratio of total mercury, methyl mercury and selenium in sediments, mussels and fish. *Water Res.*, 19: 1387-1392.

2 - Kwokal, Z., Franciskovic-Bilinski, S., Bilinski, H. and Branica, M. 2002. A comparison of anthropogenic mercury pollution in Kastela Bay (Croatia) and pristine estuaries in Ore (Sweden) and Krka (Croatia). *Mar. Pollut. Bull.*, 44: 1150-1155.

3 - Barisic, D., Vertacnik, A., Lulic, S., Mihelcic, G., Sondi, I., Juracic, M., Prohic, E. and Crmaric, R., 1998. Natural radionuclides in recent marine sediments of the Adriatic Sea. *Rapp. Comm. int. Mer Medit.* 35: 228-229.

HEAVY METAL CONCENTRATIONS IN THE SEA SURFACE MICROLAYER AND ASSOCIATED NEUSTON IN NW MEDITERRANEAN WATERS

S.W. Fowler *, E. Wyse, J.C. Miquel, B.Gasser, R. Cassi, S. Azemard & S. de Mora

IAEA Marine Environment laboratory, 4 Quai Antoine 1er, Principality of Monaco - * S.Fowler@iaea.org

Abstract

Analyses of Barcelona and Banyuls-sur-mer coastal waters indicated that heavy metal concentrations were generally higher in the surface microlayer (SML) than in the underlying waters. The highest concentrations of many metals in the SML were noted in one sample from Barcelona that may have been influenced by the presence of oil slicks. The relatively elevated levels of metals such as Zn, Pb and Cu in neuston from Barcelona are likely a reflection of the high SML enrichment factors of these metals (Zn, 12X; Pb, 21X; Cu, 35X).

Key words: metals, surface microlayer, neuston

Introduction

The sea surface microlayer (SML) plays a key role in material transfers between the atmosphere and ocean (1). Furthermore, the SML (i.e. top few hundred microns) is often enriched in trace metals relative to the underlying waters, and therefore could lead to metal enrichments in biota living in this layer (2); however, a general understanding of the impact of anthropogenic activities on the sea surface ecosystem is far from clear. For the Mediterranean, very little information is available on trace element chemistry of the SML and even fewer data exist on trace element concentrations in the neustonic community inhabiting the SML. Therefore, within the EU-sponsored AIRWIN project, selected heavy metals were measured in the SML, subsurface waters (SSW) and associated neuston from two contrasting sites that were considered as relatively "polluted" (Barcelona) and "clean" (Banyuls sur Mer).

Material and Methods

Sampling

SML samples were collected from the upper 40-50 µm using glass plate and ultra clean techniques (2), and stored in acid-cleaned 250 ml Teflon bottles. For collecting SSW, bottles were capped, immersed ~0.5 m below the surface, opened and re-capped under water.

Neuston was collected by towing a pre-cleaned neuston net 15 m behind an inflatable rubber boat. Samples were carefully examined, subsequently cleaned of detritus, and freeze-dried.

Analyses

Water samples were diluted 20X with milli-Q water and the dilutions analysed directly for trace metals by high resolution ICP-MS using a microconcentric nebulizer and a standard double-pass condensing spray chamber (3). In addition to direct analysis, a modified preconcentration method employing hydrated Chelex-100 resins was also used (4). CASS-4 seawater reference material was analysed along with all samples as a check on the analytical accuracy.

Weighed neuston was placed in Teflon vessels and digested in concentrated HNO_3 - HF for ~40 minutes at 200 °C. The samples were brought to 50 mL volume with Milli-Q water and analysed by ICP-MS. Standard reference materials were also analysed with each run.

Results and discussion

In general, most metal concentrations in the SSW were quite uniform at both sites (Table 1) except for one of the samples taken off Barcelona that contained higher concentrations of nearly all the metals, possibly a reflection of the greater suspended particulate load observed that day. Metal concentrations in the SML were generally higher than in the SSW at both locations. Little variability was noted between concentrations in the SML samples from Banyuls except perhaps for Pb (4X). At Barcelona the variability among SML concentrations was much greater due to the significantly higher metal concentrations in one of the samples, possibly due to the presence of surface oil slicks noted during that time. If that sample is not considered, then metal concentrations in the SML from both locations are quite similar. At Banyuls metal enrichments were not marked except in the case of Pb and to some degree Cu. Likewise off Barcelona, some metals showed little enrichment, e.g. Cr, Ni and Cd. In contrast, the single SML sample associated with the slicks displayed the highest enrichment factors, particularly for Cu, Pb and Zn (Table 1).

Information on metal concentrations in the Mediterranean SML is extremely limited, therefore comparisons with other areas in the region are difficult to make. The only published data are derived from two SML samples collected with a nylon screen between mainland France and Corsica in 1983 (5). SML values were 4800 ng l^{-1} Cd and 2600 ng l^{-1} Pb and, compared with SSW from 10 m depth (87 and 140 ng l^{-1} of Cd and Pb), resulted in corresponding EFs of 55 and 19, respectively. These SML concentrations were considerably higher than those we measured except for Pb (4810 ng l^{-1}) in the single enriched sample from Barcelona.

Table 1. Trace element concentrations* (ng l^{-1}) in the surface microlayer (SML) and subsurface waters (SSW), resulting SML enrichment factors (EF), and mean trace element concentrations in neuston (µg g^{-1} dry) in the northwestern Mediterranean.**

	Cr	Co	Ni	Cu	Zn	Ag	Cd	Pb
SML								
Barcelona	26-160	20-100	450-730	525-4020	1810-13700	1.3-1.7	15-59	719-4810
Banyuls-sur-m	17-21	30-38	290-430	590-2060	1410-3400	1.1-2.8	17-35	401-1570
SSW								
Barcelona	23-32	9-25	230-610	116-273	907-1710	1.1-2.0	16-19	84-272
Banyuls-sur-m	17-34	19-20	250-300	198-384	870-3920	0.9-1.6	15-47	50-255
EF								
Barcelona	0.9-5.0	1.4-9.0	1.2-3.1	2.3-35	1.7-12	0.65-1.5	0.81-3.7	2.6-21
Banyuls-sur-m	0.5-1.2	1.2-2.0	1.1-1.5	1.5-6.5	0.65-2.3	0.73-1.8	0.36-2.3	1.6-19
Neuston								
Barcelona	31.9	2.1	20	110	494	0.23	3.8	117
Banyuls-sur-m	14.3	2.4	11	20.7	192	0.83	0.48	25

* Range of 3 samples taken over 3 days at Barcelona and 2 days at Banyuls.

** Average of 2 samples taken at Barcelona and 4 samples at Banyuls using a 90 µm mesh net.

Following the same trend noted for the SML, neuston sampled off Barcelona contained higher mean concentrations of Cr, Ni, Cu, Zn, Cd and Pb than those from Banyuls (Table 1). Although simultaneous sampling the subsurface plankton was not done, some insight into possible metal enrichment in neuston can be gained by comparisons with previously determined metal concentrations in subsurface microplankton from this region (6). Such comparisons suggest that neuston is enriched in Cr, Co, Ni and Pb whereas no clear trends in enrichment were suggested for Cu, Zn, Ag and Cd. Although not definitively tested here, it would appear there is a definite linkage between the metal enrichment in the SML and the high levels measured in neuston associated with it.

References

1 - Hardy, J.T., 1982. The sea surface microlayer: Biology, chemistry, and anthropogenic enrichment. *Prog. Oceanogr.*, 11: 307-328.

2 - Hardy, J.T., Apts, C.W., Crecelius, E.A. and Bloom, N.S., 1985. Sea-surface microlayer metals enrichments in an urban and rural bay. *Estuar., Coast. Shelf Science*, 20: 299-312.

3 - Field, M. P., Cullen, J. T. and Sherrell, R. M., 1999. Direct determination of 10 trace metals in 50 µL samples of coastal seawater using desolvating micronebulization sector field ICP-MS. *J. Anal. At. Spectrom.*, 14: 1425-1431.

4 - Greenberg, R. R. and Kingston, H. M., 1982. Simultaneous determination of twelve trace elements in estuarine and sea water using pre-irradiation chromatography. *J. Radioanal. Chem.*, 71(1-2): 147-167.

5 - Migon, C. and Nicolas, E., 1998. The trace metal recycling component in the north-western Mediterranean. *Mar. Poll. Bull.*, 36(4): 273-277.

6 - Fowler, S.W., 1986. Trace metal monitoring of pelagic organisms from the open Mediterranean Sea. *Environ. Monitor. Assess.*, 7(1): 59-78.

LONG TERM CHANGES OF NUTRIENTS ENRICHMENT IN A GREEK ANOXIC MARINE BAY

N. Friligos *, R. Psyllidou-Giouranovits, A. Pavlidou

Hellenic Centre for Marine Research, PO Box 712, GR 190 13, Anavyssos, Attica, Greece - rpsill@ncmr.gr

Abstract

This paper concerns the nutrient status and the oxygen conditions between two different periods, 1973-1976 and 1993-1996, in the Elefsis Bay, which is an anoxic basin in the Saronic Gulf. The development of a thermohaline circulation has significant implication for nutrient cycles and oxygen distribution in the bay. The relation between the long-term accumulation of nutrients and denintification for the periods 1973-1976, 1993-1996, are discussed.

Keywords: Nutrients, eutrophication, Greek anoxic bay.

Introduction

The Gulf of Elefsis (Fig. 1) is an almost enclosed body of water which is situated in the northern Saronikos Gulf. It is a small (67 km^2), shallow area (max. depth 33 m) joined to the rest of the Saronikos Gulf by two sills, 8 m minimum depth at the western end and 12 m minimum depth at the eastern end. It differs from the rest of the Saronikos Gulf not only in its morphology, but also in the extent to which it is polluted. Most of this pollution arises form the industrial complexes on its shores. It is also polluted by sewage from the main outfall through the east channel. The present study deals with long term nutrients enrichment over a long period of time (1973-1996).

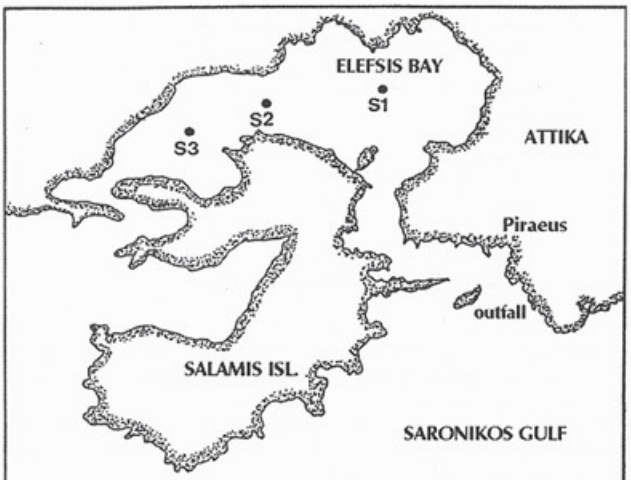


Fig. 1.

Materials and methods

The topographical setting and typical station locations are shown in Fig. 1. The sampling was performed seasonally during 1993-1996. Measurements of temperature, salinity dissolved oxygen and inorganic nutrients were performed by methods quoted by Friligos(1).

Results and discussion

Analysis of the data revealed that there was one general cycling of temperature over the year. Cooling of the upper layers reached a minimum in February-April, with temperatures of about 12-14 °C. Then water mass began warming up to maximum values of about 25 °C in August. The salinity range was 38-39 psu. The density lay within the range 26-29 σ_t and the pycnocline was related to the thermocline. During the winter the water in the Gulf was well mixed while, from May onwards, the gradual development of a thermocline led to the stratification of the water column and, in late September, there was a breakdown of the thermocline and vertical mixing of the water column.

In summer, temperature differences of 10 °C between sea surface and bottom resulted in the development of a strong stratification, which persisted for about 4 months and caused anoxic conditions below 20 m. High salinities develop in the summer as a result of evaporation and low temperatures occur during the winter as a result of the shallow maxium depth, 33 m.

The period of stratification was accompanied by deoxygenation of the water column below 20 m. The values of oxygen ranged between 1 and 7 ml/l in the water column at 0-20 m and 0.5 and 5 ml/l below 20 m. Anoxic conditions occurred below 20 m during the summer.

The values of silicate fluctuated from 1 to 10 μM down to 20 m. Below 20 m, the values were 1-45 μM. Silicate maxima occurred at the bottom of the water column at times of stratification and deoxygenation. The values of phosphate, down to a depth of 20 m, ranged from 0.1 to 0.5 μM. Below 20 m, the values were 0.30 – 3.00 μM. The highest values up to 3 μM occurred during anoxic conditions.

Increased values of nitrate of 0.5 – 2.5 μM were observed in the winter. Owing to the denitrification during the period July – October, the nitrate value fell below 0.5 μM. The values of nitrite were between 0.1 – 0.5 μM above 20 m and 0.5 – 1.0 μM below 20 m. The corresponding values of ammonia were 1 – 5 μM and 5 – 10 μM. It should be noticed that in summer with the occurrence of denitrification, nitrite exceeded nitrate. Higher ammonia values, as in the case of silicate and phosphate, occurred during anoxic conditions. The formation of ammonia and its subsequent oxidation to nitrate via nitrite proceeds throughout the winter. Also we found during this study (1993-1996), the tendency of the water of the Elefsis Bay to accumulate nutrients above the background level. The Elefsis Bay contained about three times more inorganic nitrogen than the background; this was mainly due to the ammonia, which was about five times more than the background value. Nitrate and nitrite also were two times, more than the background. Moreover, phosphate and silicate were respectively about five and four times more than the background.

Friligos(1) reported that the Elefsis Bay during the period 1973-1976 contained nine times more inorganic nitrogen than the background; this was mainly due to the ammonia which was about fifteen times more than the background value. Nitrates and nitrites also were respectively, seven and three times more than the background. However, the enrichment of phosphates and silicates were similar to the period 1993-1996.

Thus the denitrification was greater for the period 1993-1996 and the Elefsis bay worked as reductant biological treatment plant for the case of nitrogen.

References

1 - Friligos N., 1989. Nutrient and oxygen conditions in the Elefsis Bay, and intermittently anoxic Mediterranean basin. *Toxicol. and Environm. Chemistry*, 19:179-186.

SURFACE MICROLAYER STUDY IN THE SEA LAKE (ROGOZNICA LAKE, MIDDLE ADRIATIC)

S. Frka, Z. Kozarac *, B. Ćosović

Rudjer Bošković Institute, Center for Marine and Environmental Research, 10002 Zagreb, Croatia - * kozarac@rudjer.irb.hr

Abstract

Sea-surface microlayers were studied using electrochemical methods, monolayer techniques and Brewster angle microscopy (BAM). Microlayer samples (ML) and the underlying seawater (ULW) were collected from a Middle Adriatic eutrophicated sea lake Rogoznica in different seasons and different conditions from March 2001 till nowadays. ML were studied in an original sample without any pretreatment and as *ex-situ* reconstructed films after previous extraction with organic solvents of different polarity. Content of surface active substances in ML and ULW was determined by alternating current voltammetry. Enrichment factors were calculated. The elastic properties of different ML were estimated from surface pressure measurements. BAM was used for optical characterization and visualization of ML.

Keywords: Rogoznica Lake, sea surface microlayer, electrochemical methods, monolayer technique, Brewster angle microscopy.

The sea surface microlayer is the upper 1 to 1000 μm thick boundary layer between the sea and the atmosphere. This interface region is a subject of number unique and dynamic, non-equilibrium processes such as wind stress, water transpiration, solar energy flux and atmospheric inputs. The exchange of gaseous and particulate material between the atmosphere and the ocean in this microenvironment is of fundamental importance. The sea surface microlayer is generally enriched in different natural and anthropogenic organic substances, which concentrate in the surface microlayer because of their surfactant nature, hydrophobic properties, and possible association with floatable particles, vertical diffusion mechanisms or bubbles scavenging. In this area large vertical gradients exist and physical, chemical and biological properties are most altered relative to subsurface water. Adsorbed organic substances change the physicochemical properties of natural interface, depending on the nature of organics, i.e., the nature of polar groups, architecture of the hydrophobic chain, ionic strength, pH and temperature. Although the physical and chemical properties of sea-surface microlayers have been studied extensively, knowledge is still lacking about the morphology, chemical composition and rates of surface film formation, alteration and disappearance.

In the study of the sea surface microlayer related to the morphology of natural films, relationship between the concentration and type of substances and the properties of films regarding the exchange between the film and subsurface, the main location of sea surface microlayer sampling was eutrophicated Rogoznica Lake (Middle Adriatic). Since 1994 in Rogoznica Lake investigations of seasonal variations of temperature, salinity and concentration of dissolved oxygen as well as vertical distribution of dissolved organic matter, surface active substances, phytoplankton and reduced sulphur compounds have been performed(1). Since steep cliffs shelter the lake and there is practically no wind effect on the water mixing, Rogoznica Lake represents a convenient model system for natural surface microlayer study. The sea surface microlayer was investigated from March 2001 till nowadays, in different seasons and under different weather condition. Original microlayer sample has been fractionated by extraction with organic solvents of different properties (*n*-hexane, chloroform and dichloromethane). The extracts have been successfully used for the studies of *ex-situ* reconstructed films. Investigation of the original microlayers as well as of *ex-situ* reconstructed films was performed using electrochemical methods, monolayer technique and Brewster angle microscopy (BAM)(2).

Phase sensitive alternating current voltammetry (*out-of-phase* signal) was used for quantification of adsorbable surface active substances (SAS) in original microlayers (ML) and underlying water samples (ULW) collected at ~0.5 m depth, expressed as equivalent amount of the selected standard tert-octylphenol ethoxylate (T-X-100)(3). Seasonal variability of SAS concentrations during the investigated period is shown in Table1. The mean SAS value of 1.2 mgl^{-1} was determined for ML samples and 0.12mgl^{-1} for ULW samples. Observed enrichment factors (EF) are several times higher than those found in the Northern Adriatic Sea (1.6-2.2)(4) and in May they reached the highest values. Generally, the concentrations of SAS of ML determined in May-October period were higher from those in winter season what could be related with the periods of more extensive phytoplankton activity in the Rogoznica Lake(1).

The *ex-situ* reconstructed microlayer films were studied by modified electrochemical method. The method is modified in the sense that the organic solvent extract of natural surface film was spread onto electrolyte solution and transferred from the air-water interface to the mercury surface by vertical dipping the electrode through the film. The capacitance of the film was determined by ac. voltammetry (*out-of-phase* signal). The obtained results for reconstructed microlayers were compared with those for model lipid monolayers. To our knowledge the method has not been used for the characterization of natural aquatic films until present.

Table 1. Seasonal variability of SAS concentrations in microlayer (ML) and underlying water samples (ULW) and enrichment factors (EF) in Rogoznica Lake.

Date sampled	SAS/mgl^{-1} eq. T-X-100		EF
	ML	ULW	
March 2001	0.71	0.11	6.4
May 2001	1.60	0.06	26.7
October 2001	0.71	0.19	3.7
February 2002	0.60	0.17	3.5
May 2002	3.80	0.22	17.3
January 2003	0.29	0.08	3.6
April 2003	0.48	0.08	6.0
August 2003	1.40	0.11	12.7
October 2003	1.30	0.27	4.8

Additional characterization of the structure of marine films was carried out by ac. voltammetry (*in-phase* signal) using an electrochemical probe. Redox processes of cadmium, as a potential pollutant in natural waters, were chosen as an indicator of the permeability of different films adsorbed at the mercury electrode. Results show a strong inhibition of cadmium reduction and oxidation in the presence of adsorbed films.

Monolayer studies, particularly measurements of surface pressure-area (π-A) isotherms, have been applied for comparison of physical states and elastic properties of different microlayers. Brewster angle microscopy was used for optical characterization and visualization of original microlayers and reconstructed films. BAM images have been recorded under surface pressure control to correlate the morphology and the monolayer phase state of the natural microlayers and *ex-situ* reconstructed films.

References

1 - Ciglenečki I., Kodba Z., Viličić D, Ćosović B., 1998a. Seasonal variation of anoxic conditions in the Rogoznica Lake. *Croatica Chemica Acta*, 71: 217-232.

2 - Kozarac Z., Ćosović B., Frka S., Möbius D., Hacke S., Complex methodological approach to the studies of natural microlayers at the air/water interface. *Colloids and Surfaces A*, 219: 173- 186.

3 - Ćosović B., Vojvodić V., 1998. Voltammetric Analysis of Surface Active Substances in Natural Seawater. *Electroanalysis*, 10: 429-434.

4 - Marty J. C., Žutić V., Precali R., Saliot A., Ćosović B., Smodlaka N., Cauwet G., 1988. Organic matter characterization in the Northern adriatic sea with special reference to the sea surface microlayer. *Marine Chemistry*, 25: 243-263.

NEW ESTIMATION OF THE ATMOSPHERIC ^{210}PB FLUX TO THE NORTHWESTERN MEDITERRANEAN SEA

Garcia–Orellana J. [1] *, Sanchez–Cabeza J.A. [1, 2], Masqué P. [1, 2] and Bruach J.M. [1]

[1] Grup de Física de les Radiacions - Departament de Física, Universitat Autònoma de Barcelona. 08193 Bellaterra, Spain
* Jordi.Garcia@uab.es

[2] Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona. 08193 Bellaterra, Spain

Abstract

One of the key parameters needed in geochemical models of ^{210}Pb, a well known radiotracer of particle dynamics in the marine environment, is its atmospheric flux. There is a scarcity of data about this parameter in the Western Mediterranean Sea, especially regarding long term records. In this work we have evaluated the ^{210}Pb annual atmospheric flux from the analysis of 10 soils collected from coastal and island areas. ^{210}Pb fluxes ranged from 31±3 to 132±11 Bq·m^{-2}·y^{-1} with and average of 75 Bq·m^{-2}·y^{-1}, and correlate well with mean annual rainfall.

Keywords: 210Pb, atmospheric flux, Western Mediterranean

^{210}Pb ($T_{1/2}$=22.3 y) is one of the most widely used radiotracers to study biogeochemical processes in the oceans. One of the parameters that intervene to constrain the ^{210}Pb cycle is its atmospheric flux. In the Mediterranean Sea there is a scarcity of data about the ^{210}Pb atmospheric fluxes, especially regarding long term records (1 - 5). The most common procedure to estimate the annual flux is by collection of wet and dry deposition during long enough time periods to accommodate seasonal and episodic variations. Other ways are the use of natural repositories such as snow fields, lake sediments and soils that integrate large periods of time. In the Western Mediterranean, the atmospheric ^{210}Pb flux has been estimated in 81.2 Bq·m^{-2}·y^{-1} as measured in a microbial mat from the Ebro River Delta (558 mm^{-1} rainfall) (1), 110 and 102 Bq·m^{-2}·y^{-1} in Monaco (883 mm^{-1}) (4, 5), measuring wet deposition sampled in man-made collectors.

In this work we have evaluated the ^{210}Pb atmospheric flux that has been deposited over the Mediterranean Sea by determining its inventory in 10 undisturbed soils from coastal areas and islands, including Tanger (Morocco); Gata Cape and Minorca (Spain); Frejus, Port Vendres and Corsica (France); Porto Palo and Camarina (Sicily, Italy) (Fig. 1). Soils were usually sampled in a land with low vegetation and without anthropogenic impact. Excess (atmospheric) ^{210}Pb was determined by the difference of total ^{210}Pb and ^{226}Ra activities. The ^{210}Pb activity profiles were exponential with depth and the penetration in soils ranged from 5 cm to 30 cm depending mainly on the type soil. ^{210}Pb fluxes (F) were calculated using $F = I \cdot \lambda$, where I is the inventory and λ is the ^{210}Pb decay constant (0.0311 a^{-1}).

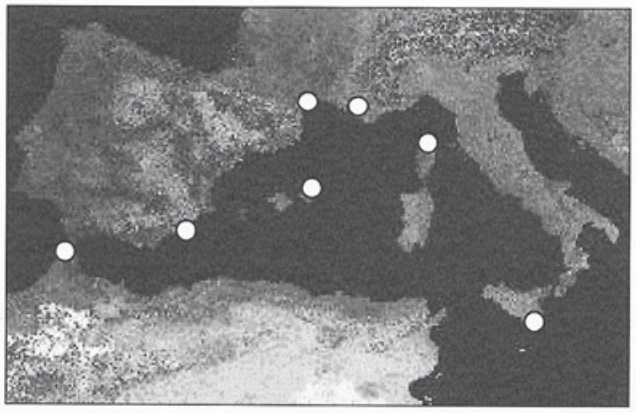


Fig. 1. Distribution of soils collected in this work.

Specific surface activities range from 46 ± 3 Bq·kg^{-1} in Sanitja (Minorca) to 102 ± 5 Bq·kg^{-1} in Port Vendres. Rainfall in the region is highly variable. For instance, in the North Western Mediterranean rainfall varies from 428 mm^{-1} in Corsica to 883 mm^{-1} in Frejus. ^{210}Pb fluxes ranged from 31 ± 3 to 132 ± 11 Bq·m^{-2}·y^{-1} with a mean value of 75 ± 27 Bq·m^{-2}·y^{-1} and correlated strongly with rainfall (R^2 = 0,87) (Fig. 2). On the basis of this correlation, we suggest that the ^{210}Pb atmospheric flux in a given area can be estimated if the mean annual rainfall is well known at any specific site from the Western Mediterranean. This facilitates the use of ^{210}Pb as a tracer of biogeochemical processes in the Mediterranean Sea and the study of erosion in soils by using this radiotracer.

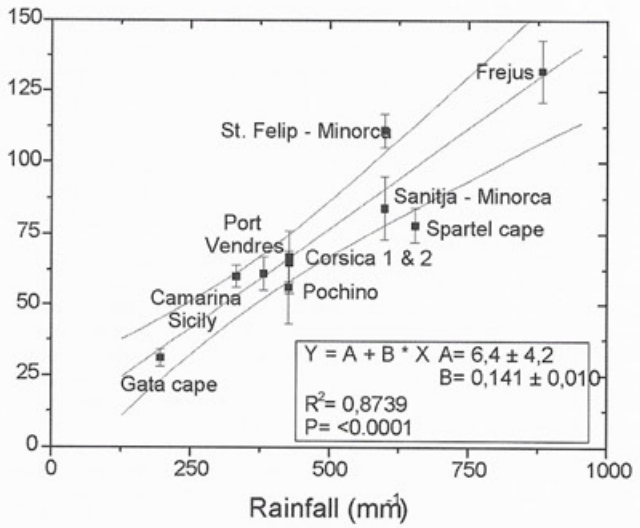


Fig. 2. Atmospheric ^{210}Pb fluxes vs rainfall in the Western Mediterranean (y= ^{210}Pb atmospheric flux and x= rainfall).

References

1 - Sanchez-Cabeza, J.A., Masqué, P. Martínez – Alonso, M., Mir, J. and Esteve I., 1999. ^{210}Pb atmospheric flux and rowth rates of a microbial mat from the Northwestern Mediterranean Sea (Ebro River Delta). *Environ. Sci. Technol.* 33: 3711-3715.

2 - Balkanski, Y.J., Jacob, D.J. and Gardner, G.M., 1993. Transport and residence times of continental aerosols inferred from global three – dimensional simulation of ^{210}Pb. *J. Geophys. Res.* 98: 20573-20586.

3 - Preiss, N., Melieres, M.-A. and Pourchet M., 1996. A compilation of data on lead-210 concentration in surface air and fluxes at the air – surface and water – sediment interfaces. *J. Geophys. Res.* 101: 28847-28862.

4 - Heyraud, M., 1982. Contribution a l'étude du Po-210 et Pb-210 dans les organismes marins et luer environment. Pp. 144. *In:* phD research work. Université Pierre et Marie Curie, Paris.

5 - Tateda, Y., Carvalho, F.P., Fowler, S., Miquel, J.C., 2003. Fractionation of ^{210}Po and ^{210}Pb in coastal waters of the NW Mediterranean continental margin. *Cont. Self Res.* 23: 295-316.

ATMOSPHERIC ^{210}PB FLUXES DUE TO SAHARAN DUST INPUT TO THE NORTHWESTERN MEDITERRANEAN SEA

Garcia–Orellana J. [1 *], Masqué P. [1, 2], Avila A. [3], Bruach J.M. [1] and Sanchez–Cabeza J.A. [1, 2]

[1] Grup de Física de les Radiacions - Departament de Física, [2] Institut de Ciència i Tecnologia, Ambientals (ICTA),
[3] Centre de Recerca Ecològica i Aplicacions Forestals (CREAF)
Universitat Autònoma de Barcelona, Spain - * Jordi.Garcia@uab.es

Abstract

One of the fundamental parameters needed in geochemical models of ^{210}Pb, a well known radiotracer of particle transport in the marine environment, is its atmospheric flux. The Mediterranean Sea is an area affected by events that inject large amounts of Saharan dust to the atmosphere that can significantly contribute to the atmospheric flux of nutrients, metals and other substances, including ^{210}Pb. In this work we have evaluated the annual flux of ^{210}Pb due to Saharan dust events registered in bulk deposition in the Montseny area, north of Barcelona, yielding a value of ca. 26 Bq·m^{-2}. This flux represents a fraction of about 20% of the total atmospheric deposition of ^{210}Pb in the area.

Keywords: 210Pb, atmospheric flux, Saharan dust, Northwestern Mediterranean

The Mediterranean area is globally affected by events that inject large amounts of dust originated in North Africa to the atmosphere. Saharan dust introduces large quantities of nutrients (N, P, Fe), key elements (C) and pollutants (metals, organic compounds, radionuclides) in the water column that can alter the biogeochemical processes of this ecosystem (1). These events ("red rain") are relatively frequent: it is estimated that, in average, their frequency is 3 events per year in NE Spain (2). The source regions providing this dust are, by order of importance, the Moroccan Atlas, the Western Sahara and central Algeria.

^{210}Pb ($T_{1/2}$ = 22.3 y) is a member of the ^{238}U decay series widely used as a tracer of biogeochemical processes in the oceans (3, 4). It is introduced to the Earth surface after decay of ^{222}Rn exhaled from the continental crust, mainly by wet deposition. The atmospheric flux of ^{210}Pb in the Northwestern Mediterranean is estimated to range between 80 and 130 Bq·m^{-2}·y^{-1} (5, 6, 7 and unpublished data). Saharan dust inputs may significantly contribute to the ^{210}Pb atmospheric flux. In this work we have evaluated the fraction of ^{210}Pb due to Saharan dust events that has been deposited in the Montseny area (north of Barcelona) during the period 1983-2000. Bulk deposition was sampled weekly by using open collectors consisting of 4 polyethylene funnels of 19 cm diameter connected each to a 10 L polyethylene bottle. A total of 110 samples were identified from the filtration of bulk deposition during red rain events. Dust deposition was highly variable from year to year. Indeed, five events accounted for 70% of total dust deposition in the 17-yr record. Avila *et al.* (8) determined the annual dust deposited in the area to be, in average, 5.3 g·m^{-2}·y^{-1}. This value is low if it is compared with areas where dust storms are more important, such as Central and Eastern Mediterranean Sea where the average deposited annual mass fluxes are estimated to be 12 and 35 g·m^{-2}·y^{-1}, respectively (1)

The ^{210}Pb specific activities ranged from 0.77 ± 0.07 to 8.0 ± 0.5 kBq·kg^{-1}, with a mean value of 4.8 kBq·kg^{-1}. Calculated ^{210}Pb fluxes vary from 0.25 ± 0.05 to 153 ± 8 Bq·m^{-2} per event. The average of the annual atmospheric flux of ^{210}Pb associated to Saharan dust inputs was estimated to be about 26 Bq·m^{-2}·y^{-1}. In a companion paper (this volume) we show that total ^{210}Pb inventories in soils collected in the Western Mediterranean correlate with rainfall. Using that, we estimated that ^{210}Pb deposition in the Montseny area is of the order of 120 Bq·m^{-2}·y^{-1}. Therefore, the ^{210}Pb flux associated to Saharan dust deposition accounts for about 20%.

Some of the implications of this finding are:

i. ^{210}Pb atmospheric deposition studies in the Mediterranean area should take into account large time intervals as Saharan dust events are highly irregular.

ii ^{210}Pb atmospheric deposition due to dust in areas where precipitation is very low and there are large fluxes of Saharan dust (such as Central and Eastern Mediterranean Sea) is relevant.

iii. Large inputs of ^{210}Pb associated to individual dust events have to be considered when using ^{210}Pb as biogeochemical tracer in the water column.

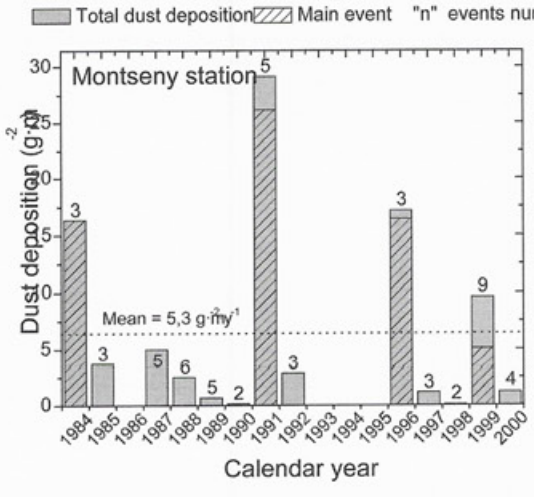


Fig. 1. Dust deposition per year during the studied period 1983 -2000.

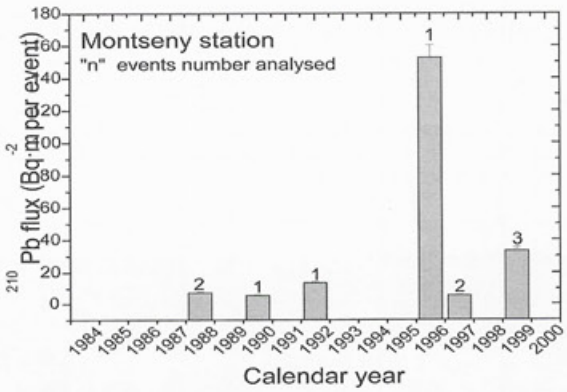


Fig. 2. ^{210}Pb fluxes on atmospheric samples analysed.

References

1 - Guerzoni, S., Chester, *et al.,* 1999. The role of atmospheric deposition in the biogeochemistry of the Mediterranean Sea. *Prog. Oceanog.*, 44: 147-190.

2 - Martin-Vide, J. and Moreno, C., 1985. Les pluges de fang a Barcelona, *Rev. Cat. Geog.*, 1: 60-70.

3 - Bacon, M.P., Spencer, D.W. and Brewer, P.G., 1976. Pb-210/Ra-226 and Po-210/Pb-210 disequilibria in seawater and suspend particulate matter. *Earth Planet. Sci. Lett.* 32: 277–296.

4 - Radakovitch, O., Sanchez-Cabeza, J.A., *et al.,* 2003. Meso- and small-scale variations of ^{210}Pb fluxes on the Nortwestern Mediterranean continental margins. *Cont. Self Res.* 23: 693-715.

5 - Sanchez-Cabeza, J.A., Masqué, P. *et al.,* 1999. ^{210}Pb atmospheric flux and rowth rates of a microbial mat from the Northwestern Mediterranean Sea (Ebro River Delta). *Environ. Sci. Technol* 33: 3711-3715.

6 - Balkanski, Y.J., Jacob, D.J. and Gardner, G.M., 1993. Transport and residence times of continental aerosols inferred from global three – dimensional simulation of ^{210}Pb. *J. Geophys. Res.* 98: 20573-20586.

7 - Preiss, N., Melieres, M.-A. and Pourchet M., 1996. A compilation of data on lead-210 concentration in surface air and fluxes at the air – surface and water – sediment interfaces. *J. Geophys. Res.* 101: 28847-28862.

8 - Avila A., Queralt I., *et al.,*., 1996. African dust over Northeastern Spain: mineralogy abs source regions Pp. 201-205. *In:* Guerzoni and R. Chester (ed.), The impact of desert dust across the Mediterranean. Academic Publishers, Dordrecht.

METAL GEOCHEMISTRY IN SEDIMENTS OF A SEMI-ENCLOSED BAY IN THE ISLAND OF LESVOS, GREECE

Apostolos M. Gavriil and Michael O. Angelidis *

Department of Environmental Studies, University of the Aegean, Greece
University Hill, 81100 Mytilene, Lesvos, Greece - magel@aegean.gr

Abstract

The concentrations of Al, Li, Fe, Mn and Ni were determined in sediment cores from the semi-enclosed Kalloni Bay, in the island of Lesvos, Greece. The mineralogical variations in the different drainage basins and especially the ultramafic minerals in the drainage basin of the stream Vouvaris, appear to be the main reason for the Mn, Fe and Ni enrichments in the sediments of the eastern part of the Bay. Diagenetic processes also influenced the concentrations of Mn in the sediments of the central part of the Bay.

Keywords: metals, marine sediments, geochemistry, Kalloni Bay.

Introduction

Coastal marine sediments are the major depositories for persistent substances such as heavy metals and their mineralogy is greatly affected by of the geological background of the neighboring landmasses. A detailed knowledge of the parameters that may affect the natural metal variability is necessary in order to evaluate the possible anthropogenic impact from pollution sources. In the present study natural fluctuations in metal concentrations were studied in sediment cores from a semi-enclosed shallow marine system, Kalloni Bay, in the island of Lesvos, Greece (Fig.1).

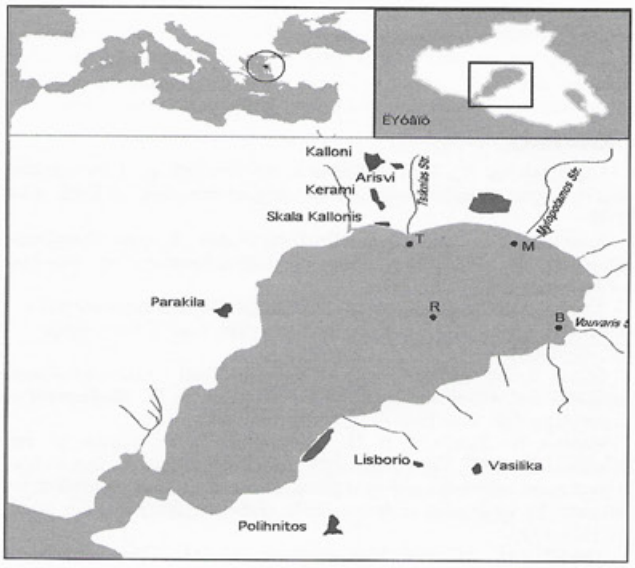


Fig. 1. Sampling stations

Materials and methods

Sediment cores were collected at four stations in the Bay during March 2000. Three cores (stations B, M and T) were collected near the mouths of the major streams of the area and a core was collected from the inner part of the Bay (station R). The cores were sliced and analyses were performed in the <1mm fraction using AAS [1].

Results and discussion

The concentrations of Al and Li in core B (3.80 ± 0.22% and 10.7±2.4 µg/g respectively) were aproximately half in comparison to the corresponding values in the other cores. Higher values were found in the finer aluminosilicate material, which escapes from the coastal zone and is deposited to the central parts of the Bay (Station R). Both elements did not present significant fluctuations along the cores depth.

Manganese concentrations in cores R and B were about three times higher compared to cores M and T. The high concentrations of Mn in core B were attributed to the geological background of stream Vouvaris watershed, which consists of ultrabasic rocks [2]. In the core R, at the centre of the Bay, Mn enhancement could be attributed to Mn remobilization from other parts of the Bay. Manganese, because of its redox sensitivitie, may be removed from the solid phase of the sediment, transported through water and re-deposited elsewhere, when oxic conditions occur [3]. The mobilization of Mn from the sediments and its diffusion through pore water to the water column, is supported by the high concentrations of the element near the surface in all cores (Fig.2).

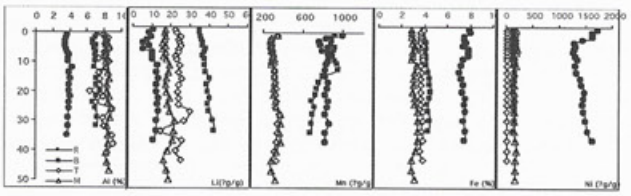


Fig. 2. Profiles of metal concentrations in the sediments of the Bay of Kalloni.

Iron concentrations were much higher in station B (7.5±0.2 %) than in the other stations (3.1±0.2% - 4.2±0.2%). The weathering of ultrabasic rocks rich in Fe in the drainage basin of the stream Vouvaris [2] is again the reason for Fe enhancement. No significant variations were found along the cores probably because of the relatively restricted remobilization of Fe. In contrast to the oxidation of Mn (II) to Mn (IV), the oxidation of Fe is very rapid [4]. As a consequence, when ions Fe^{2+} were diffused through pore water into oxygenated water column, they are immediately oxidized and precipitated before being transported.

The concentrations of Ni in core B were one to two orders of magnitude higher than the other cores (1438±134 µg/g in core B and 158±7, 165±18 and 15±3 µg/g respectively in cores R, M and T). The high Ni values were also attributed to the geological background of Vouvaris watershed, exclusively consisting of ultrabasic rocks (peridotites) and nickeliferous minerals rich in Ni [2].

Conclusions

The ultrabasic minerals of the drainage basin of Vouvaris appears to be the main reason for the marked enhancement of Fe, Mn and Ni in the coastal sediments at the eastern part of the Bay of Kalloni. The natural distribution of metals in the Bay of Kalloni is greatly influenced by the local geology on a relatively small scale. On the other hand, the redox sensitive Mn, which is also deposited on the coastal zone near the stream Vouvaris, is more easily remobilized and transported to greater distance, influencing the Mn distribution in the central part of the Bay.

References

1 - Loring, D.H., and Rantala, R.T.T., 1992. Manual for the geochemical analyses of marine sediments and suspended particulate matter, *Earth Science Reviews*, 32: 235-283.

2 - Varnavas, S., 1989. Pollution of Kalloni Bay in Lesbos by toxic metals, Proceedings of the 1st Congress of Environmental Science (Lekkas, Th., ed.), Mytilene, pp. 211-220.

3 - Stumm, W., and Morgan, J.J., 1981. Aquatic chemistry. An introduction emphasizing chemical equilibria in natural waters. 2nd Edition. J.Wiley & Sons, N.York. 780 p.

4 - Emerson, D., 2000. Microbial oxidation of Fe(II) and Mn(II) at circumneutral pH. Pp. 31-52. In: Lovley, D.R., (Ed.), Environmental Microbe-Metal Interactions. ASM Press, Washington.

ORGANOCHLORINE LEVELS IN THE MUSCLE OF A DEEP SEA FLATFISH IN EASTERN MEDITERRANEAN WATERS

E. Georgakopoulos-Gregoriades and V. Vassilopoulou *
National Centre for Marine Research, Hellinikon, 16604, Greece – celia@ncmr.gr

Abstract
DDTs were the dominant contaminants in the flesh of four-spotted megrim in the Aegean Sea, their concentrations ranging in the various seasons between 12,5-32,3 ng/g, while those of PCBs between 4,5 and 12,1 ng/g. Variations in pollutant concentrations seemed to be related to variations in lipid content. PCBs 153 and 138 were the most prevalent congeners, while in relation to DDTs, p,p'-DDE dominated.

Keywords: PCBs, DDTs, lipids, flesh, four-spotted megrim, Aegean

Introduction

Persistent lipophilic organic pollutants, and among them PCBs and DDTS, are widely distributed in the marine environment, presenting a highly bioaccumulative nature in many life forms. Although monitoring programs of the aforementioned pollutants usually take place at coastal areas, which mainly receive urban, industrial and riverine inputs, open sea waters deserve also special consideration, since these compounds extend the boundaries of their distribution all over the marine ecosystem. Moreover, data on pollutant concentrations in edible fish are of great importance with respect to both human health and potential impacts on higher aquatic consumers. The present study provides data on the concentrations of PCBs and DDTs in the muscle of four-spotted megrim (*Lepidorhombus boscii*), in the Aegean Sea; the species is an edible flatfish dwelling on muddy bottoms, mainly between 200 and 450 m in the study area (1).

Material and methods

The sampling area was located off the Sporades Isles in the central Aegean at depths from 200 to 400 m. Samples were collected seasonally by a commercial trawler. Subsequent to their capture, fish were preserved in a freezer in glass jars. In the laboratory, the total length (TL) of each specimen was recorded, and then the muscle was removed, lyophilized, grounded, mixed and stored at 4^0C, till used for further analysis. Samples were Soxhlet-extracted, and the solvent extract was evaporated to dryness and the residue was weighted for the determination of the lipid percentage. The organic extract was prepared according to Satsmadjis *et al.* (2). Gas chromatographic analysis was performed with a Varian 3700 GC equipped with a ^{63}Ni electron capture detector and a fused silica Megabore column DB-1, 30m x 0.53mm i.d. Quantification of PCBs was made using an external standard calibration mixture of selected congeners, the load of the muscle was estimated on the basis of seven PCB congeners (Nos. 101, 105, 118, 138, 153, 156, 180). DDTs were quantified as the sum of p,p'-DDT, o,p'-DDT, p,p'-DDD and p,p'-DDE. Concentrations of PCBs and DDTs are presented as ng/g on a dry weight basis.

Results and discussion

Mean total lengths, PCBs, DDTs concentrations and percentage of lipids in the flesh of the four-spotted megrim in each season are given in Table 1. DDTs were the dominant contaminants and their concentrations were in the range of 12,5-32,3 ng/g, while those of PCBs were 4,5-12,1 ng/g.

Table 1. Seasonal concentrations of PCBs and DDTs (ng/g dry weight) in the flesh of four-spotted megrim in the Aegean Sea.

Month	Mean TL (mm)	Lipids (%)	ΣPCBs	ΣDDTs
September	136,8±6,16	3,75±0,84	11,65±3,22	23,90±9,00
December	142,8±5,75	2,31±0,26	4,45±1,23	12,48±8,39
March	141,5±7,05	2,93±0,22	10,77±3,85	29,10±7,65
June	138,1±7,14	3,61±0,42	12,04±3,01	32,28±9,51

Among DDT metabolites, p,p'-DDE was dominant in the muscle with percentages ranging from 72,5% to 88,4%. The ratio of p,p'-DDE to total DDT is cited as an indicator of whether new sources of DDT are entering an ecosystem. It is suggested that a ratio greater than 0.6 reflects a relatively stable system with no new inputs (3).

In relation to PCBs, hexachlorobiphenyl congeners 153 and 138 were found in major amounts contributing respectively 29,17% and 29,68% to the total PCB concentrations in the muscle of the four-spotted megrim. PCB 118 and 180 accounted respectively for the 14,2% and 13,6% of total PCBs. In western Mediterranean waters the most prevalent PCB congeners in the four-spotted megrim were also the highly chlorinated ones (4). The richness of a PCB isomer in a given organism is the result of the composition of PCBs present in the environment, modified by the decomposition processes that occur in organisms. PCB 153 is extremely persistent (5), while PCBs 118, 138 and 180 are considered as difficult to metabolize (6), the latter being related to the presence/absence of H-atoms in the molecule and their positions (5).

Both PCBs and DDTs values exhibited seasonal differences, and the trends were closely related to lipid contents of the muscle. In winter (December), when the species exhibited low feeding intensity (7), lipid content was significantly lower in relation to the other seasons. The latter appeared to have a direct impact on pollutant concentrations, which exhibited lowest levels during that season.

References

1 - Vassilopoulou, V., 2000. Abundance and distribution of four-spotted megrim (*Lepidorhombus boscii*) in the Aegean Sea. *Belg. J. Zool.*, 130: 83-88.
2 - Satsmadjis, J., Georgakopoulos-Gregoriades, E. and Voutsinou-Taliadouri, F., 1988. Separation of organochlorines on alumina. *J. Chromatogr.*, 437: 254-259.
3 - Aguilar, A.,1984. Relationships of DDE/DDT in marine mammals to the chronology of DDT input into the ecosystem. *Can. J. Fish. Aquat. Sci.*, 41: 840-844.
4 - Garcia, L. M., Porte, C. and Albaiges, J., 2000. Organochlorinated pollutants and xenobiotic metabolizing enzymes in W. Mediterranean mesopelagic fish. *Mar. Poll. Bull.*, 40(9): 764-768.
5 - Kannan, N., Reush, T. B. H., Schulz-Bull, D. E., Petrick, G. and Duinker, J. C., 1995. Chlorobiphenyls: model compounds for metabolism in food chain organisms and their potential use as ecotoxicological stress indicators by application of the metabolic slope concept. *Envir. Sci. Tech.*, 29: 1851-1859.
6 - Storelli, M. M. and Marcotrigiano, G. O., 2001. Persistent organochlorine residues and toxic evaluation of polychlorinated biphenyls in sharks from the Mediterranean Sea (Italy). *Mar. Poll. Bull.*, 42(12): 1323-1329.
7 - Vassilopoulou, V., 1998. Study of the biology of the four-spotted megrim (*Lepidorhombus boscii*) in the north Aegean Sea. PhD. Thesis, Univ. of Patras (Greece) (in greek) 211 p.

NIVEAUX DE CINQ MÉTAUX LOURDS (FE, CU, ZN, CR, MN) DANS LES SÉDIMENTS SUPERFICIELS DE LA BAIE D'ANNABA (MÉDITERRANÉE SUD-OCCIDENTALE)

Gharsallah Z., Retima A., Derbal F. and Kara M. H. *

Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie - * kara_hichem@yahoo.com

Résumé

Cinq métaux lourds (Fer, Cuivre, Zinc, Chrome, Manganèse) sont analysés dans les sédiments superficiels, dans sept stations réparties le long du littoral d'Annaba, au cours du mois de juin 2001. Les concentrations métalliques sont mesurées à l'aide d'un spectrophotomètre d'absorption atomique. Le calcul des indices de contamination, faisant référence aux normes existantes, montre que le Cuivre et le Zinc sont présents en quantités anormalement élevées à l'intérieur du port.

Mots-clés: pollution, métaux, sédiment, MED, Algérie.

Introduction

Siège d'une importante activité industrielle et portuaire, le littoral d'Annaba est soumis à un risque de pollution non négligeable. Cependant, mis à part les connaissances sur la teneur des eaux en sels nutritifs (1), très peu de travaux ont été consacrés à la qualité de l'environnement côtier dans cette région.

La détermination du niveau de pollution métallique revêt une grande importance, en raison de son impact sur l'écosystème marin. L'objectif de cette étude est de déterminer le degré de contamination des sédiments superficiels par cinq métaux lourds (fer, cuivre, zinc, chrome, manganèse). Ce compartiment est considéré comme un puits de stockage pour les micro-polluants (2).

Matériel et méthodes

Les sédiments sont prélevés à l'aide d'un carottier en PVC, au cours du mois de juin 2001, dans sept stations situées à l'intérieur de la baie d'Annaba (Algérie Nord-Est) (Fig. 1). A partir de la couche superficielle, les éléments recherchés sont extraits par minéralisation de la fraction granulométrique inférieure à 63 µm. Les micro-polluants sont mis en solution par une digestion acide, utilisant un mélange d'acide nitrique et d'acide chlorhydrique. Les dosages sont réalisés à l'aide d'un spectrophotomètre d'absorption atomique à flamme (Shimadzu AA-6601). La concentration des éléments métalliques est obtenue par la formule de Joanny *et al.* (3). Le niveau de pollution est déterminé par le calcul de l'indice de contamination, préconisé par l'A.B.R.M.C. (4).

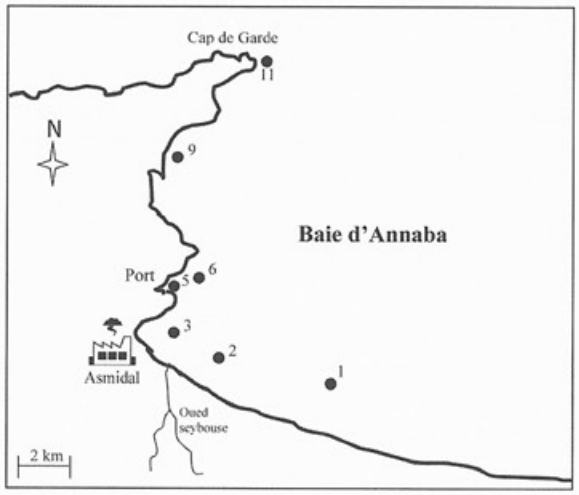


Fig. 1. Localisation des stations de prélèvement des sédiments dans la baie d'Annaba.

Résultats et interprétation

La valeur moyenne de la concentration de chaque métal dans le sédiment de chacune des sept stations (Fig. 2) montre que le Fer est l'élément le plus abondant, avec une concentration moyenne de 1464 µg. g^{-1} de sédiment sec. Le Cuivre n'est détecté qu'au niveau de deux stations voisines, l'une en face du rejet du complexe d'engrais phosphatés (Asmidal) (station 3) avec 20 µg. g^{-1}, l'autre à l'intérieur du port (station 5) avec 208 µg. g^{-1}. Le Zinc se trouve en quantités variables d'un site à un autre, tout en étant totalement absent dans les stations 2 et 9. Ses valeurs varient entre 0 et 400 µg. g^{-1} avec une moyenne de 140,71 ± 156,26 µg. g^{-1}. Le Chrome est présent dans toutes les stations et montre lui aussi des fluctuations significatives, puisqu'il varie entre 153 et 823 µg. g^{-1}, avec une teneur moyenne de 452,71 µg. g^{-1} ± 253,96. Le Manganèse est omniprésent avec une valeur maximale de 749,51 µg. g^{-1} dans la station 1.

Les fortes concentrations en fer montrent l'existence d'importantes sources localisées. En effet, les eaux littorales reçoivent indirectement les rejets d'un complexe sidérurgique (El Hadjar), et, directement les effets de l'exportation du minerai de fer *via* le port d'Annaba. Le Cuivre comme le zinc montrent des concentrations moins élevées, probablement en raison de leur utilisation par les organismes vivants (5). La forte concentration du cuivre à l'intérieur du port serait due à l'utilisation de peintures anti-fouling dans le recouvrement des coques des bateaux. La présence régulière du chrome pourrait être liée aux effluents domestiques et industriels (métallurgie). Des teneurs en Manganèse relativement faibles sont observées au niveau du port malgré son fond vaseux, considéré comme le substrat sur lequel cet élément s'absorbe le plus (6).

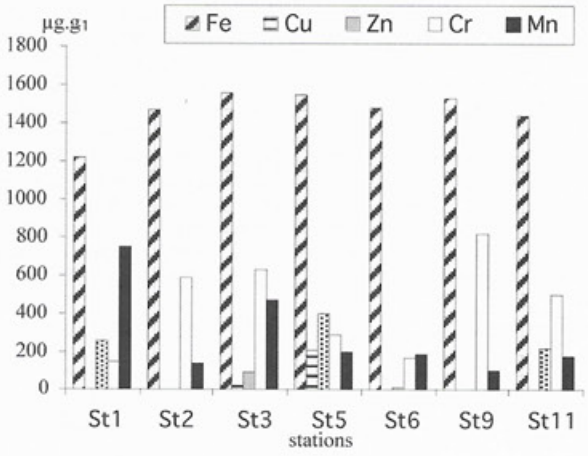


Fig. 2. Variations spatiales de la concentration des cinq métaux lourds dans les sédiments superficiels de la baie d'Annaba.

L'indice de contamination, calculé pour les cinq métaux considérés, montre que la station 5, située à l'intérieur du port, est polluée par le cuivre et par le zinc.

Références

1 - Frehi H., 1995. Etude de la structure et du fonctionnement du système phytoplanctonique dans un écosystème côtier: eutrophisation de la Baie d'Annaba. Thèse de Magister, Univ. Annaba, Algérie. 160 p.

2 - Cossa D., Elbaz-Poulichet F., Gnassia-Barelli M. & Romeo F., 1993. Rapport Scientifique et technique. IFREMER. N°3, 76 p.

3 - Joanny M., Chaussepied M., & Corre F., 1980. Présentation des résultats d'une calibration internationale. Centre national pour l'exploitation des océans. Centre océanologique de Bretagne (CNEXO / COB), 49.

4 - A.B.R.M.C., 1990. Pollution du Rhone, Projet mer Méditerranée, Greenpeace, 62 p.

5 - Asso A., 1982. Contribution à l'étude des polluants métalliques chez la moule *Perna perna* dans la région d'Alger. Thèse de Doctorat 3ème cycle. Univ. Aix Marseille, 135 p.

6 - Cauwet G . & Faguet D., 1982. The role of organic matter in transport processes of metals in estuarine environments. *Thalassa Ugoslavia*, 379-392.

MEDFLUX : BIODEGRADABILITY OF LARGE PARTICLES OF DIFFERENT SINKING VELOCITIES

Goutx M. [1], Moriceau B. [2], Guigue C. [3], Pete R. [3], Lee C. [4], Armstrong R. [4], Wakeham S.G. [5], Peterson M.L. [6]

[1] Laboratoire de Microbiologie Marine, Campus de Luminy, Marseille, France - * goutx@com.univ-mrs.fr

[2] Institut Universitaire Européen de la Mer, Site du Technopole Brest-Iroise, Place Nicolas Copernic, Plouzane, France - Brivaela.Moriceau@univ-brest.fr

[3] Laboratoire de Microbiologie Marine, Campus de Luminy, Marseille, France -guigue@com.univ-mrs.fr, pete@com.univ-mrs.fr

[4] Marine Sciences Research Center, Stony Brook University, Stony Brook, NY, USA -cindylee@notes.cc.sunysb.edu

[5] Skidaway Institute of Oceanography, Savannah, GA, USA - stuart@skio.peachnet.edu

[6] Department of Oceanography, University of Washington, Seattle, WA, USA - mlpmlp@u.washington.edu

Abstract

Particle flux is a major vector for the export of biological production from the euphotic layer to the deep ocean. The mechanisms of transformation of organic carbon during its transfer from the surface to the sediment, are important to determine the role of oceans as source or sink of CO_2, a major goal for oceanographic studies. Of particular interest are those implied in degradation and mineralisation of aggregates in the less known mesopelagic layer of the water column (1). In May 7-14 2003, during a multidisciplinary cruise on board the RV *Seward Johnson* II, in North-Western Mediterranean, the NSF-MedFlux program offered a unique opportunity to collect and work on specific components of the particle flux with the aim to elucidate decomposition process during particle sinking.

Key Words: organic matter degradation, particle flux

In the Central Ligurian sea, at the DYFAMED site, lateral transfers are weak, and surface production is rapidly transported to depth through a heterogeneous particle flux. Indeed, the functioning of ecosystems in the productive layer is driven by size structure predator-prey relationships and produces a large variety of sinking particles (2). Flux composition and resistance to bacterial attack of its various components during sinking are important parameters to identify the critical depths of organic matter mineralization in the water column (3).

In order to characterize the flux, large particles were collected from 200 m depth using a new conical, free-floating NetTrap and sorted by sinking velocity using an elutriator. Particles with four different settling velocities were incubated at *in situ* temperature for several days. Bacterial numbers and degradation of organic carbon, lipids and biogenic silica were followed as a function of time. Fig. 1 shows the change in bacterial biomass in the four fractions over time. The biomass is normalized to the amount of organic carbon initially added. Fig. 2 shows the change in OC/TN in two of these fractions over time. The TN was too low to measure in the other two fractions, but it is clear that the initial C/N was very different in fractions separated by settling velocity. Results give insight into relationships between ecosystem size structure and biogenic matter export process to depth by the particle flux. Lipid, amino acid and carbohydrate data will provide further information on the composition of the material.

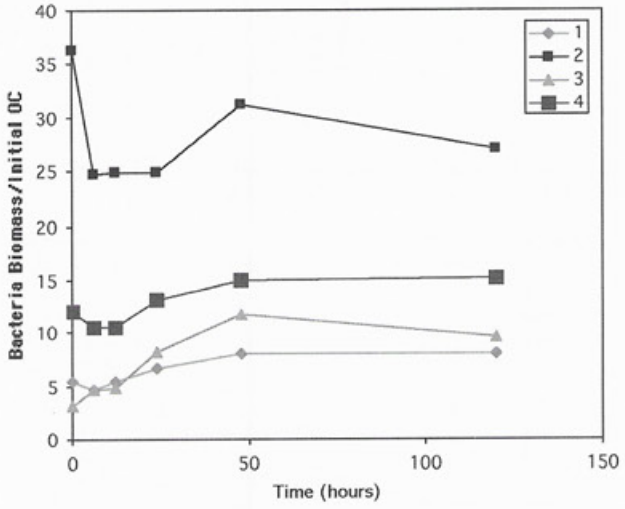


Fig. 1. Change with time in bacterial biomass normalized to initial C (mmol bact C/mol total C) in samples separated by settling velocity.

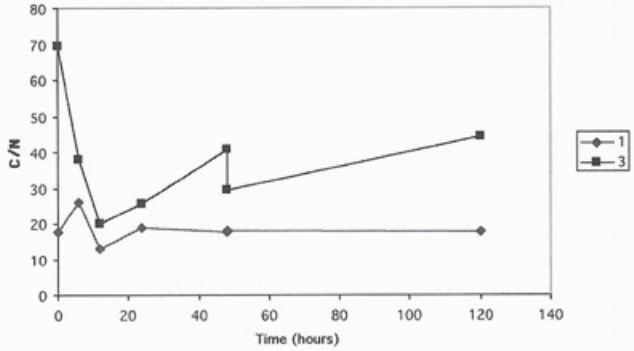


Fig. 2. Change in C/N molar ratio with time in two of the samples separated by settling velocity.

References

1 - Armstrong, R. A., C. Lee, J. I. Hedges, S. Honjo, and S. Wakeham, 2002. A new mechanistic model for organic carbon fluxes in the ocean, based on quantitative association of PoC with ballast mineral. *Deep-Sea Res.*, II, 49, 219-236.

2 - Goutx, M., Momzikoff A., Strilby L., Andersen L.V., Marty J.C., and Vescovali. I., 2000. High-frequency fluxes of labile compounds in the central Ligurian Sea, northwestern Mediterranean. *Deep-Sea. Res. I*, 47: 533-556.

3 - Sheridan C.C., Lee C., Wakeham S.G., and Bishop J.K.B., 2003. Suspended particle organic composition and cycling in surface and midwaters of the equatorial Pacific Ocean. *Deep-Sea Res. I,* 49: 1983-2008.

DIAGNOSTIC DE L'IMPACT DE L'ACTIVITÉ PÉTROLIÈRE PORTUAIRE SUR L'ENVIRONNEMENT CÔTIER.

R. Hamouda*, N. Ouertani Et H. Belayouni

Faculté des Sciences de Tunis, Laboratoire de Géochimie Organique, Département de Géologie Campus Universitaire 1060 Tunis.
* hamoudarym@yahoo.fr

Resumé

Dans le cadre du diagnostic de l'état de pollution des côtes à proximité d'un port pétrolier, nous avons effectué une campagne d'échantillonnage pour le prélèvement des sédiments de surface. Le but étant de déterminer les teneurs en hydrocarbures totaux en identifiant les différentes fractions et d'analyser la fraction saturée par Chromatographie Gazeuse.

L'étude des hydrocarbures a permis de déterminer la nature de ces produits et de distinguer la fraction d'hydrocarbures naturels de celle qui pourrait provenir d'une pollution. On a pu ainsi, démontrer le rôle joué par les bassins de décantation et les systèmes lagunaires naturels dans l'épuration (effet de bioremédiation).

Mots clefs : activité pétrolière, systèmes lagunaires, hydrocarbures, GC, COT.

Au niveau des installations portuaires pétrolières, les eaux de purge des réservoirs de stockage des hydrocarbures, ainsi que les eaux provenant des opérations de déballastage des pétroliers, constituent une source potentielle de pollution par les hydrocarbures des environnements côtiers. Dans le terminal pétrolier du sud de la Tunisie, ces eaux sont collectées dans des bassins de décantation disposés en série avant d'être déversées dans une lagune naturelle qui communique avec la mer Méditerranée. Par le phénomène de marée, une partie plus ou moins importante de cette lagune est périodiquement inondée par l'eau de mer. L'objectif de ce travail est le diagnostic de l'état de pollution de la lagune. L'étude est basée sur l'analyse du COT et sur les techniques de chromatographie en phase liquide et gazeuse.

La répartition des teneurs en COT dans les sédiments de surface de la lagune permet l'établissement de 3 zones:
– une première zone limitrophe de la côte de 7 à 8 m de largeur où les sédiments sont quotidiennement lessivés par les mouvements de la marée. La valeur de COT est très faibles (0,30 %);
– une deuxième zone recouverte par endroit par une couche importante d'algues ce qui permet une rétention de l'eau (même à marée basse) dans des petites alvéoles. Sous les tas d'algues, les teneurs en COT sont importantes, elles varient entre 4,12 et 8,3%.
– une troisième zone se trouvant à 200 mètres de la mer, constituée de sables jaunes avec absence de végétation, les teneurs en COT sont < 1%.

L'étude des hydrocarbures dans ces sédiments montre que :
– les teneurs en hydrocarbures totaux sont faibles, elles varient entre 200 et 4020 ppm;
– la corrélation positive calculée entre le COT et les hydrocarbures totaux (coefficient de corrélation = 0,94), témoigne de l'homogénéité de la matière organique (1) contenue dans les sédiments;
– les % en hydrocarbures saturés et insaturés non aromatiques varient entre 6 et 12% et sont classiques pour une matière organique héritée de la biomasse originelle (2, 3, 1);

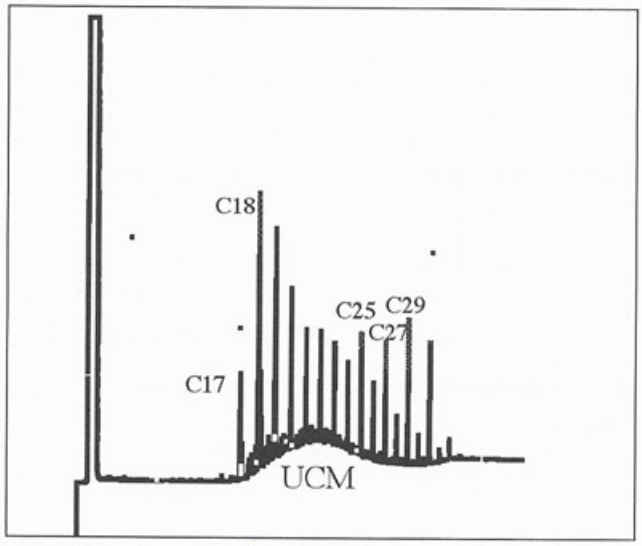


Fig. 1. Chromatogrammes type des hydrocarbures saturés et insaturés non aromatiques des échantillons pris à la surface de la lagune.

– la distribution des n-alcanes est bimodale (Fig. 1). Le premier mode est caractérisé par une distribution en C21-C33 et un indice d'imparité de l'ordre de 2,1. Ce type de distribution est caractéristique d'une matière organique issue de végétaux supérieurs, elle est liée à la décarboxylation des acides gras lourds à nombre pair d'atomes de carbone, constituants majeurs des cires cuticulaires des végétaux supérieurs (4, 1, 5, 6). Le deuxième mode est centré sur les n-alcanes à faible poids moléculaire de C17 à C20 sans prédominance d'atomes de carbone pairs ou impairs et caractérise une matière organique autochtone marine (7, 8, 9). La matière organique présente donc une origine mixte marine et terrestre. La présence d'U.C.M. (composés non-résolus) avec une bosse développée sous toute la gamme des n-alcanes témoigne d'une importante activité microbienne dans le milieu (10).

En conclusion, on pourrait dire que les sédiments de surface de la lagune semblent ne pas être contaminés par les eaux en provenance des systèmes de traitement des eaux de purge riches en hydrocarbures. Ces résultats montrent le rôle joué par les bassins de décantation et la lagune naturelle dans la rétention et l'élimination de la pollution (effet de bioremédiation).

Références

1 - Tissot B. P., et Welte D. H., 1984. Petroleum Formation and Occurrence. 2ème édition : Berlin, Springer-Verlag, 538 p

2 - Pelet R., 1977. Géochimie organique des sédiments marins profonds de la mer de Norvège, Vue d'ensemble. Géochimie organique des sédiments marins profonds. ORGON I Mer de Norvège (Août, 1974). Ed C.N.R.S., Paris. pp. 281-296.

3 - Huc, A. Y., Roucache, J., Bernon, M., Caillet, G., and Da Silva, M., 1976. Application de la chromatographie sur couche mince à l'étude quantitative et qualitative des extraits des roches et des huiles. *Revue de l'Institut Français du Pétrole*, v. 31: 67-98.

4 - Saliot A. et Tissier M.J., 1977. Interface eau-sédiment : acides gras et hydrocarbures dissous et particulaires dans l'eau de mer. Géochimie organique des sédiments marins profonds. ORGON I Mer de Norvège (Août, 1974). Ed. C.N.R.S., Paris. pp. 197-208.

5 - Colombo, J.C., E. Pelletier, C. Brochu, and M. Khalil. 1989. Determination of hydrocarbon sources using n-alkanes and polyaromatic hydrocarbon distribution indices. Case study: Rio de La Plata Estuary, Argentina. *Environ. Sci. Technol.*, 23:888-894.

6 - Jaffé R., Mead R., Hernandez M. E., Peralba M. C. et DiGuida O.A. 2001 : Origin and transport of sedimentary organic matter in two subtropical estuaries : a comparative, biomarker-based study. *Organic Geochemistry*, 32. 507-526

7 - Clark, R.C., Jr., and M. Blumer. 1967. Distribution of n-paraffins in marine organisms and sediment. *Limnol. oceanogr.*, 17:79-87.

8 - Lytle, J.S., T.F. Lytle, J.N. Gearing, and P.J. Gearing. 1979. Hydrocarbons on benthic algae from the Eastern Gulf of Mexico. *Mar. Biol.*, 51:279-288

9 - Miranda A.C.M.L., Loureiro M.R.B., Cardoso J.N. 1999 : Aliphatic and aromatic hydrocarbons in Candiota coal samples: novel series of bicyclic compounds. *Organic Geochemistry*, 30: 1027-1038

10 - Zhu G. Ye X. Hou J. Zhu J. et Lu B., 1990. Geochemical characteristics of particulate alkane in the Changjiang estuary. In Biogeochemical study of the changjiang estuary. March 21-25, 1988. Ed. China Ocean Press. pp. 623-641.

PAH DISTRIBUTION IN WATER COLUMN AND SURFACE SEDIMENTS OF THERMAIKOS GULF, GREECE

I. Hatzianestis *, E. Sklivagou

Hellenic Centre for Marine Research, 19013 Anavyssos Attikis, Greece - * jhat@ncmr.gr

Abstract

The distribution of polycyclic aromatic compounds (PAH), was studied in the water column and surface sediments collected from Thermaikos gulf, in order to investigate the effects of resuspension events on the cycling and impact of these organic pollutants. The PAH compositional patterns and the application of various diagnostic criteria suggested that in February 2002 the increased values of their concentrations measured in the water column were clearly related to resuspended material from sediments.

Keywords: Thermaikos Gulf, resuspension, PAH

Introduction

PAHs show a high affinity to aquatic particles, especially to the organic carbon or lipid component. Because the sediments are the main repositories for such particle reactive contaminants, it is important to understand the processes that control chemical fluxes. Two major processes can move chemicals from the sediments to the overlying water column [1]: a) diffusive flux of dissolved species and 2) resuspension of in-place sediments with potential for redistribution of organic contaminants from the sediment to the water column. The aim of this work was to study the effects of natural resuspension occurred during stormy conditions and of anthropogenic resuspension induced by the intense trawling activities in the area of Thermaikos Gulf on the cycling and impact of PAHs.

Materials and methods

Surface sediment samples (0-2 cm) and seawater samples (20 L) were collected from 10 stations in Thermaikos Gulf during September 2001 (before the trawling activity), October 2001 (during trawling activity) and February 2002 (during natural/stormy induced resuspension events) (Fig. 1). Polycyclic aromatic hydrocarbon concentrations were determined by gas chromatography / mass spectrometry after extraction, cleanup and fractionation [2]. PAHs determined included the parent compounds with 2 – 6 aromatic rings, dibenzothiophene, retene and the methylated derivatives of dibenzothiophene and phenanthrene

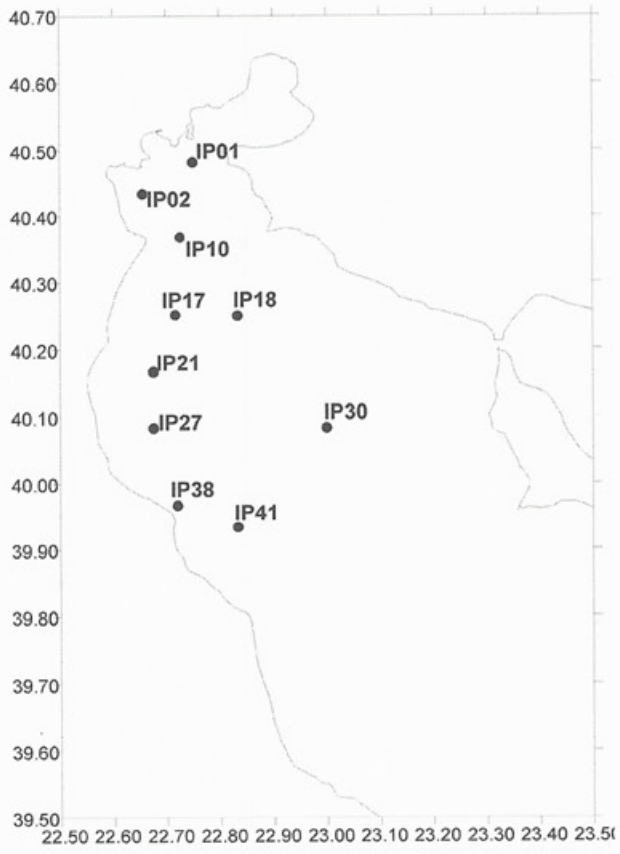


Fig. 1. The sampling locations in Thermaikos Gulf.

Results and discussion

Concentrations of total polycyclic aromatic hydrocarbons in surface sediments ranged from 27.2 to 280.5 ng/g (mean value 164.3 ng/g) in September, from 59.6 to 261.9 ng/g (mean value 160.7 ng/g) in October and from 62.7 to 285.9 ng/g (mean value 165.8 ng/g) in February. These values can be generally characterized as low and are similar to those found in relatively unpolluted marine areas. Slightly elevated concentrations were found in station 1, whereas considerably low values were recorded in station 18. No differences in PAH concentrations were observed among the three sampling periods. PAH with 4 or 5 aromatic rings originating from pyrolytic sources dominated the PAH composition in all cases, whereas petroleum related compounds accounted for less than 15% of the total PAHs.

Concentrations of total polycyclic aromatic hydrocarbons in the water column ranged between 0.8 and 13.4 ng/L (mean value 5.8 ng/L) in September, between 1.5 and 16.9 ng/L (mean value 7.0 ng/L) in October and between 4.4 and 16.8 ng/L (mean value 8.9 ng/L) in February. No important spatial variation was observed, whereas increased values were measured in the whole water column during October and February. These higher values are probably related with increased inputs of riverine or atmospheric inputs of land derived PAHs. In most cases and in all sampling periods PAH values in bottom water were slightly higher than those in the overlaying water masses. PAH compositional patterns can be used in order to examine their sources and pathways. It is known that low MW PAHs are more water soluble and usually predominate in the water column, whereas the high MW pyrolytic PAHs with negligible water solubility but high stability towards physicochemical or biological degradation are easily accumulated in sediments. In the water samples of Thermaikos gulf combustion PAHs accounted for the 0.1-7.6% of the total PAHs in September (mean value 3.3%), whereas in October and especially in February these percentages were clearly higher (1.9-17.6%, mean value 6.1% and 4.6-14.2%, mean value 7.6% respectively). This increase, which was more pronounced in the bottom water samples (Fig. 2), is a strong indication that there was a contribution from sedimentary PAHs in the water column in October and February, probably related to the resuspension events occurred during these periods.

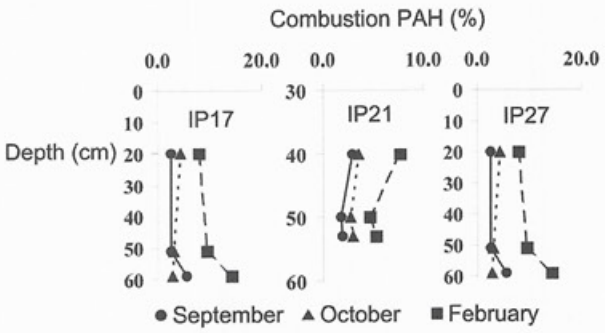


Fig. 2. Combustion PAH percentages in the water column.

References

1 - Latimer, J.S, Davis, W.R and Keith, D.J., 1999. Mobilization of PAHs and PCBs from In-Place Contaminated Marine Sediments During Simulated Resuspension Events, *Estuarine, Coastal and Shelf Science*, 49: 577-595.

2 - UNEP/IOC/IAEA, 1992 Determination of petroleum hydrocarbons in sediments. Reference Methods for Marine Pollution Studies, No 20, UNEP.

ATMOSPHERIC INPUT OF NUTRIENTS, IMPACT ON EAST MEDITERRANEAN WATERS

Barak Herut [1] *, Michael Krom [2] and Patricia Carbo [2]

[1] Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa, Israel - * barak@ocean.org.il
[2] School of Earth Sciences, Leeds University, Leeds, UK - m.d.krom@earth.leeds.ac.uk, pre@earth.leeds.ac.uk

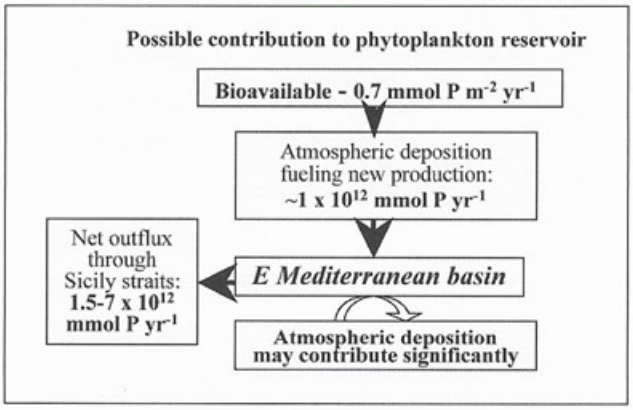
Abstract

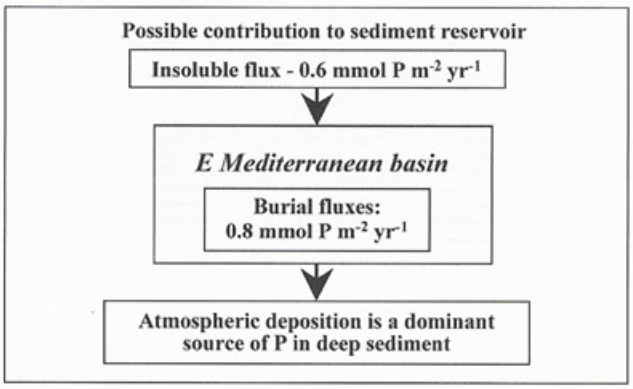
In the long-term, atmospheric deposition (especially dry fallout) play an important role in the supply of new nitrogen and phosphorus to surface water in the East Mediterranean, and contributes significantly to the relatively high N:P ratios in Levantine deep water. In the short-term, while clear fertilizing response was observed in an on-board dust gradient microcosm experiment, no such field response was seen through a dust storm event. More detailed field measurements are required during dust events before clear conclusion can be made on their short-term impact.

Key words: nutrients, dust, seawater, atmosphere, Mediterranean

Recent long-term (annual scale) studies have examined the leachability of nutrients from dry aerosols and provided annual flux estimates of seawater leachable (bioavailable) inorganic nitrogen (IN) and phosphorus (IP) into the East Mediterranean (1-4). These estimates emphasize the dominant role of the dry deposition mode in supplying new nitrogen and phosphorous into this basin. This annual-scale fertilizing impact integrates solubility variations which follow the aerosol character or source. Desert type aerosols exhibit lower P and N seawater solubilities as compared to aerosols associated with European air masses. Nevertheless, aerosol from both origins tend to increase the N/P ratios well above the Redfiled ratio found in most other oceanic areas and are probably an important driver for the unusual high ratios in the deep water.

It has been found that the atmospheric input of nutrients fuel the new production in similar amounts as exported by the anti-estuarine circulation through the Straits of Sicily (Fig. 1), while insoluble P is supplied at a rate similar to burial fluxes in the Levantine basin (Fig. 2).





It has been argued that short-term Sahara Dust pulses can cause phytoplankton blooms in summer when there is no nutrient supply by water column mixing. Results from the CYCLOPS program (Cycling of Phosphorus in the Mediterranean) indicates that while clear fertilizing response was observed in an on-board dust gradient microcosm experiment, no such field response was seen through a dust storm event. More detailed measurements are required during dust events before clear conclusion can be made on the short-term impact of dust events.

References

1 - Guerzoni S., Chester R., Dulac F., Moulin C., Herut B., Loye-Pilot M-D., Measures C., Migon C., Rossini P., Saydam C., Soudine A. and Ziveri P., 1999. The role of atmospheric deposition in the biogeochemistry of the Mediterranean Sea. *Prog. Oceanog.,* 44: 147-190.

2 - Herut B., Krom M.D., Pan G. and Mortimer R., 1999. Atmospheric input of nitrogen and phosphorus to the SE Mediterranean: sources, fluxes and possible impact. *Limnol. & Oceanog.,* 44: 1683-1692.

3 - Herut B., Collier R. and Krom M.D., 2002. The role of dust in supplying N and P to the SE Mediterranean. *Limnol. & Oceanog.,* 47: 870-878.

4 - Kouvarakis G.M., Tselipides N. and Stavrakakis A., 2001. On the importance of atmospheric inputs of inorganic nitrogen species on the productivity of the eastern Mediterranean Sea. *Global Biogeochemical Cycles,* 15: 805-817.

DÉVELOPPEMENT D'UNE MÉTHODOLOGIE POUR CARACTÉRISER ET DÉTERMINER LA POLLUTION DES EAUX DE MER PAR LES HYDROCARBURES EN UTILISANT DES IMAGES SATELLITES.

Houma Fouzia [1] *, Khouider Ali [2], Boulahdid Mustapha [1]

[1] ISMAL Sidi Fredj, Algérie - * houmabachari@yahoo.fr

[2] Département de chimie, Université de sciences et de technologie Houari Boumédiène, Bab-Ezzouar, Alger, Algérie

Résumé

Nous nous sommes intéressés à combiner des informations requises par différents satellites pour caractériser la pollution des eaux de mer par les hydrocarbures. Une analyse corrélative entre les teneurs en hydrocarbures et les réflectances calculées par les images satellites nous offre la possibilité de transformer des images brutes en images traitées qui peuvent s'interpréter en carte de pollution aquatique.

Mots clés : Pollution, mer, hydrocarbure, image satellite.

Introduction

Le littoral d'Alger est touché par diverses pollutions: une densité urbaine importante sur la côte qui déverse ses rejets dans les eaux marines, des usines qui rejettent leurs déchets industriels et contribuent à polluer le milieu sous l'effet des substances toxiques et corrosives et un trafic maritime très important. L'eau de mer est considérée comme un corps noir avec une faible réflectance dans la bande du visible. L'utilisation de la télédétection peut avantageusement remplacer les méthodes traditionnelles longues, coûteuses et fastidieuses pour la surveillance de la qualité des eaux. Les bandes spectrales Thematic Mapper étaient utilisées davantage pour corréler avec les propriétés spectrales de l'eau et sa teneur en matière organique ou encore pour la caractérisation de la couleur, la salinité et la concentration en chlorophylle de l'eau de mer [1, 2, 3]. En s'inspirant des différentes approches développées et des caractéristiques des satellites SPOT et Landsat, nous avons essayé de mettre en évidence l'utilisation de la télédétection afin de trouver des relations entre les paramètres optiques et la concentration en hydrocarbures présents dans l'eau.

Outils et méthodes

Le but de ce travail est de mettre en évidence des relations entre les mesures satellitaires et les mesures effectués *in situ*. Pour réaliser ce travail on a utilisé des images satellites (LANDSAT TM, SPOT XS, IRS1-C), des cartes bathymétriques de la région, des cartes des zones de dévasement des égouts et un bateau d'océanographie pour effectuer l'échantillonnage. Les images satellites brutes sont transformées en image réflectance (Ref) à l'aide d'un simple modèle de correction radiométrique. Les échantillons prélevés sont traités au laboratoire et on a déterminé pour chaque station les concentrations hydrocarbures polyaromatiques (HPA) et hydrocarbures totaux (HT).

Résultats et discussion

L'ensemble des résultats est mis dans un logiciel de traitement statistique (Statistica.5) afin de réaliser une analyse corrélative entre les différents paramètres. Le résumé d'analyse corrélative est présenté dans le tableau.1.

Tableau 1. Corrélation des réflectances et teneurs en Hydrocarbures

Fonctions	Droites d'ajustement Régression linéaire	Coefficient de corrélation
Ref (XS1) = f (HPA)	Ref 1 = 0.31505 + 0.0031 *HPA	R = 0.80123
Ref (TM1) = f (HPA)	Ref 1 = 0.08239 + 0.00352 HPA	R = 0.79845
Ref (TM2) = f (HPA)	Ref2 = 0.07104 + 0.00284 HPA	R = 0.80254
Ref (MSS4) = f (HPA)	Ref4 = 0.07769 + 0.00313 * HPA	R = 0.80129
Ref (XS1) = f(HT)	Ref1 = 0.31424 + 0.00013 * HT	R = 0.79704
Ref (TM1) = f(HT)	Ref1 = 0.7313 + 0.00147 * HT	R = 0.79514
Ref (TM2) = f (HT)	Re2f = 0.06358 + 0.00118 * HT	R = 0.79823
Ref (MSS4) = f (HT)	Ref 4 = 0.06948 + 0.00130 * HT	R = 0.79696

Dans le cas du capteur HRV-XS, la corrélation est meilleure pour XS1 que XS2, et pour XS2 que XS3, par contre pour le capteur TM on enregistre une forte liaison sur les deux premiers canaux et seulement le canal MSS4 donne une corrélation appréciable pour le système MSS. On peut conclure que les canaux XS1, TM1, TM2 et MSS4 peuvent être utilisés comme outils indicateurs de la pollution marine.

En utilisant le logiciel PCSATWIN [4] nous avons transformé l'image réflectance en une image qui permet d'estimer dans certaine mesure la pollution des milieux par les hydrocarbures. En effet, il existe une forte liaison entre les réflectances et la teneur de ces éléments. Les figures 1 et 2 nous permettent de classer clairement les zones polluées par la distinction de la couleur de chaque région à partir de l'image satellitaire transformée, soit plusieurs classes observées indiquant un degré différent de pollution.

Conclusion

Ce travail nous a montré la possibilité d'estimer certains polluants à partir des images satellitaires. L'analyse corrélative a rendu réalisable la détermination des indicateurs de la pollution à partir des satellites SPOT et Landsat. La spatialisation des valeurs mesurées sur le terrain facilite en effet le suivi environnemental de la qualité des eaux et les interventions sur le milieu. La capacité des bandes spectrales visibles est cependant très remarquable, elles peuvent servir à d'autres études plus approfondies pour établir de véritables cartes de pollution qui peuvent donner des informations sur la qualité des eaux côtières par le biais des satellites mis en orbite.



Fig. 1. Spatialisation des Hydrocarbures polyaromatiques. HPA(µg/l) = - 658.5 + 2092.8 * XS1



Fig. 2. Spatialisation des Hydrocarbures totaux. HT(mg/l) = - 1559 + 4975.3 * XS1

References

1 - Ferrari GM., Tassan S. 1992. Evaluation of the influence of yellow substance absorption of the remote sensing of water quality in the Golf Naples: a case study. *Int. J. Remote Sensing*, Vol. 13, 12: 2177-2189.

2 - Jaquet J.M., 1989. Limnologie et télédétection : Situation actuelle et développements futurs. *Revue Sciences de l'eau*, 2 : 457-481.

3 - Jaquet J.M., Zand B., 1989. Colour Analysis of Inland Waters Using Landsat TM Data. ESA, SP-1102: 57-67.

4 - Bachari N., Benabadji N., Abdellaoui A., 1997. Développement du logiciel d'analyse spectrale et temporelle des images satellite type SPOT, LANDSAT et METEOSAT, *A.M.S.E. J.*, Vol. 38, 1 et 2:15-34.

INDUCTION OF P53 IN MUSSEL *MYTILUS GALLOPROVINCIALIS* TISSUES

Željko Jakšić

Laboratory for Marine Molecular Toxicology, Center for Marine Research Rovinj, Rudjer Bošković Institute, Giordano Paliage 5, HR-52210 Rovinj, Croatia - jaksic@cim.irb.hr

Abstract

The tumor suppressor phosphoprotein p53 as a biomarker of genotoxic stress in marine mussel *Mytilus galloprovincialis* were investigated. The effect of direct and indirect acting genotoxic xenobiotic compounds on p53 protein family levels were determinated using the Western blot analysis and immunoassay detection. The well known DNA damaging agents: N-methil-*N*'-nitro-nitrosoguanidine (MNNG), 4-nitroquinoline-N-oxide (NQO), and benzo[a]pyrene (B[a]P) induced level of p53 in a time and dose dependent manner. The aim of the study was to establish the applicability of the p53 induction as a genotoxic stress estimation tool and promised use of p53 as a biomarker in marine ecotoxicological monitoring research.

Keywords : biomonitoring, ecotoxicology, genotoxic agents, musell Mytilus galloprovincialis, p53

Introduction

The investigation of tumor suppressor p53 gene and protein family is in the focus of much interest in last decade. Their sequence, biochemical properties and biological function were well described and characterized. Up to date the induction of the p53 protein as an indicator of genotoxic damage which leads to cell cycle arrest and DNA repair or apoptosis were investigated in several types of cell lines. The identification of genotoxic agents effects by p53 induction has arising interest in last several years (1).

A few scientific research teams in US showed attention on soft calm *Mya arenaria* p53 induction. The expression of *p53* gene homologue in this organism (2) and structural and functional data for p53 and p73 gene products (3) were under investigation for a several years. The clam leukaemia were initially detected and characterized in hemolymph tumor cells (4). The differential expression of *p53* family members between normal hemocytes and leukaemia cells were showed by approximately equal amounts of *p53* but no *p73* is detectable in normal hemocytes (5.)

Those investigations lead as to make an attempt to establish the p53 induction/level determination, as existing pathway in marine invertebrates upon genotoxic agents effects, in Mediterranean mussel *Mytilus galloprovincialis* tissues. In this study the preliminary results of p53 protein family members induction by chemical xenobiotics are presented.

Materials and methods

All chemicals were of the highest analytical or molecular biology grade. Six different Mouse monoclonal antibodies against human p53 and Goat Anti-Mouse IgG, Alkaline Phosphatase conjugate were purchased by Upstate Biotechnology, USA.

Mussels *Mytilus galloprovincialis* were collected in Rovinj area, Northern Adriatic, and transferred to the laboratory basin, treated with 0-10 g MMNG, NQO and B[a]P /g mussel and incubated in seawater with flow, at 16- C. After 2, 6, 12, 24, 48 and 168 hours the mussel gills and hemolymph were taken from each of the mussel. All the experiments were performed with 5 mussels in each sample group.

Discontinuous SDS electrophoresis and Western blot were performed using the BioRad Mini System. Immunochemical detection of p53 protein levels were performed using polyclonal rabbit anti-p53 proteins and goat anti rabbit-HRP conjugate.

Western blots were photographed and scanned. Although each protein lane contained the same amounts of proteins and the quantization of p53 specific bands was performed by densitometry of the whole lane areas.

Results and discussion

In present study the induction of the p53 protein family members in mussel tissues were examinated by using direct and indirect acting genotoxic xenobiotics.

The effect of 0-10 :g MMNG /g mussel shows a dose dependent response and highest level of p53 in the first few hours after treatment of mussels. Mussels injected with the same amount of indirect acting genotoxic agents: NQO and B[a]P also showed the dose-dependent p53 induction but the maximum level of protein (increased half-life of p53 protein) were determinated after several hours of incubation. This xenobiotic needs biological activation (*via* P450 pathway) which leads to high level of DNA damage and p53 induction.

This study shows that p53 induction in mussel *Mytilus galloprovincialis* tissues could be effective tool to identify environmental genotoxins. The p53 protein family induction/level as a biomarker in marine invertebrates has a promised role in the estimation of genotoxic potential in the marine environment. Their suitability for genotoxicity assessment of pollution impact on aquatic organisms and environmental monitoring, to predict the environmental changes upon induced genotoxic effects of mixed xenobiotics presented in marine environment, has to be under high interest and further investigation.

References

1 - Yang J., and Duerksen-Hughes P., 1998. A new approach to identifying genotoxic carcinogens: p53 induction as an indicator of genotoxic agents. *Carcinogenesis*, 19: 1117-1125.

2 - Van Benden J. R., Walker C. W., and Laughner E. S., 1997. Characterization of gene expression of a *p53* homologue in the soft-calm (*Mya arenaria*). *Mol. Mar. Biol. Biotechnol.*, 6: 116-122.

3 - Kelley M. L., Winge P., Heaney J. D., Stephens R. E., Farell J. H., Van Benden J. R., Reinisch C. L., Lesser M. P., and Walker C. W., 2001. Expression of homologues for p53 and p73 in the softshell calm (*Mya arenaria*), a naturally-occurring model for human cancer. *Oncogene*, 20: 748-758.

4 - Barker C. M., Calvert R. J., Walker W. C., and Reinisch C. L., 1997. Detection of mutant p53 in calm leukaemia cells. *Exp. Cell Res.*, 232: 210-245.

5 - Stephens R. E., Walker C. W., Reinisch C. L., 2001. Multiple protein differences distinguish clam leukaemia cells from normal hemocytes: evidence from normal hemocytes: evidence for the involvement of p53 homologues. *Comp. Biochem. Physiol.*, 129: 329-338.

TRACE ELEMENTS CONCENTRATIONS IN THE SURFACE SEDIMENTS AND THE WATER COLUMN OF KAVALA GULF (NORTHERN GREECE)

N.I. Kamidis, N. Stamatis and G. Sylaios *

National Agricultural Research Foundation, Fisheries Research Institute, Nea Peramos 640 07, Kavala, Greece - * fri@otenet.gr

Abstract

The total metal content for Cd, Cr, Cu, Ni, Pb and Zn, in surface sediments (0-5 cm, 24 samples) and in bottom suspended particulate matter (27 samples), from the coastal zone of the Kavala Gulf (northern Aegean) was investigated. Sediment analysis showed maximum values for Cu, Cd and Zn at the industrial zone while Ni, Pb and Cr at the deeper parts. For bottom SPM trace elements distributions showed almost equal values of Ni, Zn and Cu at all areas, increased Cd at the deeper parts, Pb at the fish-farming and industrial areas and Cr at the industrial and tourist areas.

Keywords: metal pollution, sediment, suspended particulate matter, Kavala Gulf

Introduction

A series of land-based activities take place along gulf's coastline, such as tourism at the western part of the gulf, urban and industrial activities (including phosphoric fertilizer plant, waste water treatment works, oil refineries and a commercial harbor) at the central and eastern part, and fish-farming activities (including extensive aquaculture in four coastal lagoons and mussel-culture farms) at the eastern gulf. The scope of this study was to determine the spatial distribution of six trace elements (Cd, Cr, Cu, Ni, Pb and Zn), in the surface sediments and the water column (suspended particulate matter) at a semi-enclosed coastal water body (Kavala Gulf, northern Greece).

Materials and methods

A total number of 24 surface sediment samples (0-5 cm) were collected from the Gulf of Kavala, using a Van Veen sampler. Pretreatment of samples was performed according to [1]. Sediment samples were digested in a mixture of 1 ml HF and 4 ml of aqua regia in microwave oven. During the same cruise, seawater samples (2 l each) were collected from 27 stations (at the surface and bottom of the water column). Samples pretreatment and cleaning procedures were performed according to [2]. Filters were digested using a hot plate in a mixture of 8 ml HNO_3 and 1ml HF. Sediment and loaded filters were analyzed using a Perkin Elmer AAnalyst 800 atomic absorption spectrophotometer with Zeeman background correction. Precision and accuracy were checked using the MESS-3 (N.R.C. of Canada) marine sediment as reference material.

Results and discussion

Summary statistics of the heavy metal concentrations in the sediment and water of Kavala Gulf are shown in Table 1. Figure 1 presents the mean sediment metal concentrations of stations in the vicinity of each land-based activity. Maximum values for Cu, Cd and Zn were found at the industrial zone, lower concentrations were observed at the deeper stations and the fish-farming area, while the lowest values at the western tourist part. The deeper stations (where fine sediments are deposited) showed increased Ni, Pb and Cr values.

Table 1. Mean concentrations (standard deviations), minimum and maximum values (in µg/g) for all trace elements in sediments and suspended particulate matter at the bottom of the Kavala Gulf.

	Cu	Ni	Pb	Cd	Cr	Zn
Sediment values	25.1 (21.3)	19.5 (15.7)	64.7 (40.4)	0.3 (0.3)	64.9 (23.2)	157.4 (258)
min-max	0.5-75	0.4-47.3	24.9-209.1	0.01-0.9	36.9-113.8	41.8-1,353
Bottom SPM values	29 (10.5)	23.9 (11.4)	57.6 (30.2)	4.4 (1.9)	155.3 (60.4)	173.9 (64.6)
min-max	11.2-45.7	4.6-60.4	9.7-108.5	1.7-8.5	77.4-304.2	51.5-307

The distribution of trace metals at the suspended particulate matter of the water column is shown in Figure 2. Ni, Zn and Cu were distributed almost equally inside the gulf while increased Cd was found at the deeper parts of the gulf. High particulate Cr values were observed at the industrial and tourist areas. Particulate Cr and Zn showed very high values compared to the surface sediment concentrations at all stations and increased Pb values at the fish-farming and industrial areas.

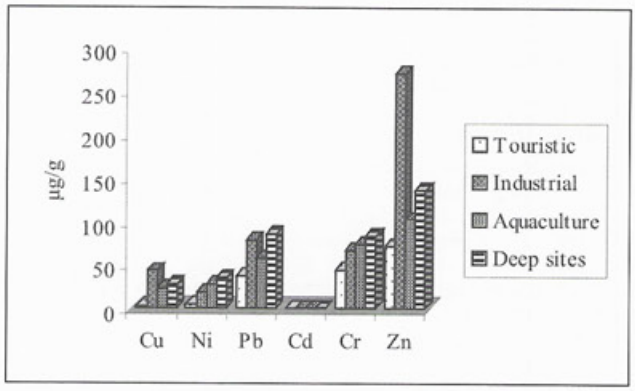


Fig. 1. Heavy metal distribution for the sediment in the four areas of Kavala Gulf.

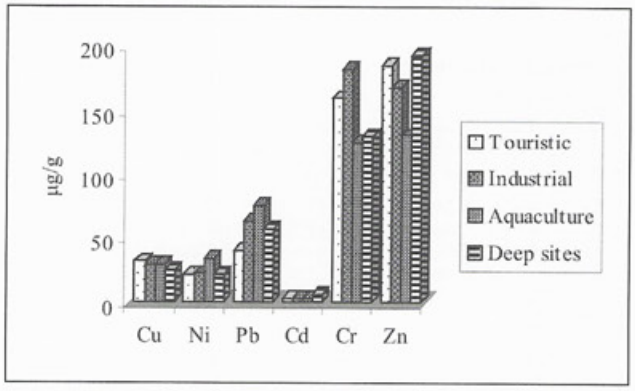


Fig. 2. Heavy metal distribution for the SPM in the four areas of Kavala Gulf.

References

1 - Aloupi M., and Angelidis M.O., 2001. Geochemistry of natural and anthropogenic metals in the coastal sediments of the island of Lesvos, Aegean Sea. *Environ. Pollut.*, 113: 211-219.

2 - Pohl C., 1997. Trace metals in marine suspended particulate matter: an international ICES intercomparison exercise. *Accredit. Qual. Assur.*, 2: 2-10.

DETERMINATION OF THE DISSOLVED COPPER FRACTION COMPLEXED WITH SOLUBLE ORGANIC LIGANDS IN COASTAL WATERS OF THE SARONIKOS GULF, GREECE

S. Karavoltsos *, A. Sakellari, M. Scoullos

University of Athens, Department of Chemistry, Laboratory of Environmental Chemistry, Panepistimiopolis, 157 71 Athens, Greece
* skarav@cc.uoa.gr

Abstract

This work deals with speciation of dissolved copper in seawaters of two sites in the Saronikos Gulf namely the Gulf of Elefsis and the coast of Piraiki. The samples were UV irradiated in order to determine the inert fraction of dissolved copper corresponding to copper complexed with dissolved colloidal organic carbon. The determined concentration of kinetically inert as for Chelex-100 resin dissolved copper ranges widely from 1.3 to 32.1 nM, corresponding to a percentage fluctuating between 8% and 67%, with a mean value of 37%, of the total dissolved copper.

Keywords: copper, speciation, UV irradiation, Greece

Introduction

The chemical forms under which metals exist in seawater affect their bioavailability and toxicity and therefore the determination of the different species of dissolved metals is of great interest. Organic complexation with natural organic ligands in seawaters is significant for trace metals such as copper [1], since it may prevent metal scavenging by suspended particulate matter and/or formation of insoluble inorganic metal complexes, maintaining thereby enhanced dissolved trace metal concentrations in seawater. The main purpose of the present study is the description and evaluation of the method employed for copper speciation and the preliminary reporting of the results obtained.

Methodology

Five coastal sampling locations were chosen in the Saronikos Gulf, four of which within the Elefsis Gulf (Aspropyrgos, Elefsis port, Loutropyrgos, Nea Peramos), an industrialized area near Athens and one station at the Piraiki coast, near Piraeus, the biggest port of Greece. From the sampling area of Loutropyrgos seawater samples were taken both from the surface and from near the sea-bottom. All stations were characterised by the presence of a significant biomass of the macroalga *Ulva rigida*. Nine samplings were carried out between May and October 1998, the period when the highest biodegradation rate of the macroalga *Ulva* was observed.

Immediately after collection and transfer to the laboratory seawater samples were filtered through 0.45Mm pore size acid-washed celluloze nitrate filters (Millipore), kept in darkness in low-density polyethylene containers and analysed within 24h. For the determination of the dissolved labile copper, 500ml of each sample were pumped through a Chelex-100 resin (200-400 mesh; Bio-Rad laboratories, Richmond California; contact time of the sample with the resin 7sec) and eluted with 10ml of HNO_3-HCl 2:1M. The concentration of copper was measured by a flameless atomic absorption spectrophotometer (VARIAN SpectrAA 640 Z) equipped with Zeeman background correction. For the determination of the total dissolved metal, the filtered sample was UV irradiated for 100min before the preconcentration step. UV digestion of samples was carried out by irradiation of solutions using a 400 W medium pressure lamp (Cleo HPA, Philips), positioned in an aluminum lamp housing device built in purpose, placed inside a fume cupboard cooled by a fan. Each sample was put into a teflon beaker with quartz glass cap, where the distance between the light source and the beaker was 2 cm. The sample was stirred continuously employing a magnetic stirrer. The efficiency of the procedure was tested with the analysis of CASS-4 certified reference seawater (certified copper value 0.592 ± 0.055 µg/l, measured value 0.568 ± 0.067 µg/l) as well as with synthetic solutions of Salicylic acid (1.5 mg/l; >90% decomposition) and commercial humic acid (1.0 mg/l; Fluka Lot 45729/1) containing a Cu(II) concentration. Although UV irradiation for 100min resulted in the decomposition of approximately 60% of the humic acid contained in the samples, the complexed Cu was almost fully released, as shown by Cu analysis with DPASV. DOC was measured by a Shimadzu-5000A TOC analyser.

Results and discussion

The concentrations of kinetically inert, as for Chelex-100 resin dissolved copper, which is calculated by subtracting the concentration of the labile fraction of dissolved copper from total copper, were found to range from 1.3 to 32.1 nM in a total of 52 samples analysed. The mean concentrations were 5.8 nM for Piraiki, 9.0 nM for Aspropyrgos, 8.4 nM for the port of Elefsis, 5.4 nM for surface and 8.5 nM for bottom samples of Loutropyrgos and 8.1 nM for Nea Peramos. These concentrations correspond to a percentage of inert fraction of dissolved copper over the total dissolved copper ranging from 8% to 67% with a mean value of 37%. By correlating these results to those of researches from other seas [2, 3] it becomes evident that UV irradiation accelerates the release of a major part of the inert fraction of dissolved copper which corresponds to copper bound predominantly to organic colloids. The percentage of this fraction in the aforementioned cases was around 44%. Lewis and Landing [4] showed that in seawater samples from the Black Sea following preconcentration in a series of sequential columns where Chelex-100 was included, the percentage contribution of organically bound copper was never less than 50%.

The concentrations of DOC ranged from 38 to 338 nM. There was no correlation observed between the concentrations of inert dissolved copper and those of DOC (r=0.15), due to the contribution of a single part of dissolved organic matter to the complexation of dissolved copper.

Inert dissolved copper measured in bottom seawater samples taken from Loutropyrgos (mean value 8.5 nM) were higher compared to the corresponding concentrations (mean value 5.4 nM) of surface seawater samples. This difference is attributed to the decomposition of the *Ulva rigida* biomass accumulated at the seabed. The dissolved organic matter released aggregates forming colloids or even particulate matter, either through biotic mechanisms including bacterial activity or by abiotic procedures such as adsorption on solid surfaces, increasing the copper complexing capacity of seawater.

It is noteworthy that other researchers [5] attribute the stable complexation of copper to relatively low molecular weight colloidal organic ligands. The phenomena recorded require further investigation which is currently under way.

References

1 - Plavšić M., Ćosović B., Lee C., 2001. The copper complexing properties of melanoidins and marine humic material. *Rapp. Comm. Int. Mer Medit.*, Monaco, 36: 154.

2 - Wells M.L., Smith G.J., Bruland K.W., 2000. The distribution of colloidal and particulate bioactive metals in Narragansett Bay, RI. *Mar. Chem.*, 71: 143-163.

3 - Sunda W.G., and Huntsman S.A., 1991. The use of chemiluminescence and ligand competition with EDTA to measure copper concentration and speciation in seawater. *Mar. Chem.*, 36: 137-163.

4 - Lewis B.L., and Landing W.M., 1992. The investigation of dissolved and suspended-particulate trace metal fractionation in the Black Sea. *Mar. Chem.*, 40: 105-141.

5 - Wells M.L., Kozelka P.B., Bruland K.W., 1998. The complexation of 'dissolved' Cu, Zn, Cd and Pb by soluble and colloidal organic matter in Narragansett Bay, RI. *Mar. Chem.*, 62: 203-217.

IMPACT DE LA POLLUTION PAR LES HYDROCARBURES SUR LES TISSUS DE LA CLOVISSE COLLECTÉE DES COTES TUNISIENNES

Z. Khedir-Ghénim [1], M. Hammami [2], D. Saïdane-Mosbahi [1] *

[1] Laboratoire d'analyse de polluants chimiques et microbiologiques de l'environnement, Faculté de Pharmacie, Avenue Avicenne, 5000 Monastir, Tunisie - * Dalila.Saidane@fphm.rnu.tn

[2] Laboratoire de biochimie, Faculté de Médecine, Monastir, Tunisie.

Résumé

L'objet de cette étude est d'évaluer la contamination par les hydrocarbures (HC) des tissus de la clovisse collectée des côtes tunisiennes. Une étude organique sur les composés lipidiques présents dans les tissus de l'animal a été effectuée. Elle consiste à extraire les lipides libres et les fractionnés par chromatographie en phase liquide. Les HC saturés et insaturés non aromatiques sont analysés par chromatographie en phase gazeuse. Les résultats montrent que les clovisses collectées du canal de navigation accumulent, en été, des HC d'origine pétrolière, alors que celles du canal de Rades, de Bizerte et de Sfax s'avèrent non polluées.

Key words : petroleum, molluscs, pollution.

Introduction

Les mollusques étant des filtreurs accumulent les hydrocarbures (HC) en suspension dans l'eau de mer et sont considérés par conséquent comme des espèces sentinelles indicatrices de pollution (1). Le but de cette étude est d'évaluer la contamination par le pétrole des tissus de la clovisse collectée à partir des côtes tunisiennes.

Matériel et méthodes

Les échantillons proviennent de 4 sites différents : le canal de navigation de Tunis, le canal de Rades, oued Meltine à Sfax et une station d'élevage à Bizerte.

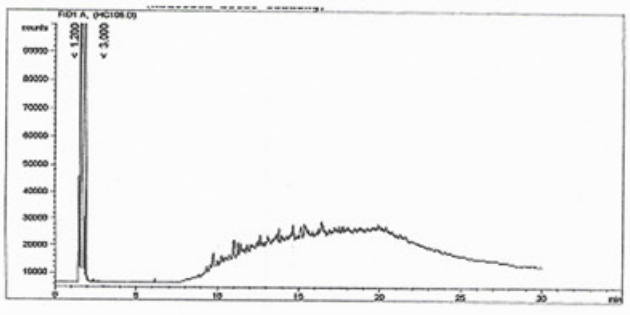
Après lyophilisation de la chair de l'animal, les lipides sont extraits par du chloroforme et fractionnés par chromatographie en phase liquide sur colonne de silice. On obtient des HC saturés et insaturés non aromatiques (F1), des HC aromatiques (F2) et des composés polaires (F3). F1 est analysé par chromatographie en phase gazeuse.

Résultats et discussion

Les teneurs en HC totaux de nos échantillons sont très élevées et varient de 3993 à 63700 ppm. Ces résultats dépassent les teneurs trouvées dans les tissus de bivalves en Arabie Saoudite (1500 ppm) (2).

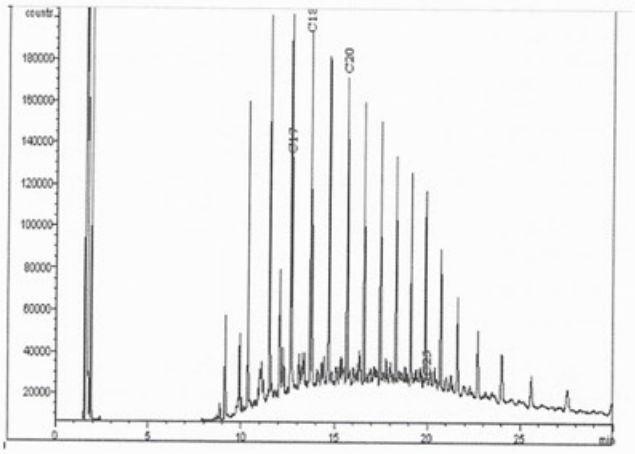
L'examen des pourcentages pondéraux de F1, F2 et F3 a montré que les échantillons collectés à partir de Tunis, Sfax et Bizerte présentent une prédominance de (F3) qui varient de 50% à 98%. Ces teneurs élevées de F3 témoignent en faveur d'une origine biogène des HC présents dans les tissus.

Les échantillons de canal de Rades montrent que F1 constitue une fraction majeure par rapport à F2 et F3 et varient de 43% à 67%. Cette prédominance de F1 peut être l'indice d'une contamination des tissus de la clovisse par des HC exogènes probablement pétroliers (Fig. 1).



Les chromatogrammes de F1 des échantillons collectés du canal de navigation au cours des mois d'été montrent une distribution des n-alcanes marquée par la dominance des légers par rapport aux plus lourds, avec une décroissance rappelant celle du pétrole brut. Aussi les n-alcanes paires et impaires sont à égalité et le CPI ≈ 1 (3). Les échantillons obtenus en dehors des mois d'été montrent une distribution des n-alcanes sans prédominance des légers par rapport aux lourds. Le CPI # 1 et on ne remarque pas de décroissance des quantités des n-alcanes des plus légers vers les plus lourds (Fig. 2).

On peut conclure que l'accumulation des HC biogènes dans les tissus de l'animal se fait continuellement. Au cours des mois d'été, l'animal accumule en plus les HC pétroliers.



Les chromatogrammes des échantillons ramassés sur les autres côtes tunisiennes montrent des composés représentés par des pics importants qui correspondraient probablement à des HC insaturés synthétisés par ces animaux. Ce qui exclut l'hypothèse de contamination des tissus de la clovisse par le pétrole.

On pourrait expliquer l'absence de contamination dans la plupart des échantillons, malgré la pollution de leurs milieux, par la présence d'un système physiologique permettant l'épuration total du corps de l'animal. Les mollusques contaminés par le pétrole retrouvent leur goût normal après deux mois d'immersion dans de l'eau saine (4).

Références

1 - Hermida Ameijeiras A., Simal Gandara J., Lopez Hernandez J. et Simal Lozano J., 1994. Classification of the Coastal Waters of Galicia (NW Spain) on the Basis of Total Aliphatic Hydrocarbon concentrations in Mussels (*Mytilus galloprovincialis*). *Marine Pollution Bulletin.* Vol. 28, No. 6: 396-398.

2 - Ehrhardt M.G. et Burns K.A., 1993. Hyrocarbons related photo-oxydation products in Saoudi Arabian Gulf coastal waters and hydrocarbons in underlying sediments and bioindicator bivalves. *Marine Pollution Bulletin,* Vol. 27: 187-197.

3 - Granby K. et Spliid N.H., 1995. Hydrocarbons and organochlorines in common mussels from the kattegat and the Belts and their relation to condition indices. *Marine Pollution Bulletin,* Vol. 30, No. 1: 74-82.

4 - Michel P., 1976. Pollution par les hydrocarbures: Interaction avec la biocénose. La pollution des eaux marines. Edit. Gauthiers - Villars. 231 p.

DISTRIBUTION OF TRACE METALS IN DIFFERENT TISSUES OF BLUEFIN TUNA *THUNNUS THYNNUS*

Zorana Kljaković-Gašpić *, Vjekoslav Tičina, Nikša Odžak, Tomislav Zvonarić, Ante Barić
Institute of Oceanography and Fisheries, 21 000 Split, Croatia - * kljakovic@izor.hr

Abstract
Concentrations of Cd, Cr, Cu and Zn were analyzed in muscle tissue, gill and liver samples of the bluefin tuna *Thunnus thynnus* caught in the Middle Adriatic. Analytical results revealed variable distribution of metals in the examined tissues. Maximum levels of Cd, Zn and Cu were determined in the liver, while Cr concentrations were similar in all analyzed tissues.

Keywords : trace metals, distribution, bluefin tuna

Introduction

Data on trace metal content in different fish tissues are often used to study the physiological behavior of metals in the fish (1). The aim of this study was to determine the concentrations of some potentially toxic trace metals (Cd, Cr, Cu and Zn) in different tissues of the bluefin tuna *Thunnus thynnus*, in order to determine distribution patterns of metals in the organism.

Methods

Eighteen specimens of bluefin tuna were caught by purse-seine in the open waters of the Middle Adriatic, during August 1996. Collected fish were immediately frozen (-20°C) and transported to the laboratory for analysis. In the laboratory, the fork length (range: 123-240 cm; mean=157±25 cm) and weight (range: 35-165 kg; mean=69±27 kg) of each specimen were measured. Liver, gills, parts of light muscles near the head, from the middle part and the tail of the fish, as well as the red muscle from the middle part were cut out and frozen prior to analysis. Preparation of tissues for trace metal analysis included freeze drying, sample homogenization and wet digestion (2). Trace metal analyses were performed using graphite furnace atomic absorption spectroscopy. All results are reported in mg kg^{-1} dry weight. The accuracy of the analytical procedure was tested using certified reference material IAEA-350 (Tuna fish). Statistical differences between mean metal concentrations in different tissues were evaluated using non-parametric Sign Test.

Results and discussion

Heavy metal concentrations in the different fish tissues are shown in Fig. 1. Chromium concentrations were similar in all tissues ($P>0.05$). In contrast, the highest levels of Cd, Zn and Cu were determined in liver samples. Cadmium concentrations in liver were 45-55 times higher in comparison to all other tissues, among which there were no significant differences ($P>0.05$). Concentrations of Zn and Cu in liver were also 4-13 times and 9-66 times higher respectively in comparison to other tissues. Observed patterns of trace metal distribution between tissues match well with the results of other field and laboratory studies (1, 3-5). Differences between trace metal concentrations in analyzed tissues probably originate from differences in physiological functions of muscles, gills and liver (1, 6). However, distribution of Cu and Zn among the different muscle tissues also differed. Concentrations of Zn in red muscle samples and in muscles from near the head and the tail were higher than in the light muscle samples from the middle part of the fish. Unlike Zn, Cu concentrations were similar in the light muscle samples from three different parts of the fish, and 5-8 times lower than in the red muscle. This is probably due to differences in distribution and detoxification strategies of Cu and Zn in fish (1). Higher Cu concentrations in red muscle could also be related to the important metabolic role of Cu in respiratory pigments (1), which are present at high concentrations in the blood and the red muscle itself (6).

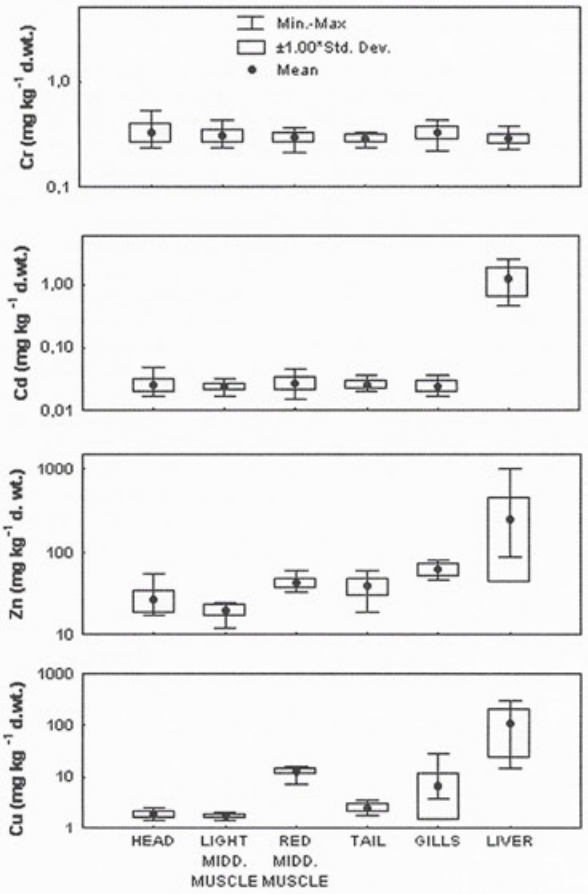


Fig. 1. Trace metal concentrations (in mg kg^{-1} dry weight) in liver, gills and muscle tissues of bluefin tuna (N=18; length: 123-240 cm; weight: 35-165 kg). Dots represent average values; lower and upper box edges represent average ± 1 SD; outlying bars are minimum and maximum values.

References

1 - Phillips D.J.H., and Rainbow P.S., 1993. Biomonitoring of Trace Aquatic Contaminants, Pp. 371. Elsevier Science Publ. LTD, Barking, Essex.
2 - Kljaković-Gašpić Z., Zvonarić T., Vrgoč N., Odžak N., and Barić A., 2002. Cadmium and lead in selected tissues of two commercially important fish species from the Adriatic Sea. *Water Res.*, 36: 5023-5028.
3 - Odžak N., and Zvonarić T., 1995. Cadmium and lead uptake from food by the fish *Dicentrarchus labrax*. *Water Sci. Technol.*, 32: 49-55.
4 - Širović A., 1995. Correlation between weight of juvenile bluefin tuna from the Adriatic and accumulation of lead and cadmium to its tissues. Pp. 32. International baccalaureate, XV Gymnasium, Zagreb.
5 - Storelli M.M., Ceci E., and Marcotrigiano G.O., 1998. Comparative study of heavy metal residues in some tissues of the fish *Galeus melastomus* caught along the Italian and Albanian coasts. *Rapp. Comm. int. Mer Médit.*, 35(2): 288-289.
6 - Bond C.E., 1996. Biology of fishes, 2nd ed., 750 p. Saunders College Publ., Florida.

SEWAGE SLUDGE IMPACT ON SEDIMENT QUALITY AND BENTHIC ASSEMBLAGES OFF THE MEDITERRANEAN COAST OF ISRAEL – A LONG-TERM STUDY

Kress N. *, Herut B. and B.S. Galil

Israel Oceanographic and Limnological Research, National Institute of Oceanography, Haifa, Israel - * nurit@ocean.org.il, barak@ocean.org.il, bella@ocean.org.il

Abstract

A long-term study at a sewage sludge disposal site off the Mediterranean coast of Israel showed a marked but localized, seasonally dependent, impact on the benthic assemblages and sediment quality in the area. The effect was mostly northward of the outfall, in the direction of the prevalent longshore current. Measurements showed that the disposal site is dispersive and no evidence of increased accumulation of sewage sludge with time was found, nor of pollutants associated with it.

Keywords: sewage sludge, marine disposal, heavy metals, benthic assemblages

The distributions of benthic assemblages, heavy metals and organic carbon (C_{org}) in sediments were examined during a long-term study at a sewage sludge disposal site off the Mediterranean coast of Israel. The disposal of sewage sludge has a marked but localized, seasonally dependent, impact on the benthic assemblages and sediment quality. Elevated concentrations of C_{org}, Hg, Cd, Cu, Zn, Pb, and to a lesser degree Ni in the sediments were detected mostly northward of the sewage outfall, in the direction of the prevalent longshore current (Fig. 1). High concentrations of C_{org} and metals were reflected by elevated populations of tolerant and opportunistic polychaetes in spring and by an azoic zone in fall (Fig. 2). The impacted area extended mainly towards the north (up to ca. 4 Km) and to a lesser extent south of the outfall (up to ca. 2.5 Km). No evidence of increased accumulation of sewage sludge with time was found, nor of pollutants associated with it. We suggest that the seasonal pattern found is due to the stratification of the water column from spring to fall on one-hand and winter storms on the other. Winter storms resuspend and disperse the fine organic particles, sweeping the site clean of sludge; accumulation of sludge takes place throughout the quiescent periods of the year, when stratification is reestablished.

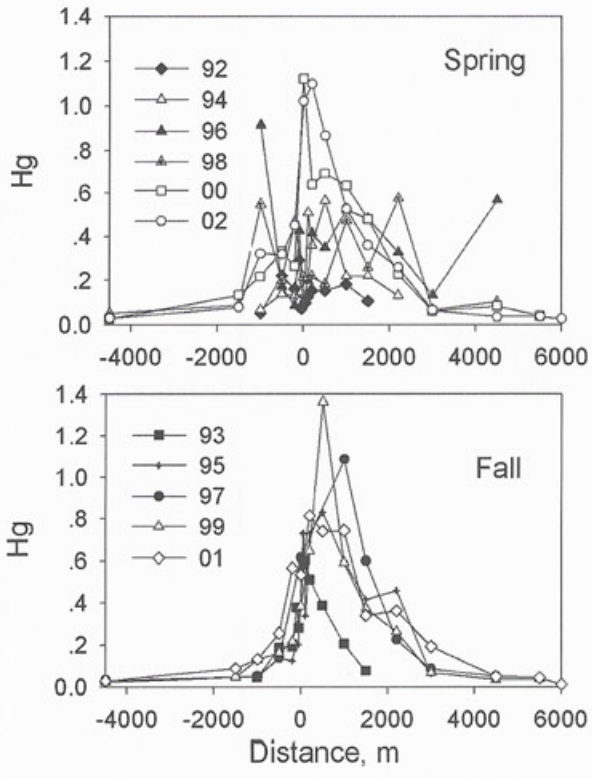


Fig. 1. Distribution of Hg (μg g^{-1} dry wt) in spring and fall along the south-north transect. Negative and positive distances are southwards and northwards of the outfall, respectively.

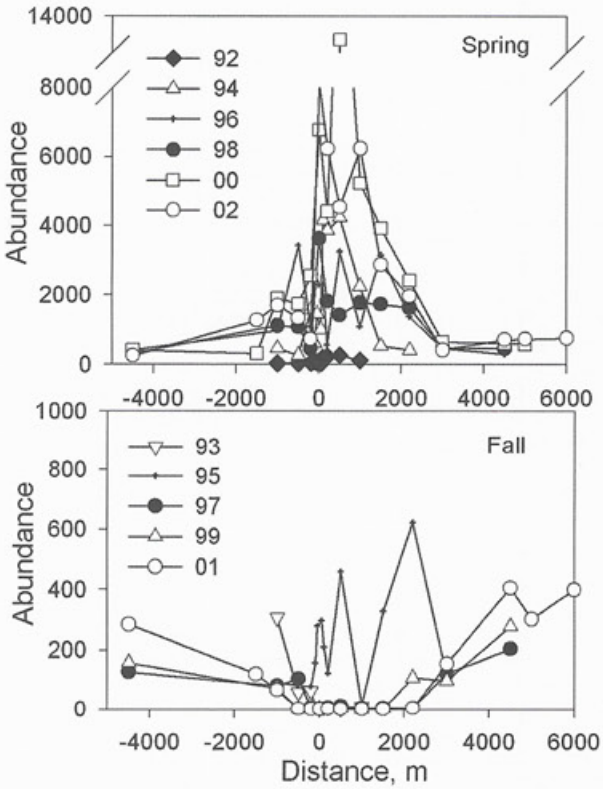


Fig. 2. Distribution of abundance (no of individuals) in spring and fall along the south-north transect. Negative and positive distances are southwards and northwards of the outfall, respectively. Please note difference abundance scale for spring and fall.

AN OVERVIEW OF NUTRIENTS AND HEAVY METALS IN THE IZMIR BAY, TURKEY, 1996-2002

F. Kucuksezgin *, A. Kontas, O. Altay, E. Uluturhan, E. Darilmaz
Institute of Marine Sciences&Technology, inciralti, 35340-Izmir - * filiz.ksezgin@deu.edu.tr

Abstract

The nutrient concentrations ranged between 0.01-0.19, 0.01-10 for o-PO_4-P; 0.10-1.8, 0.13-27 for TNO_x-N, 0.34-8.0, 0.43-39 µM for silicate in the outer and middle-inner bays, respectively. Heavy metals found in sediment varied for Hg: 0.05-1.3; Cd: 0.004-0.82; Pb: 14-113;Cr: 29-316 $\mu g g^{-1}$. High values were observed in the inner bay. Outer and middle bays show low levels of metal enrichments except Gediz River estuary. The levels gradually decreased over the sampling period. The metals found in fish varied for Hg: 4.5-928, Cd: 0.10-14, Pb: 0.10-918 $\mu g kg^{-1}$.

Key words: nutrients, heavy metals, sediment, fish, Izmir Bay

Introduction

Izmir Bay is one of the great natural bays of the Mediterranean. The Gediz River, which flows to the outer bay, is the biggest river in the bay. Inner bay intensely industrialized compared to outer bay and is heavily polluted by nutrients, organic material. Eutrophication of the inner bay is a serious problem throughout the year and red tide events are becoming more frequent. A number of studies have been carried out on the concentrations of nutrients, metals in the bay during a year, but no long-term and seasonal data are available. The main aim of this study was to monitor levels, temporal variability, distribution of nutrients, metals in edible fishes and sediments before and after wastewater plant.

Materials and methods

Data were collected during cruises of R/V *K. Piri Reis* in the bay. Sediment samples were taken using Van-Veen Grab from surface sediments. Samples were digested in microwave digestion system with an HNO_3-HF-$HClO_4$-HCl mixture. Tissues were digested with HNO_3-$HClO_4$ in a microwave system. All analyses were performed by flame (Cr), cold vapour (Hg), graphite furnace (Cd, Pb) AAS, using the manufacturer's conditions with background correction. The detection limits for heavy metals are Hg:0.05 $\mu g l^{-1}$, Cd:0.10 $\mu g l^{-1}$, Pb:0.10 $\mu g l^{-1}$, Cr:0.06 $mg kg^{-1}$.

Results and discussion

Nutrients

In the periods of 1996-2002, during autumn, TNO_x-N, o-PO_4-P levels were generally higher than the other periods (Table 1). Maximum values were recorded during autumn because of low consumption by phytoplankton. High levels of nutrients were observed during summer and autumn due to bacterial degradation in the inner bay. The phosphate concentrations in inner bay were higher than values observed in clean waters, a clear indication of the role of domestic waste. Higher chlorophyll-a values were determined in spring and autumn periods. The ratio of TNO_x to phosphate was lower than the Redfield's ratio. A two-way ANOVA was used to compare the nutrient concentrations among seasons and sampling stations. The nutrient concentrations significantly varied among season and sampling stations. Izmir wastewater treatment plant (WTP) was constructed in the beginning of 2000. The concentrations of TNO_x-N have been reduced after WTP except sudden discharges, while increases were recorded for the levels of o.PO_4-P in the middle-inner bays. The capacity of WTP has not been found enough for the phosphate. High levels of ammonia were found in the middle-inner bays due to the intensive rain.

Table 1. Range, mean values of nutrients (µM) in Izmir Bay.

	Year	Outer Bay		Middle-Inner Bays	
o.PO_4P	96-98	0.01-0.19	0.06±0.001	0.01-10	0.83±0.06
	00-02	0.01-0.19	0.05±0.003	0.13-4.4	1.2±0.17
TNO_xN	96-98	0.11-1.8	0.48±0.01	0.13-27	2.6±0.25
	00-02	0.10-1.4	0.44±0.02	0.15-18	2.4±0.55
NO_2N	96-98	0.01-0.23	0.03±0.001	0.01-18	0.53±0.09
	00-02	0.01-0.16	0.04±0.003	0.01-12	0.85±0.29
NH_4N	96-98	0.10-0.96	0.30±0.02	0.10-21	2.5±0.18
	00-02	0.10-0.79	0.25±0.01	0.10-50	3.6±1.3
Si	96-98	0.30-4.1	1.5±0.02	0.50-39	4.2±0.28
	00-02	0.38-4.8	1.3±0.05	0.43-26	5.5±0.83

Heavy metals in sediment

The highest concentrations of metals were found in the inner bay. The maximum level of Hg (1.3 $\mu g g^{-1}$ dry wt) was measured at harbour in 2000. High levels of mercury were found in the NW part of the outer bay due to old center of mercury mining. The highest cadmium (0.82 $\mu g g^{-1}$) was also found at harbour in 1997. Lead (113 $\mu g g^{-1}$) and chromium (316 $\mu g g^{-1}$) were quite high in the sediments of middle-inner bays. The main source of lead is probably the traffic, since the great majority of the cars have no catalytic converters and burn leaded fuel. Maximum levels of Cr were observed at the Gediz River estuary due to the leather tanning plants. Metal concentrations decreased in 2002 at all sampling stations in the bay except Cr depending on the treatment of wastewater by WTP. The concentrations of metals in the outer bay were generally similar to the Aegean except chromium (1). The levels of metals are lower in the inner bay than polluted areas of Mediterranean (2).

Heavy metals in fish

Mullus barbatus was recommended by FAO/UNEP as monitoring species. *Solea vulgaris* was also selected as monitoring species because it is important commercially and commonly consumed by humans. In *M.barbatus* Hg level increased in 2002, while decreases were recorded for the values of Pb. All metal levels were significantly lower in *S.vulgaris* than *M.barbatus*. Regression between Hg concentrations and the fish length was statistically significant ($p<0.05$). An increase in Hg with increasing length was noted for *M.barbatus*, in good agreement with results from the Aegean Sea (3). ANCOVA was used to compare metal concentrations among seasons, no significant differences were detected. Metal concentrations found in this study were higher than those from clean areas of Aegean Sea (3), and are likely due to natural and industrial inputs to Izmir Bay. On the other hand, metal concentrations in Izmir Bay are considerably lower than those found in polluted areas of Mediterranean, such as Tyrrhenian Sea and Saranikos Gulf (4,5).

References

1 - Friligos N., Moriki A., Sklivagou E., Krasakopoulou E., and Hatzianestis I., 1998. Geochemical characteristics of the surficial sediments of the Aegean Sea. *Rapp. Comm. int. Mer Médit.*, 35: 260.

2 - Zvonaric T., and Odzak N., 1998. Distribution of Hg,Cu,Zn,Cd and Pb in surface sediments from the coastal region of the central Adriatic. *Rapp. Comm. int. Mer Médit.*, 35: 312.

3 - Kucuksezgin F., Altay O., Uluturhan E., and Kontas A., 2001. Trace metal and organochlorine residue levels in red mullet (*Mullus barbatus*) from the eastern Aegean, Turkey. *Water Res.*, 35: 2327-2332.

4 - Taliadouri-Voutsinouu F., 1980. Trace metals in marine organisms from the Saronikos Gulf (Greece). *Ves Journées Etud. Pollutions, CIESM*, 275-280.

5 - Barghigiani C., and De Ranieri S., 1992. Mercury content in different size classes of important edible species of the Northern Tyrrhenian Sea. *Mar. Pollut. Bull.*, 24: 114-116.

CHANGES OF OXYGEN SATURATION IN THE BOTTOM LAYER OF THE MIDDLE-EASTERN ADRIATIC DURING THE PERIOD 1972-2002

G. Kušpilić *, B. Grbec, G. Beg-Paklar, M. Morović and A. Barić
Institute of Oceanography and Fisheries, 21000 Split, P.O. Box 500, Croatia - * kuspe@izor.hr

Abstract
Based on the results of regular monthly cruises in the area of the middle-eastern Adriatic a drop in oxygen saturation of the bottom layer was observed in the period 1992-1996. The decrease of oxygen content was coupled with a nutrient enrichment in this layer. This phenomenon seems to be connected with an unusual low water exchange rate between the Adriatic and the Mediterranean.

Keywords: Adriatic Sea, nutrients, oxygen saturation, time series

Introduction

The upper part of the water column (0-75 meters) in the middle-eastern Adriatic area is throughout the year characterised by moderate primary production, balanced oxygen saturation and low nutrient concentrations with relatively small seasonal oscillations. In contrast to the upper layer, the seasonal variability of nutrient and oxygen concentrations in the water column below 75 m is much higher and depends on the vertical particulate organic carbon fluxes and Levantine intermediate water (LIW) inflow. Extremes of oxygen and nutrient concentrations in this layer are usually established during late summer. As the LIW inflow seems to be controlled by a horizontal pressure difference between the mid-northern Atlantic and the south eastern Mediterranean (1), large scale interannual climatic variability could be an important factor for the hydrographic and chemical properties of deep water layers.

Material and methods

Hydrographic and chemical data collected in the period 1972-2002 from a station in the middle Adriatic Sea (43°00.0' N, 16° 20.0' E) were analysed. Temperature and salinity were obtained by reversing thermometers, salinometers and CTD probes, whereas nutrients were measured on different Technicon AutoAnalysers (I, II and III) and oxygen by the classical Winkler titration.

Results and discussion

Data analysis of the basic hydrographic and chemical parameters has shown a pronounced decrease of oxygen saturation as well as an increase of nutrient concentrations in the bottom layer during the period 1992-1996 (Fig. 1). In contrast to the bottom layer no significant changes of chemical parameters and primary production in the euphotic zone were observed. The absence of the relation between primary production and bottom oxygen content points to circulation induced changes of chemical properties. In the period 1987-1995 the thermohaline structure in the Adriatic has shown a decreasing temperature and salinity trend in the intermediate and bottom layer. These trends agree with observed changes of general thermohaline Mediterranean circulation (2) indicating lower rates of LIW (saltier and warmer) inflow to the Adriatic and Adriatic bottom water outflow. Observed changes of chemical parameters seem to be the result of the remineralisation of autochthonous organic matter (probably from the productive area of the northern Adriatic) and a certain stagnation of the bottom water in the area of south and middle Adriatic.

Conclusion

Observed changes of oxygen saturation and nutrient concentrations in the bottom layer of the middle Adriatic was found to be in relation with changes of thermohaline and dynamic properties in this layer.

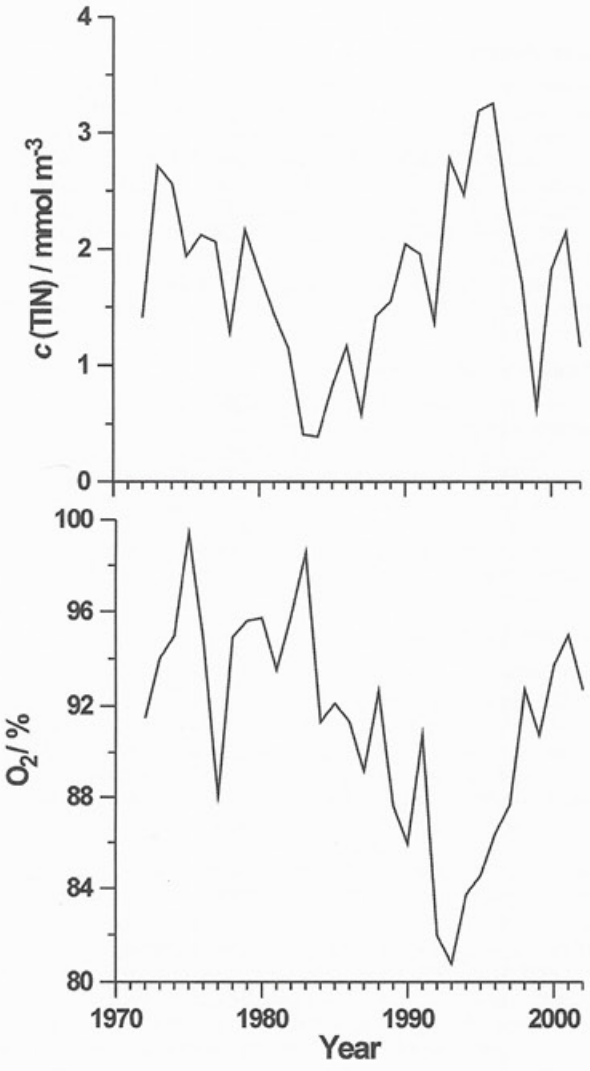


Fig.1. Yearly means of oxygen saturation and dissolved inorganic nitrogen concentrations in the bottom layer during 1972-2002.

References

1 - Grbec B., Morović M., and Zore-Armanda M., 2003. Mediterranean Oscillation and its relationship to salinity fluctuation in the Adriatic Sea. *Acta Adriat.*, 44 (1): 61-76.

2 - Stratford K., and Haines K., 2002. Modelling changes in Mediteranean thermohaline circulation 1987-1995. *J. Mar. Syst.*, 33-34: 51-62.

PIGMENTS IN ALGAL-MATS OF A SMALL AND SHALLOW BAY IN GREECE

M. Ladakis, M. Dassenakis * and A Pantazidou

University of Athens, Dept of Chemistry, Section III, Laboratory of Environmental Chemistry, Panepistimiopolis 157 71 Athens, Greece

Abstract

This paper describes the identification and measurement of pigments in coastal organosedimentary forms, using HPLC. Various types of pigments were determined but Chlorophyll α was the dominant one. An increasing trend was observed during spring and autumn and a decreasing one during summer and winter. Chlorophyll-b, Pheophytyn-a and Carotenoids were also detected in considerable amounts. Traces of Foucoxanthine and Luteine were identified in some cases. Microscopic study of the system revealed that Cyanobacteria was the dominant group; Chlorophytes and diatoms were also present

Keywords : Pigment, chlorophyll, HPLC, algal-mat

Introduction

Photosynthetic pigments are of great importance for several biochemical procedures in the marine environment. Chlorophylls are the most important group of such compounds and probably the most frequently measured biochemical parameter in oceanographic studies. The concentration of chlorophylls reflects the primary production and eutrophication level in marine systems. Photosynthetic pigments also appear in marine sediments coming from benthic ecosystems that include many algal species. An interesting case is that of recent stromatolites developed in some shallow Mediterranean coasts. They are defined as organosedimentary structures produced by sediment trapping, binding, and/or precipitation due to the growth and metabolic activity of benthic microorganisms principally cyano-bacteria (1). These structures consist of various colored layers. Most of the organisms can be found in the surface layer (algal-mat).

The concentrations of various pigments and their seasonal fluctuation were studied in such organosedimentary structures from a small enclosed, shallow bay near Athens, where environmental conditions are favorable for them (Mesotrophic level, low tides, shallow and warm waters, sunlight)(2).

Methodology

Sediment cores of about 10 cm long, were collected on monthly basis from July 2000 to June 2001 from three different points of the bay. Samples were fractionated in three layers: the upper one, 0.5-1.2 mm thick that includes the algal-mat; the middle one, up to 5 cm thick, of dark color, anoxic; the third one 5 to 10 cm represents the background sediment of the bay.

After freeze-drying, the separated layers were sieved through 0.24mm sieves and stored under inert atmosphere, in darkness at –18° C.

The HPLC technique was selected for the detection and measurement of the pigments as the most accurate and reliable one. The measurement of pigments by a Waters HPLC instrument (600/60F) with a 996 Diode Array Detector and a C18 column, followed their extraction procedure (3). The separation and measurement of pigments was achieved using a system of three eluants in a gradient elution procedure (4). Identification of cyanobacteria was carried out by light microscope on live field and cultured material.

Results and discussion

The microscopic analysis of natural and cultured material taken from the surface layer or the samples revealed that cyanobacteria was the dominant group of the system phototrophs. Chlorophytes and diatoms were also present but in a lesser degree. The composition of the cyanobacteria communities of the surface layer does not differ significantly among the samples. Six taxa of cyanobacteria were identified. Among them the filamentous Lyngbya *aestuarii* and *Microcoleus chthonoplastes* were the most abundant. Evidently, there is a reduction of phototrophs occurring in the second black layer. However specimens from its upper part (aprox. 1 cm deep) when put in culture, shown growth of cyanobacteria.

A representative chromatograph of the pigments is shown in Fig. 1. The seasonal mean values of Chlorophyll α, Chlorophyll-b, Pheophytin-a and Carotenoids are presented in Table 1. Foucoxanthine and Luteine were detected only in traces. Increase of all pigment concentrations was observed during springtime and autumn and decrease during summer and winter. The relevant concentrations in the second dark colored layer were found to be about one order of magnitude lower.

The distribution and fluctuations of pigments in this organosedimentary system indicate its complexity and ecological significance. This rarely observed in Greek coasts system, is probably affected by changes in environmental conditions and marine pollution. These influences are under research in our laboratory.

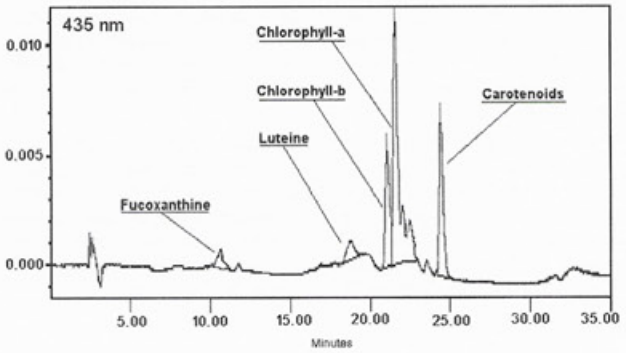


Table 1. Seasonal concentration of pigments in the upper layer of the sediment core (in μg / g)

Pigment	Summer 2000	Autumn 2000	Winter 2001	SpringTime 2001
Chlorophyll α	116,8	175,3	186,2	211,3
Chlorophyll-b	44,6	72,4	36,6	59,2
Pheophytin-a	17,7	20,4	14,8	29,3
Carotenoids	9,8	12,4	8,0	16,2

References

1 - Lucas J.S., 2000. The Ecology of Cyanobacteria. Kluwer Academic Publishers, pp. 63-64.

2 - Ladakis M. and Dassenakis M., 2002. Physicochemical study of a small, closed, and shallow bay's waters in Saronikos gulf. First Scientific Conference of EFMS: Oceanographical aspects for a sustainable Mediterranean. Athens 27–29 September 2002.

3 - Jeffrey S.W, Mantura R.F.C., and Wright S.W., 1997. Phytoplankton pigments in oceanography. UNESCO Publishing, pp. 269-271.

4 - Jeffrey S.W, Mantura R.F.C., and Wright S.W., 1997. Phytoplankton pigments in oceanography. UNESCO Publishing, pp. 330-333, 453-456.

LE PHÉNOMÈNE D'IMPOSEX OBSERVÉ POUR LA PREMIÈRE FOIS EN TUNISIE CHEZ UN MOLLUSQUE GASTEROPODE, *MUREX TRUNCULUS*

Y. Lahbib [1], N. Trigui El-Menif [1] *, M. Le Pennec [2] et M. Bou Maiza [1]

[1] Université de Carthage, Faculté des Sciences de Bizerte, Département de Biologie, Laboratoire d'hydrobiologie, Tunisie
[2] Institut Universitaire Européen de la Mer, Université de Bretagne Occidentale, site Technopôle Brest Iroise, F-29280 Plouzané, France

Résumé

Des prélèvements mensuels de 120 individus de *Murex trunculus* ont été réalisés de juillet 2002 à juin 2003 dans deux stations de la lagune de Bizerte: Menzel Jemil et Menzel Abderrahmen et dans le canal de communication de cette lagune avec la Méditerranée, la station de la cimenterie. L'examen des tissus a montré la présence d'un tractus génital mâle externe chez toutes les femelles de la station du canal, traduisant un phénomène d'imposex. 38 à 40% des femelles de la station de Menzel Abderrahmen possèdent aussi un pénis mâle tandis que ce phénomène est totalement absent chez les individus de la station de Menzel Jemil.

Mot clès: imposex, Murex trunculus, Méditerranée

Introduction

Le rocher fascié *Murex trunculus* est un gastéropode marin qui se rencontre en abondance sur pratiquement tout le littoral tunisien depuis la zone intertidale jusqu'à une profondeur de 3 à 4 m. Depuis quelques années son exploitation s'est intensifiée intervenant d'abord en complément de l'exploitation de la palourde *Ruditapes decussatus*, puis, à partir de 1994, comme pêche de substitution du vénéridé touché par des phycotoxines provenant de la prolifération de la microalgue *Gymnodinium sp*.

Ce gastéropode se trouve exposé, dans certains sites du littoral tunisien, à des rejets divers: agricoles, industriels, urbains et également à des molécules issues des peintures antisalissures, recouvrant les coques des bateaux. La lagune de Bizerte étant un lieu de trafic intense de bateaux civils et militaires nous avons voulu nous rendre compte de l'éventuel impact des composés organostanniques sur *Murex trunculus*, par le biais de l'analyse de l'imposex.

Matériel et méthodes

De juillet 2002 à juin 2003, nous avons effectué des prélèvements mensuels du rocher fascié, *Murex trunculus*, à raison de 120 individus répartis en trois classes de taille (30-39.9 mm; 40-49.9 mm et 50-60 mm). Les trois sites de prélèvements se situent au nord de la Tunisie: Menzel Jemil et Menzel Abderrahmen dans la lagune de Bizerte (Fig. 1) et dans le canal de communication de cette lagune avec la Méditerranée: la station de la cimenterie. Une fois au laboratoire, les parties molles des animaux sont retirées des coquilles afin de déterminer le sexe et de voir s'il y a une éventuelle manifestation du phénomène d'imposex.

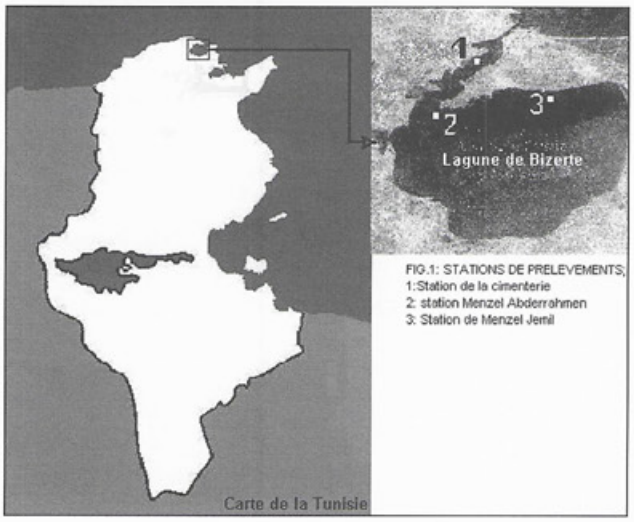


FIG.1: STATIONS DE PRELEVEMENTS;
1:Station de la cimenterie
2: station Menzel Abderrahmen
3: Station de Menzel Jemil

Résultats

Les observations révèlent des différences au niveau du tractus génital externe. En effet, les spécimens récoltés dans la station de la cimenterie sont caractérisés par la présence d'un pénis chez les femelles. La longueur du pénis étant pratiquement la même pour une même taille d'individus pour les sexes mâles et femelles. Ce phénomène de surimposition d'un pénis est relevé sur la totalité des femelles du canal tout au long de la période d'étude. A Menzel Abderrahmen, par contre, le taux d'imposex observé est inférieur et varie de 37 à 40%. Enfin, dans la station de Menzel Jemil, aucun cas d'imposex n'a été relevé, quelque soit la classe de taille des individus et la période de prélèvement.

Discussion et conclusion

Le phénomène d'imposex observé, en Tunisie, chez le rocher fascié a été également rencontré chez d'autres espèces de gastéropodes comme *Nassarius obsoletus* et *Ocenebra erinacea* (1) et sur *Littorina littorea* prélevée sur des côtes nord méditerranénne et atlantique (2). Des travaux expérimentaux réalisés par certains auteurs comme (3) sur *Nucella lapillus* ont montré l'étroite relation existant entre la concentration du milieu en tributyl étain (TBT) et le taux d'apparition du phénomène d'imposex. Selon ces auteurs, l'imposex commence à se produire à des concentrations en étain inférieures à 1 ng/l et une concentration de 2 ng/l peut engendrer un imposex à toute la population de gastéropode vivant dans le même milieu. Ceci laisse supposer que, pour certains sites de la lagune de Bizerte et notamment dans la station de la cimenterrie, la concentration en étain est égale ou supérieure à 2 ng/l si nous admettons que les espèces *Murex* et *Nucella* présentent la même sensibilité vis à vis de ce composé stannique. A Menzel Jemil, l'inexistence de ce phénomène peut être interprétée comme une absence de TBT dans ce site lagunaire. Par contre, la station de Menzel Abderrahmen qui se situe entre à la sortie de la lagune et à l'entrée du canal, semble avoir une concentration en TBT intermédiaire entre celles de Menzel Jemil et de la cimenterie. Une étude écotoxicologique, en cours de réalisation, devrait permettre de mettre en évidence une relation entre la concentration en composés organostanniques et la taille du pénis chez *Murex trunculus*.

Références

1 - Feral, 1976: Etude statistique de la présence d'un tractus génital mâle externe chez les femelles d'un mollusque gastéropode gonochorique: *Ocenebra erinacea* (L). *Cah. Biol. Mar.*, 16, 61-76.

2 - Bauer, 1995: TBT effects on the female genital system of *Littorina littorea*: a possible indicator of tributhyltin pollution. *Hydrobiologia*, 309 ; 15-26.

3 - Bryan G. W., Gibs P. E., Hammerstone L. G. et Burt G. R., 1987: The effects of tributyltin accumulation on adult dog-welks, *Nucella lapillus*, long term field and laboratory experiments. *J. Mar. Biol. Ass.* UK, 67; 524-544.

MEDFLUX: ASSOCIATION OF ORGANIC MATTER WITH BALLAST MINERALS IN SINKING PARTICLES

Lee Cindy [1] *, Armstrong Robert A. [1], Wakeham Stuart G. [2], Peterson Michael L. [3], Cochran J. Kirk [1], Miquel Juan Carlos [4], Masqué Pere [5], Goutx Madeleine [6]

[1] Marine Sciences Research Center, Stony Brook University, Stony Brook, NY, USA, *cindylee@notes.cc.sunysb.edu
[2] Skidaway Institute of Oceanography, Savannah, GA, USA, stuart@skio.peachnet.edu
[3] Department of Oceanography, University of Washington, Seattle, WA, USA, mlpmlp@u.washington.edu
[4] Marine Environment Laboratory, IAEA, Monaco, j.c.miquel@iaea.org
[5] Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Bellaterra, Spain, Pere.Masque@uab.es
[6] Laboratoire de Microbiologie Marine, Campus de Luminy, Marseille, France, goutx@com.univ-mrs.fr

Abstract

Recent evidence points to a relatively constant ratio of organic matter to mineral ballast in particles sinking in the deep ocean. We hypothesize that ballast minerals physically protect a fraction of their associated organic matter, and that this protected OM dominates over the unprotected fraction deeper in the water column. We suggest that the ratio of organic carbon to ballast may be key to predicting variability in export fluxes and sinking velocities of organic carbon as estimated using radiotracers. Using data collected at the DYFAMED site in the western Mediterranean, we present results that bear on these hypotheses.

Keywords: organic mater, ballast minerals, sediment trap, particulate matter

We recently hypothesized that minerals produced by organisms, or introduced into the surface ocean by winds, critically influence carbon export to the deep ocean and sediments (1). Minerals typically constitute more than half the mass of sinking particles, and are important for making less dense organic matter sink (2). Minerals may also protect organic matter from degradation, allowing it to penetrate deeper into the ocean. We demonstrated (a) that ratios of particulate organic carbon to mineral ballast converge to a nearly constant value (~6 wt% OC) at depths >1800 m (1), and (b) that decreases in flux of over two orders of magnitude are attended by minimal changes in bulk organic composition (3). Because these patterns are the hallmark of physical protection, we hypothesize that a substantial fraction of particulate organic matter raining through marine water columns is protectively associated with mineral grains. Thus, the types and amounts of mineral ballast introduced to the surface ocean may be critical, although largely overlooked, determinants of the ocean's ability to take up and store bioactive elements.

Data obtained from the DYFAMED site in the western Mediterranean bear on these hypotheses. Besides our standard in-situ pump, Niskin bottle, and IRS sediment traps, we used for the first time a new conical, free-floating NetTrap, an elutriator, and an IRS trap in the sinking velocity mode. The sinking velocity mode allowed collection of particles with sinking rates from 1-1000 m/d. We measured a large suit of organic and inorganic parameters.

At 200 m, mass fluxes decreased from about 1000 mg/m^2/d in early March to about 10 mg/m^2/d in early July. Sediment traps operated in a "sinking velocity" mode were used to obtain a sinking velocity profile. The IRS valve used to prevent the entrance of swimmers into the trap was rotated once each day to allow particles to fall into the trap. The trap collector cups were then rotated in a time-sequence that allowed us to determine the particle settling rate within the trap. The sorted particles could then be retrieved and subjected to analysis. Fig. 1 shows the mass fluxes at the settling velocities measured. Most material settled at around 200 m/d. Chemical analysis of this material includes organic, inorganic and radiochemical parameters. Fig. 2 shows the results of preliminary analyses of percent organic and inorganic carbon and total nitrogen. The C/N ratio does not change greatly over the velocity profile. However, the %OC, and less so the OC/IC, increases towards the slower settling velocities. Given that much of the mass not represented by OC, IC and TN is due to mineral ballast, these results suggest that the OC/ballast ratio is higher for more slowly settling material. In addition, the fact that %OC increases more than OC/IC at lower settling rates suggests that other materials, e.g., biogenic silica, may be more important ballast than IC at 200m. Further chemical analyses will show whether organic matter composition changes with settling velocity.

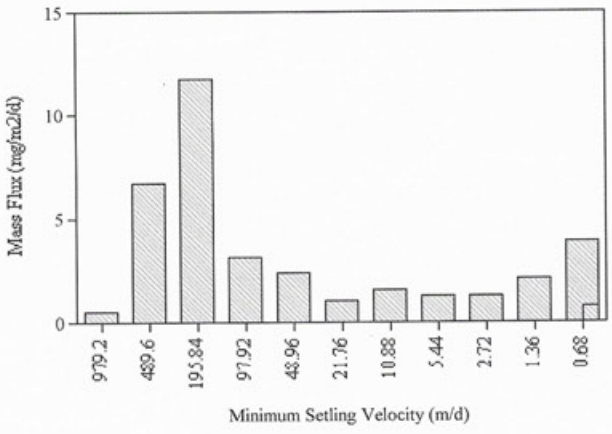


Fig. 1. Mass fluxes at 200 m measured at different settling velocities.

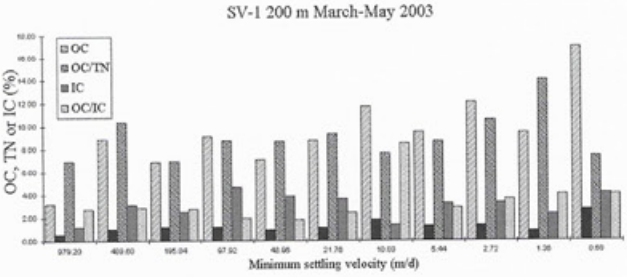


Fig. 2. Organic carbon and total nitrogen (black bars) fluxes, C/N ratio, inorganic carbon flux, and OC/IC ratio at 200 m measured at different settling velocities.

References

1 - Armstrong R.A., Lee C., Hedges J.I., Honjo S., and Wakeham S.G., 2002. A new, mechanistic model for organic carbon fluxes in the ocean, based on the quantitative association of POC with ballast minerals. *Deep-Sea Res. II*, 49: 219-236.

2 - Klaas C., and Archer D.E., 2002. Association of sinking organic matter with various types of mineral ballast in the deep sea: Implications for the rain ratio. *Global Biogeochem. Cycles*, 16: Art. No. 1116.

3 - Hedges J.I., Baldock J.A., Gélinas Y., Lee C., Peterson M.L., and Wakeham S.G., 2001. Evidence for non-selective preservation of organic matter in sinking marine particles. *Nature*, 409: 801-804.

NITROGEN AND AOU: USEFUL TOOLS FOR SHORT-TERM PREDICTION OF END SUMMER HYPOXIC EVENT IN THE NORTH ADRIATIC SEA BOTTOM LAYER

M. Marini [1], A. Russo [2], R. Signell [3], F. Grilli [1], A. Campanelli [1], A. Artegiani [1] *, D. Bigazzi [2]

[1] CNR – Institute of Marine Science (ISMAR), Ancona, Italy
[2] University of Ancona, Dept. of Marine Science, Italy
[3] SACLANT Undersea Research Centre, La Spezia, Italy

Abstract

During late summer 2002 three oceanographic cruises carried out in the North Adriatic Sea allowed analysis of a hypoxic event in the bottom layer . Physical and chemical parameters (Nitrogen and AOU: apparent oxygen utilization) were studied to define an approach for prediction of hypoxic events in the North Adriatic Sea. A 1D equation was formulated to predict the evolution of bottom dissolved oxygen content. The utilized methodology is supported by the weak circulation in the bottom layer of the hypoxic area during the period.

Keywords: Chemical oceanography, dissolved oxygen, nitrogen, hypoxia, Adriatic Sea

The Adriatic is a continental basin of the Eastern Mediterranean Sea, located between the Italian peninsula and the Balkans; it is elongated in the SE-NW direction.

The northern sub-basin is vary shallow and gently sloping, with an average bottom depth of about 35 m. River runoff is particularly strong in this area and affects the circulation through buoyancy input and the ecosystem by introducing large amounts of organic matter. Po river, with an average annual discharge of 1500 m^3s^{-1} , accounts for about 50 % of the total northern Adriatic river runoff (1).

The bottom water layer most frequently exposed to hypoxic events (2) is often influenced by a cyclonic circulation gyre governed by the Po plume, trapping its fresh waters at surface (3). Low current velocities at the gyre centre, enhanced stratification (reducing vertical mixing) and high turbidity (stopping sunlight in the first meters) due to the fresh water, high production and sedimentation are some of the factors that cause hypoxic events in this area (typically occurring between Sept.-Nov.).

Three oceanographic cruises were conducted in the northern Adriatic Sea (more than 600 CTD casts) from 16 September to 16 October 2002 by the R/V G. Dallaporta and R/V Alliance. Both utilized CTD probes were SBE 911plus, equipped with redundant T-C sensors, SBE 43 dissolved oxygen (DO) and other ancillary sensors, and coupled with SBE Carousel water samplers. Water samples were collected to analyze nutrient salts (4) and DO with potentiometric titration method (5) were used to verify the probe DO sensors.

The bottom layer currents were examined through the ROMS ocean model, initialised by the CTD data and forced by the LAMI meteorological model.

During the period of investigation, the hypoxic area increased on the bottom layer (Fig. 1). In some stations dissolved oxygen reached about 30 % of saturation.

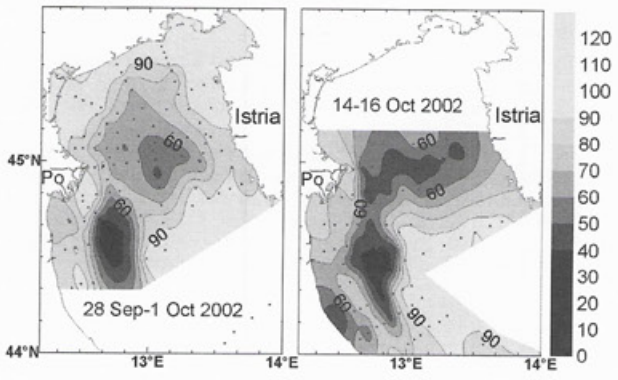


Fig. 1. Bottom dissolved oxygen (expressed as % of saturation) distribution; sampling dates are reported within each map.

The average AOU:N(NO_2+NO_3) ratio obtained on 30 bottom stations, in the hypoxic area, during the total period studied whose 35 ± 22, in agreement with Zavatarelli *et al.* (6) and Degobbis (7). High standard deviation associated with this ratio reflected the high variability of the data and of the biological and physical processes controlling the nutrient levels in the North Adriatic basin. Also the linear correlation coefficient between the paired data used to compute the ratio was calculated; the linear relationship are statistically acceptable: $p<0.01$.

The oxygen saturation values found on the bottom stations are used to calculate a prediction equation of hypoxic event in the time in this area. The daily consume found is: 0.7825%, the kinetics is:

$$O_2\%_{sat}=O_2\%_{\text{initial value}} - 0.7825t_{day}$$

$r=0.604$; $n=49$ statistically acceptable at $p< 0.01$. It represents a good tool to predict the temporal evolution of bottom hypoxic events at the end of summer in stable weather conditions. Model simulations demonstrated that the bottom layer of the hypoxic area was influenced only by weak currents, and bottom waters inside the hypoxic area were nearly stagnant. This fact justifies the stationary hypothesis assumed for the equation. The observed AOU:Nitrogen ratio is normal for this region hence supporting the general validity of this kinetics. In conclusion this equation can be assumed generally valid during conditions when cooling and mixing events are not sufficiently strong to mix the entire water column.

References

1 - Poulain P.M. & Raicich F., 2001. Forcing. Pp. 45-65. *In*: Cushman-Rosin B. *et al.* (eds.), Physical Oceanography of the Adriatic Sea. Kluwer Academic Publisher. Netherlands.

2 - Justic D., 1991. An analysis of factors affecting oxygen depletion in the northern Adriatic Sea. *Acta Adriat.* 32 (2): 741-752.

3 - Artegiani A., Gacic M., Michelato A., Kovacevic V., Russo A., Paschini E., Scarazzato P. and Smircic A., 1993. The Adriatic Sea hydrography and circulation in spring and autumn (1985-1987). *Deep-Sea Res.* II 40 (2): 1143-1180.

4 - Strickland J.D.H. & Parsons T.R., 1972. A practical handbook of sea-water analysis. *Bull. Fish. Res.* Bd. Can. 167:1-310.

5 - Winkler L.W., 1888. Bestimmung des im Wasser gelosten Sauerstoffes. *Ber. Dt. Chem. Ges.*, 21: 2843-2855.

6 - Zavatarelli M., Raicich F., Bregant D., Russo A. & Artegiani A.,1998. Climatological biogeochemical characteristics of the Adriatic Sea. *J. Mar. Sys.* 18: 227-263.

7 - Degobbis D., 1990. A stoichiometric model of nutrient cycling in the northern Adriatic Sea and its relation to regeneration processes. *Mar. Chem.* 29, 235–253.

CYTOCHROME P450 RESPONSES AND ACETYLCHOLINESTERASE ACTIVITY IN THE GOLDEN GREY MULLET *LIZA AURATA* FOR EVALUATING URBAN EFFLUENTS EFFECTS IN A COASTAL MARINE AREA : GULF OF TUNIS.

W. Masmoudi [1] *, Romdhane M.S. [2], Khériji S. [1] and El Cafsi M. [1]

[1] Faculté des Sciences de Tunis, département des Sciences Biologiques, Laboratoire de physiologie animale, Campus universitaire, 1060 Tunis, Tunisie. * maswiem@lycos.com

[2] Institut National Agronomique de Tunisie, Agrocampus, 43 av. Charles Nicolle 1082 Tunis, Tunisie

Abstract

Biomarkers measurements were investigated in juveniles of the golden grey mullet *Liza aurata* sampled in autumn /Spring (2002/2003) from two sites of Tunis gulf in order to asses the impact of two urban effluents "Khelij channel" and "Meliane wadi". Results showed a strong induction of EROD in fishes captured from both Khelij and Meliane outlets and they indicate probably a contamination by aromatic and chlorinated hydrocarbons. Also a significant inhibition of acetylcholinesterase activity was demonstrated in fishes from the two sites in autumn. We suspected then the presence of neurotoxic compounds as organophosphates and carbamates.

Keywords: Pollution, Biomarkers, Fish.

Introduction

The Biomarker constitute the biological reaction measurement implied in the early intoxication steps. Among biochemical biomarkers, the cytochromes P450 family is implied in oxidative metabolism of xenobiotics such as aromatic and chlorinated hydrocarbons. The measurement of EROD activity (ethoxyresorufin-o-deethylase activity, a cytochrome P450 dependant monooxygenase) in fish liver is widely validated in monitoring programs. The acetylcholinesterase (AChE), enzyme implied in the neurotransmission, is also considered as a useful biomarker since it's inhibited by organophosphorus and carbamate compounds. The aim of the present study was to asses the quality of a coastal marine area in Tunis gulf by measuring AChE and EROD activity in an euryhaline fish, the golden grey mullet (*Liza aurata*), captured from mouths of two channels, "Khelij" and "Meliane", flowing into the sea

Methodology

Juveniles of golden grey mullet (6-8 cm long) were caught around the outlets of "Khelij" and "Meliane" channels during autumn/spring (2002/2003). Liver and fragments of muscle are removed and kept in liquid nitrogen for biomarkers analyses. EROD measurement was performed in fish liver according to the French normalized method [1]. AChE activity was determined in the muscle of fish according to Ellman method [2]. Statistical analyses were performed with Satistica software (StatSoft, USA). Data were log-transformed for achieving normal distribution before running ANOVAs to determine statistical differences among sampling sites and season.

Results

Results on EROD activity showed that this biomarker was significantly elevated ($p < 0.05$) in fishes caught in both Khelij and Meliane outlets (Table 1) when compared to control fishes reared in our laboratory (43.3 ± 23 pmol/min/mg protein). These biomarkers levels are probably linked to the presence of high levels of compounds known to induce metabolic activity in fish livers as aromatic and chlorinated hydrocarbons. We have already reported the presence of an organochlorine pesticide, the lindane, in the sediment of Khelij outlet [3]. EROD levels in the present study are higher than those reported in the leaping mullet (*Liza saliens*) from a highly contaminated bay of the Aegean sea (Izmir bay) exposed to river/water contamination [4]. EROD values in control fishes are similar to those registered in the grey mullet from a reference site in the Orbetello lagoon, Italy [5]. A significant difference in EROD activity between sites are registered in spring. In Fact, in this season, the biomarker levels are higher in Meliane outlet than in Khelij site. These results suggest that exposure to some xenobiotics varies according to the different locations. And they reflect the influence of differential contamination levels on a short time scale.

Concerning AChE activity, we registered also a significant inhibition of this enzyme ($p<0.05$) in the muscle of fishes from the two sites in autumn and from Khelij outlet in spring in comparison to the activity measured in reference fishes reared in the laboratory(Table 1). Similar levels of reduction was already registered in red mullet from Italian coastal marine area [6]. These data point out the exposure of mullet fishes to anticholinesterase compounds. In fact, the leaching of pesticides into the sea from agricultural land and the discharge of urban wastewaters in these areas are responsible to this contamination.

Table 1. Results of biomarkers measurements in golden grey mullet. EROD activity is expressed as pmol/min/mg protein. AChE activity is expressed as nmol/min/mg protein. Data are expressed as mean ± standard deviation

		Khelij	Meliane	Control
EROD	Autmn	654.8±602	1007.5±767.3	43.3±23
	spring	466.6±322	1356.5±390	
Ln-transformed EROD	Autmn	6±1	6.5±1	3.65±0.5
	spring	5.8±1	7.3±0.3	
AchE	Autmn	1079±500	910± 546	2360±708
	spring	1360±345	2117±1117	
Ln-transformed AChE	Autmn	6.8±0.4	6.6±0.5	7.7±0.3
	spring	7.1±0.2	7.5±0.5	

In conclusion, this work highlighted the first data about health status of the gold mullet from Tunis gulf. These preliminary results showed that the use of biomarkers in this fish species might reflect the early exposure to micropollutants. As we dispose a few information about contaminant levels in this coastal area, a more detailed investigation must be done.

References

1 - Afnor, 2001. Méthode de mesure de l'activité enzymatique EROD chez le poisson d'eaux douces et marines. Norme NF T 90-385, septembre 2001.

2 - Ellman G.L., Courtney K.D., and Anders V., 1961. A new and rapid colorimetric determination of acetylcholinesterase activity. *Biochemical pharmacology*, 7 : 88-95.

3 - Masmoudi W., Romdhane MS., Khériji S. and El Cafsi M., 2001. Bioaccumulation of Lindane in wild larvae of *Mugil cephalus, Liza aurata and Liza ramada.* MEDCOAST 01 Fifth International Conference on the Mediterranean Coastal Environment; 23-27 October, Hammamet (Tunisia)

4 - Aeinç E., and Sen A., 1999. hepatic cytochrome P450 1A and 7-ethoxyresorufin-o-deethylase induction in mullet and common sole as an indicator of toxic organic pollution in Izmir Bay, Turkey. *Mar. Env. Res.*, 48 :147-160.

5 - Corsi I., Mariottini M., Sensini C., Lancini S., and Focardi S., 2003. Cytochrome P450, acetylcholinesterase and gonadal histology for evaluating contaminant exposur levels in fishes from a highly eutrophic brackish ecosystem : the orbetello lagoon, Italy. *Marine Pollution*, 46: 203-212.

6 - Lionetto M.G., Caricato R., Giordano M.E., Pascariello M.F, Marinosci L., and Schettino T., 2003. Integrated use of biomarkers (acetylcholinesterase and antioxidant enzymes activities) in *Mytilus galloprovincialis* and *Mullus barbatus* in an Italian coastal marine area. *Marine Pollution Bulletin,* 46 : 324–330.

FISH FARMING INFLUENCE ON PHYSICAL AND CHEMICAL PROPERTIES OF SEDIMENT AND WATER COLUMN IN THE MIDDLE ADRIATIC

S. Matijevic *, G. Kuspilic, D. Bogner and A. Baric

Institute of Oceanography and Fisheries, P. O. Box 500, 21000 Split, Croatia - *dosen@izor.hr

Abstract

Changes of basic hydrographic and chemical properties of water column and sediment were investigated in a semi-enclosed area of the middle Adriatic under the influence of fish farming. Changes were mainly expressed as water column enrichment with dissolved organic nitrogen and phosphorus as well as occurrence of negative sediment redox potential, enhanced sediment inorganic phosphorus concentrations and accumulation of sediment organic carbon.

Keywords: Adriatic Sea, sediments, phosphorus, organic carbon

Introduction

According to the trophic TRIX index (1) the coastal area of eastern middle Adriatic can be characterized as oligotrophic. Due to low primary production and sedimentation of particulate organic matter, sediment in this area has an oxidative surface layer 3-4 cm thick (positive redox potential), inorganic phosphorus concentrations (2.94-38.62 mmol P kg^{-1}) and organic carbon and total nitrogen content between 0.28-1.2 % and 0.02-0.12 % respectively. Strongly increasing fish farming activities (especially tuna breeding) for the last years has induced the development of a qualitative monitoring program of the marine environment in affected areas. Results of investigated changes of basic hydrographic and chemical parameters in water column and sediment for one fish farm will be documented in this paper.

Materials and methods

Physical and chemical properties of sediment and water column were investigated at fish farm located in a semi-enclosed bay in the middle Adriatic during December 2001, May 2002 and March 2003. Samples were taken at 3 stations at the breeding farm area (B1, B2 and B3) and at one reference station (REF; 500 meters distanced from the farm). Investigated parameters in sediment were redox potential, organic and inorganic phosphorus concentrations, organic carbon and total nitrogen content. Parameters investigated in the bottom water were temperature, salinity, visibility, suspended matter content, oxygen saturation and dissolved inorganic and organic nutrient concentrations.

Redox potential of sediment was measured "in situ" with Pt-electrode after quinhyndrone calibration. Surface sediment cores for phosphorus concentration, organic carbon and nitrogen measurements were frozen until the laboratory analysis. Analyses of phosphorus content in surface sediment layer (0-2 cm) were done according to Aspila (2). Organic carbon and total nitrogen sediment content were analyzed on CHNS-O analyzer (CE Instruments). Hydographical and chemical data were obtained by CTD-probe, classical Winkler titration and spectrophotometric determination (3).

Results and discussion

Redox-potential in the fish farming area were constantly more negative than in the sediment of reference station which indicates an oxidation of settled organic matter with sulfate as the dominant electron acceptor. Analyses of sediment phosphorus pool showed no significant increase in organic fraction at the fish-farming stations, but the concentrations of inorganic phosphorus (3.85 to 38.23 mmol P kg^{-1}) were up to 7 times higher than at reference station (Fig. 1), which indicates that all phosphorus is in the inorganic form, probably bounded as detrital and fish debris fraction (4).

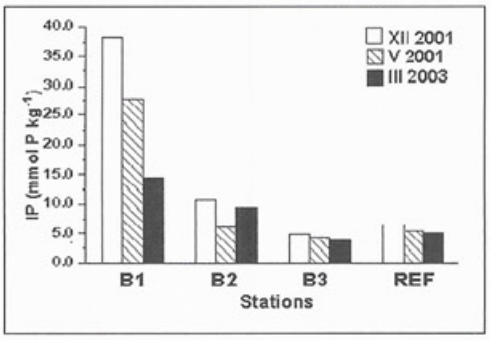


Fig. 1. Inorganic sediment phosphorus concentrations through investigated period.

Considering the role of seasonal variability of organic matter decomposition processes at sediment organic carbon content, its accumulation in sediment is calculated as ratio C-ORG at farm stations / C-ORG at reference station (Fig. 2).

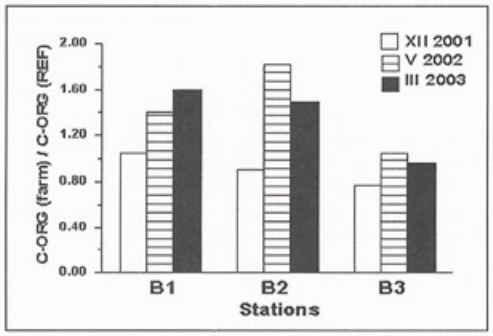


Fig. 2. Calculated ratios of C-org (farm stations) / C-ORG (reference station) through investigated period.

Ratios indicate a constant organic carbon accumulation in the most enclosed station B1, while at stations B2 and B3 mineralization seems to be more effective.

The main changes in the water column at the fish farming site were strongly increased suspended matter content (relatively to the reference station), lowered visibility and oxygen saturation, as well as enhanced dissolved organic nitrogen and phosphorus concentrations.

Conclusion

Investigations of fish farming influence on the marine environment in the middle Adriatic showed negative changes of most basic parameters in sediment and water column. The high inorganic phosphorus increase in sediment indicates on high downward flux of this element from the water column to the sediment at fish farming areas.

References

1 - Vollenweider, R.A., Giovanardi, F., Montanari, G., Rinaldi, A. 1998. Characterization of the trophic conditions of marine coastal waters with special reference to the NW Adriatic Sea: proposal for a trophic scale, turbidity and generalized water quality index. *Environmetrics*, 9: 329-357.

2 - Aspila K. I., Agemian, H. and Chau A. S. Y., 1976. A semi-automated method for the determination of inorganic, organic and total phosphate in sediments. *Analyst*, 101: 187-197.

3 - Grasshoff K., 1976. Methods of Seawater Analysis, Verlag Chemie, Weinheim, 307 p.

4 - Schenau S. J., De Lange G.J., 2001. Phosphorus regeneration vs. burial in sediments of the Arabian Sea. *Mar. Chem.*, 75: 201-217.

SUBCELLULAR PARTITIONING OF HEAVY METALS IN GILLS AND VISCERAL MASS OF BIVALVES FROM THE NEW CALEDONIAN LAGOON

M. Metian [1], L. Hédouin [1-3], C. Barbot [4], O. Cotret [1], J.-L. Teyssié [1], S.W. Fowler [1 *], F. Goudard [4], J.-P. Durand [4], P. Bustamante [2] and M. Warnau [1]

[1] International Atomic Energy Agency – Marine Environment Laboratory, 4 Quai Antoine Ier, MC-98000 Principality of Monaco
[2] IRD-Noumea Center, New-Caledonia
[3] LBEM, UPRES-EA 3168, Université de La Rochelle, France
[4] GERMETRAD, SMAB UPRES-EA 2160, Université de Nantes, France

Abstract

The present work examined subcellular distribution of 5 metals and 2 radionuclides in two bivalve species in order to assess the potential toxicity of these elements in the organisms. The results indicate that Ag and ^{241}Am are preferentially associated with the cell membranes and organelles whereas Cr, Zn, Cd, Co, and ^{134}Cs are predominantly found in the cytosolic fraction of the cells.

Keywords: Metals, Radionuclides, Subcellular Fractioning, Bivalves.

Introduction

New Caledonia is the third producer of nickel in the world and this small South Pacific island is estimated to contain no less than 20% of the total stock of Ni on the planet. Metal contamination resulting from the nickel mining industry and related activities constitutes a long lasting threat for the marine ecosystems sheltered by the second largest reef system in the world [1]. However, as almost a rule when it concerns tropical ecotoxicology, available information on metal contamination in New Caledonia waters is extremely scarce and very little is known about the extent of local contamination and possible environmental impacts [1]. Moreover, a new extraction process of Ni (lixiviation, *viz.* acidic extraction) has recently been tested at the industrial level and should be implemented in the near future (2006-2007). This process will result inevitably in increased discharges of co-occurring metals in Ni ores (e.g. Co and Cr). Thus, information is needed in order to assess the possible impact of these additional metal inputs on local ecosystems.

The objective of the present study was to determine the potential toxicity of metals in two species commonly found in the lagoon: the edible clam *Gafrarium tumidum* and the oyster *Isognomon isognomon*. Therefore, subcellular distribution of five metals (Cd, Co, Cr, Zn, Ag) and two anthropogenic radionuclides (^{134}Cs, ^{241}Am) was examined in the gills and visceral mass of both species following seawater exposure using highly sensitive radiotracer techniques.

Materials and Methods

Both bivalve species were acclimated to laboratory conditions (open circuit aquaria; water renewal 10% hr^{-1}; S, 36 p.s.u.; T, 26 ± 0.5°C) for 6 weeks prior to experimentation. The organisms were then experimentally exposed for 28 days to radiotracers of five heavy metals (^{109}Cd, ^{57}Co, ^{51}Cr, ^{65}Zn, ^{110m}Ag) and two radionuclides (^{134}Cs, ^{241}Am) directly via seawater. At the end of the experiment, 6 individuals of each species were collected and dissected. The gills and visceral mass were separated, pooled, and processed for subcellular fractioning according to a previously described method [2]. Four different fractions were isolated using differential centrifugation (see Table 1). Distribution of the radiotracers among the different subcellular fractions was determined using high efficiency gamma spectrometry [2].

Table 1. Subcellular partitioning (mean %) of radioisotopes in gills and visceral mass of two bivalves

	Gafrarium tumidum							*Isognomon isognomon*						
Gills	^{51}Cr	^{57}Co	^{65}Zn	^{109}Cd	^{110m}Ag	^{134}Cs	^{241}Am	^{51}Cr	^{57}Co	^{65}Zn	^{109}Cd	^{110m}Ag	^{134}Cs	^{241}Am
Nuclei	18	28	28	30	73	20	25	17	16	22	14	23	17	27
Lysosomes + mitochondria	6	7	6	2	6	7	6	10	19	30	15	34	12	36
Membranes	10	17	16	1	6	13	25	19	8	15	10	23	16	10
Microsomes	10	22	19	1	5	13	27	10	5	0	6	7	11	4
Cytosol	57	25	31	67	10	48	17	44	52	33	54	13	45	22
Visceral mass														
Nuclei	28	9	24	10	49	27	42	25	20	28	24	43	26	35
Lysosomes + mitochondria	13	6	10	2	12	11	22	22	10	20	15	27	19	47
Membranes	7	3	15	1	3	6	19	6	2	5	3	19	6	6
Microsomes	6	3	12	1	2	5	13	7	3	6	3	4	7	3
Cytosol	45	79	40	87	35	51	4	39	65	41	54	7	42	9

Results and Discussion

Measurements of specific enzymatic markers (acid phosphatase for lysosomes; glucose-6-phosphatase for microsomes; 5' nucléotidase for plasmic membrane) indicated that the purity of the different subcellular fractions was good. Results of the subcellular distribution of the different metal radiotracers and radionuclides in gills and visceral mass are given in Table 1.

Globally, the distributions in both tissues were similar for each given bivalve species. The only main departure from this was observed for ^{57}Co in the clam: the cytosolic fraction was much lower in the gills (25%) than in the visceral mass (79%). Cr, Co, Zn, Cd and ^{134}Cs were mainly found in the cytosolic fraction (30 - 87%) whereas ^{110m}Ag and ^{241}Am were mainly associated with membranes and organelles (65 - 96%). These results are in agreement with those reported for other bivalves from temperate waters (e.g. the scallop *Chlamys varia* [3] and the oyster *Crassostrea gigas* [4]).

The predominant distribution of Ag in the insoluble fraction could be due to specific Ag storage/detoxification in the two bivalve species. Indeed, some bivalves are well known to be able to trap Ag as non toxic Ag_2S precipitates within their tissues [5].

Preferential distribution of most radioelements in the cytosol suggests that, once incorporated into the cells, a large part of these metals could be toxic, since they are susceptible to bind key soluble components of the cells (e.g. proteins, enzymes, DNA). However, in the case of Cd and Zn, a substantial part of the cytosolic metal is most probably detoxified as "metal-metalloprotein" complexes (approx. 40% in the case of Cd according to Boisson *et al.* [2]). Furthermore, the metals preferentially associated with the cytosolic fraction are likely to be readily bioavailable to higher trophic levels preying on these organisms [6]. This is of particular concern since the clam *G. tumidum* is consumed by local populations and could therefore be a non-negligible source of human exposure to metals through seafood consumption.

References

1 - Labrosse P., Fichez R., Farman R., and Adams T., 2000. New Caledonia. Pp. 723-736. *In:* Sheppard C.R.C. (ed.), Seas at the Millennium: An Environmental Evaluation, vol. 2. Pergamon Press, Amsterdam.

2 - Boisson F., Goudard F., Durand J.-P., Barbot C., Piery J., Amiard J.-C., and Fowler S.W., 2003. Comparative radiotracer study of cadmium uptake, storage, detoxification and depuration in the oyster *Crassostrea gigas* : potential adaptive mechanisms. *Mar. Ecol. Prog. Ser.*, 254: 177-186.

3 - Bustamante P., Guyot T., and Miramand P., submitted. Subcellular and body distributions of 17 trace elements in the variegated scallop *Chlamys varia* from the Charente-Maritime coast (France).

4 - Milcent M.C. *et al.*, 1996. Identification of Cs-137 and Am-241 binding sites in the oyster *Crassostrea gigas*. *Biochem. Molec. Biol. Intern.*, 39: 137-148.

5 - Berthet B., Amiard J.C., Amiard-Triquet C., Martoja R., and Jeantet A.Y., 1992. Bioaccumulation, toxicity and physico-chemical speciation of silver in bivalve mollusks : ecotoxicological and health consequences. *Sci. Total Environ.*, 125: 97-122.

6 - Reinfelder J.R., and Fischer N.S., 1991. The accumulation of element ingested by marine copepods. *Science*, 251: 794-796.

PRESENTATION OF THE INTERDISCIPLINARY OPERATION MELISSA (FRENCH NATIONAL PROGRAMME PROOF)

Christophe Migon,

Laboratoire d'Océanographie de Villefranche, Université Paris 6, CNRS-INSUE, La Darse, BP 8, F-06238 Villefranche-sur-mer Cedex, France - migon@oceane.obs-vlfr.fr

Abstract

The Mediterranean interdisciplinary MELISSA project (MEditerranée LImitationS SAisonnières) is part of the French national PROOF programme. Its objective is to better understand the causal relationship between a given chemical forcing (availability of nutrients) and assimilation processes, phytoplankton dynamics, trophic functioning and carbon fluxes. The temporal variability of these parameters is studied at the DYFAMED time-series station (Ligurian Sea). The project is scheduled on 12 monthly campaigns (2004), 3 seasonal campaigns (2005) and a fertilising experiment in 2006 or 2007.

Keywords: nutrient availability; assimilation processes; trophic status; carbon flux.

Planktonic growth depends among others on the availability of several chemical species. As the surface layer of the western Mediterranean is subjected to seasonal succession of nutrient inputs, the main objective of the MELISSA project (MEditerranée LImitationS SAisonnières) is to better understand causal relationships between chemical constraints and the functioning of the trophic chain. Climatic changes partly determine the evolutions of such constraints, which have consequences on carbon fluxes. In this way, this project will provide data for the study of retroaction of chemical limitation of the biological production on the fate of CO_2, and, thus, on climatic evolutions.

The MELISSA project integrates time-series data acquired at the DYFAMED site (central Ligurian Sea) since 1991. The seasonal evolution of N/P ratios clearly indicates a succession of the limiting factor between N and P. This seasonal pattern is linked to the temporal variability of nutrient inputs in the western Mediterranean Sea. Certain phenomena are not well identified, and the characterisation of seasonal features is not easy (e.g., the rapid and early P to N limitation at the end of the stratification period).

MELISSA proposes multidisciplinary approaches: nutrient inputs and their availability in the euphotic zone, concomitant evolutions of the trophic system (impact of a given limitation on planktonic dynamics), and consequences on carbon fluxes. These data will be simultaneously taken into account, which will permit to better understand the involved processes, from the input of nutrient to the exported fluxes. Reciprocally, measurements of microbial respiration will provide data on the retroaction of seasonal limitations on pCO_2 variations.

Experimental and field data (processes of stimulation of the biological production, of trophic transfers, of recycling, etc.) will provide informations for the conception and development of process models.

Environmental evolutions, in particular anthropogenic perturbations, influence the C:N:P:Si ratios and the abundance of dissolved iron. Results acquired after three years in the present project (including *in vitro* and *in situ* fertilising experiments), completed by the DYFAMED time-series, will feed predictive models.

The characterisation of seasonal situations implies the understanding of the impact of events (e.g., significant atmospheric events) and assimilation processes. The different fields on which studies will focus are:

- *Atmospheric inputs*

Atmospheric fluxes of N, P, Si and Fe will be characterised and quantified, and their temporal variability (event/season) will be assessed. Solubilisation kinetics will be studied, since the physico-chemical form under which nutrients are introduced into the surface layer determines their assimilation by biota.

- *Stocks and fluxes of biogenic elements*

The seasonal succession of nutrient concentrations will be measured in surface waters together with matter fluxes. Ultra-sensitive analytical methods will be used for the stratification period. Vertical profiles will be measured in the water column at the DYFAMED site to assess the distribution of dissolved mineral and organic stoks of N, P, Si, Fe and C.

- *Production*

Primary production (particulate + dissolved) monthly data from the Service d'Observation DYFAMED will be used, as well as specific measurements during monthly campaigns in 2004. New and regenerated production will be measured. Bacterial activity will be measured in the surface water column (0-200 m). The temporal variability of exported carbon fluxes will be studied through monthly data from the Service d'Observation DYFAMED, and through specific measurements during the 2004 campaigns.

- *Biomass*

Seasonal variations of phytoplanktonic biomass (total + specific) will be monthly measured, and also during the 2004 campaigns. Seasonal variations of picoplankton abundance will be studied by flux cytometry, and the genetic diversity of populations will be studied in the water column.

- *DOM-TEP*

The biogeochemical significance of dissolved organic matter (DOM) will be addressed by chemically characterising its high molecular weight (HWM) fraction. The role of different factors that could contribute to seasonal and interannual variations in the production and sinks of this material such as variations in sources (algal and bacterial) in the availability of inorganic nutrients, and the ability of different bacterial species to hydrolyse specific dissolved biomolecules at different depths will be investigated. Transparent Exopolymeric Particles (TEP), which may be a significant source of carbon, and may be a favourable support for bacterial development, will be particularly studied.

- *Assimilation processes*

Although the observed P-limitation in several oceanic zones is due to the biological fixation of N_2, the quantification of this process has not yet been carried out in the Mediterranean. This process will be studied here by ^{15}N measurements. Genetics studies (characterisation of the genus *nifH*) will be complementary. The study of the N_2 fixation process will be carried out in relation with the quantification of other nutrient fluxes, in particular P and Fe.

The relation between nutrient limitation and microbial population diversity will be assessed. This will be studied through experiments based upon the concept of competitive assimilation of phosphate, in case of P-limitation.

The efficiency of bacterial growth will be estimated in the surface layer (0-200 m) by measuring the microbial production and respiration. Heterotrophic metabolism will be studied in relation with particulate organic carbon and dissolved organic carbon fluxes.

- *Fertilising experiments*

On the basis of nutrient atmospheric fluxes measured at the Cap Ferrat sampling station, fertilising experiments will be carried out at the DYFAMED site: LET GO apparatuses (4.5 L) will be spiked and incubated *in situ* with nutrient concentrations calculated from wet atmospheric events. The role of mineral dust (Fe, Si, P) will be also examined through *in vitro* experiments.

- *Modelling*

The processes involved in the successive chemical limitations will be modelled. The data acquired in this project will allow to follow the evolutions of the stoichiometric ratios in the exported material. On the basis of stoichiometric variations, the vertical export of carbon out of the euphotic zone will be constrained by values of i) primary production, ii) heterotrophic respiration, iii) net carbon fixation, iv) chemical composition of the dissolved and particulate exported material (C:N or C:P).

The impact of external inputs of nutrients on P:Si:N:C ratios will be modelled to forecast the trends of a system driven by climate change and anthropogenic activities (e.g., what are the consequences of the evolution of molar ratios on the planktonic populations at the decenal scale?). Neural network models will be used in order to model stochastic processes of the ecosystem.

Continuous atmospheric sampling (Cap Ferrat coastal site, SE France) and monthly campaigns are planned in 2004; 3 seasonal campaigns are planned in 2005; a *in situ* fertilisation (simulation of a natural nutrient-rich atmospheric event) is planned in 2006 or 2007. The MELISSA project gathers 44 persons and 9 French laboratories.

ATMOSPHERIC INPUTS OF DISSOLVED INORGANIC PHOSPHORUS AND SILICIUM TO NW MEDITERRANEAN OLIGOTROPHIC COASTAL WATERS: THEORETICAL IMPACT ON PHYTOPLANKTON DYNAMICS

Christophe Migon [1] *, Gretta Bartoli [2], Valérie Sandroni [3]

[1] Laboratoire d'Océanographie de Villefranche, Université Paris 6, CNRS-INSUE, La Darse, BP 8, F-06238 Villefranche-sur-mer Cedex, France - * migon@oceane.obs-vlfr.fr

[2] Institut für Geowissenschaften, Christian-Albrecht-Universität, Olshausenstr. 40, D-24118 Kiel, Germany - gb@gpi.uni-kiel.de

[3] Laboratoire d'Océanographie et de Biogéochimie, UMR 6535, Centre d'Océanologie de Marseille, Campus de Luminy, 13288 Marseille Cedex 09, France - Sandroniva@aol.com

Abstract

The atmospheric input of dissolved inorganic phosphorus (P) and silicium (Si) was monitored at the coastal sampling site of Cap Ferrat (Ligurian Sea). Their theoretical impact on phytoplankton dynamics was calculated on the basis of Redfield ratios. P-enriched atmospheric events may be responsible for significant episodic blooms, and might also episodically shift the chemical limitation of primary production in NW Mediterranean oligotrophic waters from P to Si.

Keywords: atmospheric input; oligotrophy; primary production

There is an increasing evidence that atmospheric inputs of nutrients have an impact on phytoplankton dynamics in oligotrophic conditions in the open sea (1-3), particularly in the Mediterranean Sea, owing to its reduced dimensions and because surrounding continental emission sources of nutrients are intense and continuously increasing. The theoretical input of wet inputs of dissolved inorganic phosphorus (DIP) and dissolved inorganic silicium (DISi) on primary production (PP) is examined here.

Rainwater was collected between 1986 and 2003 (102 samples) at the signal station of Cap Ferrat, SE coast of France (43° 41' N, 7° 19' 30" E). DIP was always analysed, DISi only from 2000. Phosphate and silicate were analysed by standard colourimetric methods. In both cases, the detection limit was 0.05 µmol liter^{-1}, and the blank values were always lower than the detection limit. Details on protocols can be found elsewhere (2, 4).

For each rain event, the wet input of a nutrient X (WI_X) is calculated as:

$$WI_X = C_X * H \quad (1)$$

where C_X is the nutrient concentration in rainwater and H is the rainfall amount. Maximum monthly atmospheric inputs of DIP and DISi averaged on the 1986-2003 dataset are given in Table 1.

Table 1: Maximum DIP and DISi inputs measured at Cap Ferrat between 1986 and 2003, with NP triggered by DIP inputs and compared with mean daily PP at the DYFAMED site.

Month	Maximum DIP input (µmol P m^{-2})	Maximum DISi input (µmol P m^{-2})	Atmospheric DIP-triggered NP (maximum observed inputs) (mg C m^{-2} d^{-1})	Mean daily PP (mg C m^{-2} d^{-1})
January				199
February	44.7	8.9	56.9	441
March	17.6	157.1	22.4	730
April	30.2	111.3	141.6	1187
May	70.1	18.3	89.2	518
June	16.9	86.3	21.5	493
July	310.5	182.4	395.0	518
August	263.25	56.6	334.9	234
September	200.1	144.3	254.6	276
October	529.1	1.1	673.0	219
November	24.3		30.9	155
December	114.0		145.0	236

Time-series data since 1991 at the DYFAMED station (Ligurian Sea, 43°25'N, 7°52'E) show that during the stratification period (July to mid-October), the nitrate/phosphate ratio in the photic layer is always > 20 and phosphate concentrations are very low in the 0-50 m layer (5), which confirms that P is the limiting factor in NW Mediterranean oligotrophic conditions. Hence, phosphate concentrations in surface waters greatly depends upon atmospheric events (1, 4, 6). In conditions of P-limitation, atmospheric inputs of DIP theoretically yield new productions (NP) calculated as follows:

$$NP = (DIP) * 106 * 12 \quad (2)$$

where 106 is the Redfield ratio carbon (C):P and 12 is the molar mass of carbon, in g mol^{-1}.

Table 1 shows the maximum monthly DIP-triggered NPs averaged over the 1986-2003 dataset (calculated from maximum DIP inputs) and compares them with the mean daily PP observed at the DYFAMED site (7).

Whatever the nitrate content in atmospheric inputs, the stock of dissolved N_2 can be considered as unlimited (assuming the existence of organisms capable of metabolizing atmospheric N in Mediterranean oligotrophic conditions) and, therefore, N does not limit phytoplankton growth. PP theoretically induced by significant rain events may be calculated on the basis of DIP wet inputs, insofar as no Si or iron limitation appears. It is clear that significant rain events in autumn can trigger a phytoplanktonic response able to strongly determine the mean daily PP. Rain events may thus significantly control phytoplankton dynamics at this period, much more than previously hypothesized (2).

Now can P-enriched rain events lead to episodic Si limitation? Dominant Mediterranean blooming diatoms that may gain by atmospheric Si inputs exhibit C:Si molar ratios of 4 (8). One can compute the PP induced by DISi atmospheric inputs using the relationship:

$$NP = (DISi) * 4 * 12 \quad (3)$$

The event of september 23th 2001 brought 200.1 µmol DIP m^{-2} and 144.3 µmol DISi m^{-2}, i.e. the Si-induced NP is much less significant than the P-induced one. This suggests that very high P inputs do not necessarily lead to proportional bloom of all phytoplanktonic populations. This event, although relatively rich in DISi, mostly benefit non-siliceous species, diatoms being rapidly limited by Si.

Although DISi data are still preliminary results, and under the hypothesis of N_2 fixation, the possible "secondary" limitation by Si might lead to the episodic preferential growth of non-siliceous phytoplanktonic species. Considering the increase of anthropogenic inputs of DIP (4), the frequency of blooms of non-siliceous species might increase too, which is in agreement with forecasting of Béthoux and co-workers (9). Future works should therefore focus on the study of specific phytoplanktonic biomasses related to atmospheric events, through pigment analysis.

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References

1 - Migon, C., Copin-Montégut, G., Elégant, L., Morelli, J., 1989. Etude de l'apport atmosphérique en sels nutritifs au milieu côtier méditerranéen et implications biogéochimiques. *Oceanol. Acta,* 12: 187-191.

2 - Migon, C., V. Sandroni. (1999) Phosphorus in rainwater: partitioning, inputs and impact on the surface coastal ocean. *Limnol. Oceanogr.*, 44: 1160-1165.

3 - Ridame, C., Guieu, C., 2002. Saharan input of phosphorus to the oligotrophic water of the open western Mediterranean. *Limnol. Oceanogr.*, 47: 3, 856-869.

4 - Migon, C., Sandroni, V. Béthoux, J.P., 2001. Atmospheric input of anthropogenic phosphorus to the northwest Mediterranean during the oligotrophic season. *Mar. Environ. Res.*, 52: 413-426.

5 - Marty, J.C., Chiaverini, J., Pizay, M.D., Avril, B., 2002. Seasonal and interannual dynamics of nutrients and phytoplankton pigments in the Western Mediterranean Sea at the DYFAMED time-series station (1991-1999). *Deep-Sea Res. II*, 49: 1965-1985.

6 - Bergametti, G., E. Remoudaki, R. Losno, E. Steiner, B. Chatenet, P. Buat-Ménard. 1992. Source, transport and deposition of atmospheric phosphorus over the northwestern Mediterranean. *J. Atmos. Chem.,* 14: 501-513.

7 - Marty, J.C., Chiaverini, J. 2002. Seasonal and interannual variations in phytoplankton production at DYFAMED time-series station, Northwestern Mediterranean Sea. *Deep-Sea Res. II*, 49: 2017-2030.

8 - Dafner, E.V., Boscolo, R., Bryden, H.L., 2003. The N :Si :P molar ratio in the Strait of Gibraltar. *Geophys. Res. Lett.*, in press.

9 - Béthoux, J.P., Morin, P., Ruiz-Pino, D., 2002. Temporal trends in nutrient ratios: chemical evidence of Mediterranean ecosystem changes driven by human activity. *Deep-Sea Res. II*, 49: 2007-2016.

MUSSELS *(MYTILUS GALLOPROVINCIALIS)* AS BIOINDICATOR OF CHLORINATED HYDROCARBONS POLLUTION IN THE KASTELA BAY (ADRIATIC SEA)

V. Milun*, T. Zvonaric, A. Baric

Institute of Oceanography and Fisheries, Setaliste I.Mestrovica 63, 21000 Split, Croatia - * milun@izor.hr

Abstract

Significantly increased values of chlorinated hydrocarbons in mussels (*Mytilus galloprovincialis*) transplanted to the Kastela Bay show a certain level of the pollution of the Kastela bay with organochlorines. The PCBs higher values undoubtedly indicate the presence of industrial wastewaters in the investigated area. An inverse relationship between chlorinated hydrocarbons concentrations in mussels and the specimen length was found. The comparison of the concentration of extractable organic matter to chlorinated hydrocarbons concentrations show a limited corellation. However, the detailed interpretation of the obtained results in terms of physiological effects is not yet possible because of the small number of analysis.

Key words: Adriatic Sea, mussel, chlorinated hydrocarbons, PCBs, pesticides

Introduction

Chlorinated hydrocarbons are ubiquitous contaminants in the coastal areas. To provide reable information on the contaminant presence in the environment, mussels have traditionally been used as good biological indicators of the sea pollution. However, the degree to which the organochlorines are accumulated by mussels depends not only on their concentrations in the external environment, but also on internal biological factors (e.g. age, size, reproductive cycle). The present study was designed to monitor patterns of bimonthly accumulation of chlorinated hydrocarbons in mussels over a one-year period in the area of Kastela Bay. In this paper, we report the results of only one sampling done in January 2002.

Materials and methods

Two size classes of mussel *Mytilus galloprovincialis* (class A: ~5 cm shell length and class B: ~6 cm shell length) were transferred from the clean area of the Mali Ston Bay to four experimental stations in a relatively polluted area of the Kastela Bay in November 2001. After two months of the exposure to the ambient conditions, mussel samples were taken for an analysis. Chlorinated pesticides (DDE, DDD, DDT) and polychlorinated biphenyls (Arochlor 1254, Arochlor 1260) (PCBs) were determined by the capillary gas chromatography with an electron capture detector (1).

Results and discussion

The obtained results show a significant increase of the concentration of chlorinated hydrocarbons in the mussels. The mean concentration of chlorinated pesticides increased from 3.5 to 7.3 ng/g d.w. (class A) and 3.2 to 6.0 ng/g d.w. (class B), respectively (Fig. 1). PCBs show even higher tendency of increase at all investigated stations. The mean concentration of total PCBs increased from 9.6 to 73.6 ng/g d.w. (class A) and 12.4 to 66.3 ng/g d.w. (class B), respectively (Fig. 2). The overall data on chlorinated hydrocarbons show that PCBs predominate in all mussels at all investigated stations over DDT compounds. Moreover, the change of total DDT concentrations between sampling stations is less pronounced than that shown for total PCBs. Regarding the investigated area, the spatial distribution of both groups of compounds is basically similar. The highest amount of chlorinated pesticides and PCBs was found at the Inavinil station located in the eastern part of the Kastela Bay, which is under the strong impact of industrial wastewater and urban runoff.

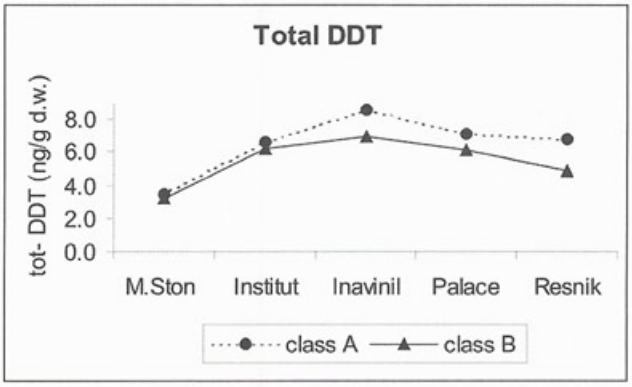


Fig. 1. Concentration of total DDT compounds in two size classes of mussels at sampling stations.

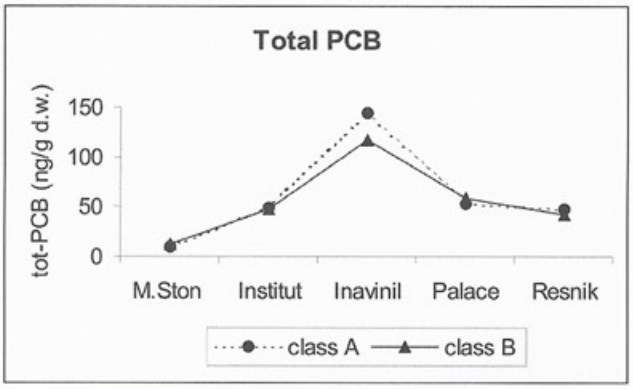


Fig. 2. Concentration of total PCBs in two size classes of mussels at sampling stations.

Regarding the length of collected mussels, we have found generally higher concentrations of chlorinated hydrocarbons in smaller mussels (class A), which is in accordance with the previously published results indicating the tissue concentrations decrease with increasing body size (2).

The extractable organic matter (EOM) content expressed on a dry weight basis, is not significantly different between the mussel classes and investigated stations. The highest value of EOM and chlorinated hydrocarbons we have found is at the Inavinil station. Limited correlation between PCBs concentration and EOM was found, which suggests that variation in the mussels' lipid cycle might be responsible for some of the variations of the organochlorines concentrations (3).

In conclusion, the analysis of mussels *Mytilus galloprovincialis* from the Kastela Bay clearly demonstrate a quite low level of pollution by DDT and PCBs compounds in the Bay. Moreover, the obtained results are lower than those previously reported in literature (4).

References

1 - UNEP/IOC/IAEA,1988. Determination of DDTs and PCBs by capillary gas chromatography and electron capture detector. Reference Methods for Marine Pollution Studies, No.40, UNEP.

2 - Gilek M., Björk M., and Näf C:, 1996. Influence of body size on the uptake, depuration, and bioaccumulation of polychlorinated biphenyl congeners by Baltic Sea blue mussels, *Mytilus edulis*. *Mar. Biol.*, 125: 499-510.

3 - Marchand M., Vas D., and Duursma E.K., 1976. Levels of PCBs and DDTs in mussels from the N.W.Mediterranean. *Mar. Poll. Bull.*, 7: 65-69.

4 - UNEP 1994. Monitoring programme of the eastern Adriatic coastal area, Report for 1983-1991, MAP Technical Report Series No.86, Athens, 135 p.

CARBON AND ^{210}PO IN THE SURFACE MICROLAYER AND ITS ROLE IN NEAR SURFACE PARTICLE FLUXES IN THE NW MEDITERRANEAN COASTAL ZONE.

Juan Carlos Miquel [1] *, Alessia Rodriguez y Baena [1, 2], Beat Gasser [1], Scott W. Fowler [1]

[1] IAEA Marine Environment Laboratory, Monaco - * J.C.Miquel@iaea.org, B.Gasser@iaea.org, S.Fowler@iaea.org
[2] Dipartimento per lo Studio del Territorio e delle sue Risorse, University of Genova, Italy - A.M.Rodriguez@iaea.org

Abstract

Carbon and ^{210}Po were measured in the surface microlayer and subsurface waters concomitantly with shallow sediment trap deployments for assessing the potential enrichment of these elements in the surface microlayer and sedimenting particles. . Higher concentrations of both elements were found in the surface microlayer. The enrichment on organic carbon and ^{210}Po observed in surface waters compared to subsurface waters was not directly manifested in the vertical C or ^{210}Po flux but rather reflected in the relative composition of the settling particles.

Keywords: surface microlayer, particle flux, carbon, polonium-210

Introduction

The sea surface microlayer (SML, i.e. top few hundred microns) is a matrix of organic and inorganic particles, detritus and micro-life. This organically-rich surface film is formed from biogenic materials produced by plankton in the water column that collect at the sea surface. The abundance of organic matter provides a substrate for the growth of larger organisms (neuston). Most studies suggest that the SML represents a highly productive, metabolically active interface and a vital biological habitat. Therefore, within the EU-sponsored AIRWIN project, carbon and ^{210}Po were measured in the SML, subsurface waters (SSW) and settling particles below the SML in order to assess the potential impact of the microlayer on the enrichment of these elements in settling particles.

Material and Methods

Vertical particulate flux was measured using a newly designed upper water, sediment trap mooring. Small cylindrical sediment traps were deployed at 0.4, 2.4, 4.4, 6.4, 8.4 and 10.4 m in a water column of 26 m depth about 1/2 miles off Banyuls (42°29.21 N, 3°08.52 E; France). Four identical particle interceptor traps constructed from transparent acryl each with a H/W ratio of 6.25 and a collection area of 0.004 m^2, were attached on a cross at the upper three depths. Traps could pivot around the fixation axis and thus remained vertical during the sampling period. A similar system with only two traps was used at the lower three depths The mooring was surface tethered and attached to a buoy 25 m distant that was fixed to a bottom weight. The traps were deployed 4 times for periods ranging from 48 - 127 hours in May-July 2002 (31 May to 3 June, 3 to 5 June, 25 to 29 June and 29 June to 4 July) and were recovered by hand from small boats. Because of the short deployment period no chemical preservatives were used.

During the deployment periods, SML samples were collected from the upper 40-50 micrometers using the glass plate method (1) with a sampler fabricated in the laboratory. One liter of seawater was collected for measuring ^{210}Po and 500 ml for total and organic carbon. ^{210}Po was also analyzed in subsurface water collected ~0.5 m below the surface. CTD-Rosette profiles were taken during the deployment period to assess environmental changes and measure carbon content in the water column.

Carbon was measured by high temperature combustion using a Vario-El CHN microanalyzer (2). Samples for polonium were spiked following pretreatment with ^{209}Po and the polonium isotopes analyzed following standard procedures (3).

Results and Discussion

Carbon content was found to be consistently higher in the SML than in the SSW. The organic C concentration was variable depending on wind conditions, with values in the range of 156 to 338 mg l^{-1} in the SML and 131-213 mg l^{-1} in the SSW and, with a SML enrichment factor (EF) of 1.2 to 1.6. The C/N ratio was also higher in the SML suggesting that there was some degradation of the accumulated organic material in the surface microlayer.

Total ^{210}Po concentrations in the SSW were very uniform, in the range of 1.62 to 1.92 mBq l^{-1}, with only 1 to 3 % of the activity in the particulate fraction. The ^{210}Po concentrations in the SML were higher, 4.66 to 6.29 mBq l^{-1}, with 2-6 % of the activity in particles. The SML enrichment factor for ^{210}Po ranged from 2.4 to 3.3. The SML data reported falls well within the range of previously published data (1.41 to 8.33 mBq l^{-1}, 4).

Carbon fluxes were the lowest during period 1 and increased progressively with depth, from 20 mg POC m^{-2} d^{-1} in the upper 2 m to 50-55 mg POC m^{-2} d^{-1} at 8-10 m. In contrast, during the second period they were the highest, reaching 120 to 130 mg POC m^{-2} d^{-1} in the upper 6 m and decreasing at greater depth. During periods 3 and 4 which occurred 20 days later, POC fluxes were intermediate and there was a trend to return to the conditions observed in period 1. The rapid change in flux observed on June 3rd was associated with changes in wind direction and consequent coastal input of particles.

^{210}Po fluxes globally showed the same pattern as POC fluxes during the 4 periods, with lowest values noted during the first sampling period - in the range of 172 to 332 mBq m^{-2} d^{-1} - and the highest during the second period - 662 to1156 mBq m^{-2} d^{-1} -. The measured fluxes are similar to those reported for other coastal Mediterranean waters (5). Interestingly, the ^{210}Po/ POC ratio was always higher in particles sedimenting very near the surface (upper 2 m) and lowest in particles settling at 4-6 m depth. This could also be a reflection of the relative lower fluxes of ^{210}Po observed at 4 m compared to corresponding fluxes just above that depth.

The enrichment of organic carbon and ^{210}Po observed in surface waters compared to subsurface waters was not directly mirrored in the vertical C or ^{210}Po flux but rather in the relative composition of the settling particles. Further analysis of the organic composition of the settling material should confirm the SML fingerprint on these particles.

References

1 - Hardy, J.T., Apts, C.W., Crecelius, E.A. and Bloom, N.S., 1985. Sea-surface microlayer metals enrichments in an urban and rural bay. *Estuar., Coast. Shelf Science*, 20: 299-312.

2 - Miquel, J.-C., Fowler, S.W., La Rosa, J. and Buat-Menard, P., 1994. Dynamics of the downward flux of particles and carbon in the open northwestern Mediterranean Sea. *Deep-Sea Res.* I, 41(2): 243-261.

3 - Shannon L. and Orren M.J., 1970. A rapid method for the determination of polonium-210 and lead-210 in sea water. *Analytica Chimica Acta*, **52**: 166-169.

4 - Heyraud M. and Cherry R.D. 1983. Correlation of ^{210}Po and ^{210}Pb enrichments in the sea-surface microlayer with neuston biomass. *Cont. Shelf Res.*, **1**(3): 283-293.

5 - Tateda Y., Carvalho F.P., Fowler S.W. and Miquel J.C., 2003. Fractionation of ^{210}Po and ^{210}Pb in coastal waters of the NW Mediterranean continental margin. *Cont. Shelf Res.*, 23: 295-316.

PHYTOPLANKTON INFLUENCE ON THE CHROMIUM SPECIATION IN SEAWATER

M. Mlakar [1] *, Y. Auger [2] , M. Branica [1]

[1] Laboratory of Physical Chemistry of Traces, Rudjer Boskovic Institute, Bijenicka 54, 10000 Zagreb, Croatia
2 Laboratory for Analytical and Marine Chemistry, University of Sciences and Technology of Lille, UPRES A CNRS 8013, 59655 Villeneuve d'Ascq, France

Abstract

Processes controlling dissolved chromium species distribution in seawater were studied. Various organic matter distributions, in-situ reduction and absorption/desorption by algae cells, particulate organic matter, contribute to the spatial speciation of dissolved chromium.

Keywords: chromium speciation, organic matter, phytoplankton.

Introduction

In seawater chromium exists as Cr(VI) and Cr(III) [1-3]. Cr(VI) is present as CrO_4^{2-} which adsorbs on proton-specific mineral surfaces, limited in the presence of competing anions such as sulfate [4]. It has high bioavailability regarding aquatic organisms. Cr(III) forms strong, kinetically inert complexes [5] and it is very stable in a hydrolyzed form [6,7]. Its toxicity and bioavailability, controlled by a solubility and formation of strong complexes with organic and hydroxo-complexes, is low. Oxidation states are influenced by: oxic and anoxic conditions [1], photochemical [8]/geochemical processes [9], and biological activities (phytoplankton bloom) [10].

Materials and methods

Sampling was done in the region of Irish sea and Celtic Sea, including surface, subsurface - 5 m and bottom waters - 5 m above. Voltammograms were recorded with Autolab polarograph (Eco-chemie, Netherlands). The system was supported by the GPES4.3 electroanalytical program. Metrohm model 663 hanging mercury drop electrode (HMDE) was used as a working (0.4 mm^2), Ag/AgCl as a reference and glassy carbon as a counter electrode, and teflon cell.

Axenic and specific strain of phytoplankton *Rhodella violacea* culture was grown in thermostated flasks (16°C) and illuminated by the 150 $\mu E/m^2s$ light in artificial seawater.

Results and discussion

Main goal of this study was to investigate Cr(VI)/(III) distribution in correlation with organic matter in seawater [2,8-10]. Samples were taken in the region of Celtic and Irish Sea, with different characteristics concerning temperature, stratification and homogenity of water column, respectively. In the Celtic Sea thermocline is formed between 20 and 40 m, while Irish Sea is homogeneous. Celtic Sea samples were taken at the surface, over and under the thermocline (20 and 45 m), and on the bottom (120 m). Dissolved Cr(VI) concentration is constant down to 20 m, in the region of thermocline increases until 40 m and remains unchanged until the bottom. The behavior of dissolved Cr(III) is opposite. These results were correlated with the appearance of the particulate organic matter. In the Celtic Sea concentration of particulate organic carbon (POC) is much higher on the surface than on the bottom. POC decrease was pronounced in the region below the thermocline. POC fractions indicate: surface waters contain an important algal but lesser content of bacterial fraction, separated by the thermocline. In the non-stratified water column of Irish Sea POC change with depth uniformly. Bacterial contribution is pronounced on the bottom, suggesting mineralization processes of the phytoplankton organic matter. Taking into account the POC origin and abundance, dissolved chromium distribution could be described: phytoplankton cells absorb Cr(VI) in the form of the chromate anion due to its resemblance to the nutrient sulfate anion. In cells reduces and after destruction is released into the sea as Cr(III). Among other processes, Cr(III) adsorbs on the phytoplankton detritus and in that way is partially eliminated from the seawater column. In the homogeneous water column same process is more pronounced in a zone of the nutrient regeneration, near sediments.

In order to verify these presumptions experiments in the laboratory with a phytoplankton batch culture of *Rhodella violacea* (chosen as one of most stable algae cultures in laboratory conditions), were done. The algae growth occurs in three phases:

1. until 9th day: the culture grows slowly and number of cells duplicate in chosen periods;
2. significant growth, from 9th to 23rd day, the phytoplankton bloom;
3. cell number decreases rapidly, different from the stationary phase normally achieved in the traditional medium for the culture development.

In each sample of the phytoplankton culture 20 nM of Cr(VI) was added. Dissolved Cr(VI) concentration diminished from 4th to 23rd day, assuming uptake by phytoplankton (Fig. 1). Cr(III) concentration increased with cell number decrease. It was presumed that Cr(VI) is reduced in the cells to Cr(III) and released as cells were destructed.

However, phytoplankton cannot completely drive the fate of chromium in dissolved phase. Positive correlations between particulate chromium and organic carbon from bacterial and uncharacterized origins appear, what suggests an "association" between chromium and organic particles built-up from senescent or degraded phytoplanktonic cells. Examination of organic carbon fractions showed more precisely that this correlation was almost exclusively due to the fresh algal component representing the larger part of the POC. It suggests that chromium behaviour could be influenced by phytoplanktonic activity. This activity produces organic exudates which are well known as chelating agents [11], i.e. phytoplanktonic exudates. Algal cells that were in a good physiological condition could remove chromium (VI) from seawater column (negative correlation), and after its incorporation/ transformation, could release chromium (III) (positive correlation).

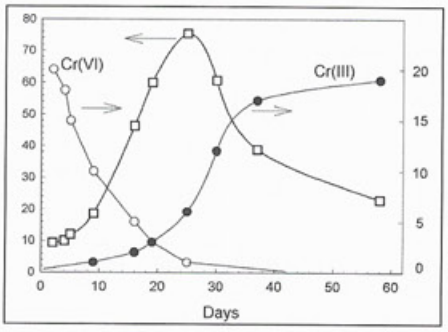


Fig. 1. Dissolved [Cr(VI)] and [Cr(III)] in dependence of time of contact with the batch culture of *Rhodella violacea*.

References

1 - Ahern, F, Eckert, J.M., Payne, C. & Williams, K.L., 1985. Speciation of Chromium in Seawater, *Anal. Chim. Acta,* 175: 147-151. And lit. cited therein.
2 - Jeandel, C., 1987. Cycles biogéochimiques océaniques du chrome et du vanadium. Ph.D. Thesis, University of Paris, 264 p.
3 - Boussemart, M.,van den Berg, C.M.G. & Gaddaf, M. (1992). The determination of the chromium species in seawater using catalytic cathodic stripping voltammetry. *Anal. Chim. Acta,* 262: 103-115.
4 - Zachara, J.M., Girvin, D.C., Schmidt, R.L. & Resch, C.T., 1987. Chromate adsorption on amorphous iron hydroxyde in the presence of major groundwater ions. *Environ. Sci. Technol.,* 21: 589-594.
5 - Pearson, R.G., 1966. Acids and Bases, *Science,* 151: 172-177.
6 - Rai, D., Sass, B.M. & Moore, D.A., 1987. Chromium hydrolysis constants and solubility of chromium hydroxide. *Inorg. Chem.*, 26: 345-349.
7 - Murray, J.W, Spell, B. & Paul, B., 1983. *The contrasting geochemistry of manganese and chromium in eastern Pacific Ocean.* Pp. 643-669. *In:* C.S. Wong *et al.* (ed.), *Trace Metals in Seawater*, Plenum Press.
8 - Kleber, R.J. & George, R.H., 1992. Indirect Photoreduction of Aqueous Chromium(VI). *Environm. Sci. Technol.,* 26: 307-312.
9 - Abu-Saba, K.E. & Flegal, A.R., 1995. Chromium in San Francisco Bay: superposition of geochemical processes causes complex spatial distribution of redox species. *Mar. Chem.,* 49: 189-199.
10 - Eckert, J.M., Stewart, J.J., Waite, T.D., Szymezek, R. & Williams, K.L., 1990. Reduction of chromium (VI) at sub-µg/l levels by fulvic acids. *Anal. Chim. Acta*, 236: 357-362.
11 - Sunda, W.G. and Huntsman, S.A., 1995. Iron uptake and growth limitation in oceanic and coastal phytoplankton. *Marine Chemistry* 50: 189-206.

MODELLING THE VERTICAL BIOGEOCHEMICAL STRUCTURE OF THE BLACK SEA

Temel Oguz
Institute of Marine Sciences, Middle East Technical University, Erdemli, Turkey

Abstract

A vertically resolved, coupled physical-biogeochemical model is developed to describe the food web structure, nitrogen cycling and redox processes taking place near the oxic-anoxic interface zone of the Black Sea. The model thus provides a unified representation of dynamically coupled oxic-suboxic-anoxic system which allows to simulate a realistic yearly succession of diatom, dinoflagellate, *Emiliania huxleyi* blooms, as well as basic features of the suboxic zone dynamics, and the way in which it is controlled by upward and downward material fluxes from the interior of the anoxic layer and chemocline zone of the surface layer, respectively.

Key words: Black Sea, phytoplankton blooms, suboxic zone, redox reactions, modeling

The major processes controlling the food web structure, recycling of nutrients, and oxidation/reduction reactions taking place nears the anoxic interface of the Black Sea is studied by a coupled physical-biogeochemical model. It relates the annual cycle of plankton production in the form of a series of successive phytoplankton, mesozooplankton blooms to organic matter generation and to the remineralization-ammonification-nitrification-denitrification chain of the nitrogen cycle as well as to anaerobic sulfide oxidation through a series of reactions catalyzed by dissolved and particulate manganese.

The ecosystem model includes three most dominant phytoplankton taxonomic groups in the Black Sea comprising Bacillariophyta (diatoms, P_d), Dinophyta (dinoflagellate, P_f), Chrysophyta (coccolithophore *E. huxleyi*, P_e). The fourth group comprises small phytoplankton community (P_s) representing phytoflagellates and picopyhtoplankton. The zooplankton community is represented by microzooplankton (Z_s), and mesozooplankton (Z_l) groups. They consume different phytoplankton groups with different preferences, as specified in their grazing terms. All plankton biomass are expressed in nitrogen units; nitrogen is considered to be the most important limiting nutrient for the interior Black Sea ecosystem. Silicate and phosphate are abundant elements in the Black Sea with respect to total dissolved inorganic nitrogen even though their anthropogenic suppy have been reduced in 1990s after the dam constructions along the River Danube; thus, silicate and phosphorus do not limit diatom and *E. huxleyi* productions, respectively. Even though *E. huxleyi* are grown in the Black Sea under nitrogen limited conditions, the model is supported by a simplified phosphorus cycle in order to explore its competitiveness under phosphorus limitation. The simplified nitrogen and phosphorus cycles involve labile pelagic detrital nitrogen (D_n) and phosphorus (D_p), as well as dissolved inorganic nitrate (N_n), ammonium (N_a), and phosphate (N_p). In addition, the model includes attached and detached coccolith concentrations as two additional prognostic variables.

The annual phytoplankton community structure simulated by the model involves a diatom-based bloom during the late winter-early spring period. It is strongest bloom of the year and followed by a series of successive other bloom events mainly dominated by subsurface summer productions of dinoflagellates, and subsequently a weaker, mixed assemblage of diatom and dinoflagellate community development in autumn months. They are robust features of the annual phytoplankton structure, and appear as distint signals in the monthly composite chlorophyll data. The signature of the intense late winter diatom bloom is high chlorophyll concentration of more than 2 mg m^{-3} distributed uniformly over the 40-50 m thick euphotic zone. The autumn bloom is less intense and relatively shallower characterized by chlorophyll concentrations of around 1 mg m^{-3} within the surface mixed layer of 25-30 m. These two blooms are linked to the weaker summer subsurface bloom confined at deeper part of the euphotic zone below the seasonal thermocline. It is characterized by chlorophyll concentrations in the range of 0.3-to-1.0 mg m^{-3}. The simulations have further suggested *E. huxleyi* as yet another essential element of the annual phytoplankton community structure during summer months within the shallow surface mixed layer. The summer *E. huxleyi* bloom typically initiates during mid-May, attains its strongest phase throughout June, and finally terminates by mid-July.

Almost continuous particulate organic matter production associated with the year-long biological activity supports an efficient nitrogen cycling within approximately the upper 75 m of the water column, where dissolved oxygen generated photosynthetically and by air-sea interactions is depleted due to consumption during aerobic particulate matter decomposition. The layer below could not be ventilated even for the conditions of exceptionally high winter cooling due to the presence of a strong density stratification. Even with a highly simplified representation of the redox processes, the model provided a quasi-steady state suboxic-anoxic interface zone structure similar to observations. It was able to give quantitative evidence for the presence of an oxygen depleted and non-sulfidic suboxic. This model pointed out the crucial role of the downward supply of nitrate from the overlying nitracline zone and the upward transport of dissolved manganese from the anoxic pool below for maintenance of the suboxic layer. The model is also used to test the assumption of isopycnal homogeneity of the SOL properties and their independence from the circulation features, as asserted previously. It is found that the SOL properties do not possess isopycnal uniformity throughout the basin, and vary depending on the intensity of vertical diffusive and advective oxygen fluxes across the oxycline. Anticyclones, with downwelling and downward diffusion (i.e, with stronger net downward supply of oxygen), attain a thinner suboxic layer at a deeper part of the water column relative to cyclones. The position of the upper boundary of the SOL changes from σt~15.6 kg m^{-3} in cyclonic to 15.9 kg m^{-3} in anticyclonic regions, whereas its position in the peripheral Rim Current transition zone occurs at intermediate density values. Re-analysis of the existing data provides firm evidence for such differences.

PRELIMINARY STUDY OF ORIGIN AND DISTRIBUTION OF ORGANIC MATTER IN SURFACE SEDIMENTS OF THE "LAC SUD" OF TUNIS

N. Ouertani *, R. Hamouda and H. Bélayouni

* Faculty of Sciences of Tunis, Geology department, Laboratory of Organic Geochemistry, Tunis, Tunisia - * nizarouertani@yahoo.fr

Abstract

Superficial bottom sediment samples inside the "Lac Sud" of Tunis were analysed for the TOC, free and potential hydrocarbon compounds, and total hydrocarbons in order to establish the origin and the spatial distribution of organic matter. Attempt was made to the compositional patterns of the aliphatic hydrocarbon to identify the petrogenic and biogenic sources of hydrocarbons.

Key words: recent sediments, Rock-Eval pyrolysis, TOC, gas chromatography, n-alkanes

The study of distribution and composition of organic matter in surface sediments of "Lac sud" of Tunis (situated at the North-East of Tunisia) allowed the individualization of 2 zones. The first one, situated in the western part of the lake, presents high contents of TOC (>6%, Fig. 1), high values of free hydrocarbons (S1= 12,51 mg of hydrocarbons/g of sediment) and high values of total hydrocarbons (from 5040 to 16380 ppm). Liquid chromatography shows that saturated and aromatic hydrocarbons represent more than 50% of the total hydrocarbon content. Chromatograms of the saturated fraction (Fig. 2) show the presence of a regular distribution of n-alkanes centred on n-C_{25} with a large UCM indicating that the hydrocarbons present have suffered a higher degree of biodegradation. All these results confirm the presence of contamination by petroleum products in these sediments (1, 2, 3, 4).

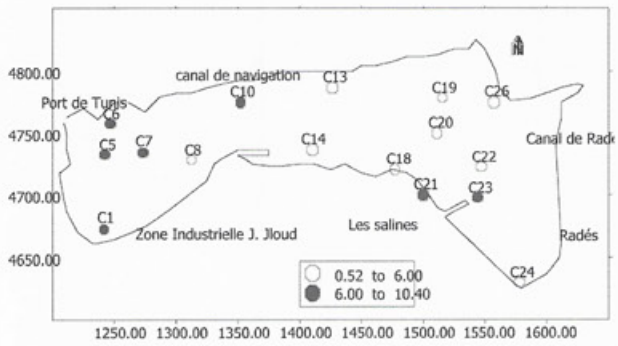


Fig. 1. Space distribution map of TOC values.

The second zone presents an organic matter inherited from the original biomass with a mixed origin: continental and marine. These sediments are characterised by: low contents of TOC (3%, Fig. 1), low values of S1 (< 1 mg of hydrocarbons/g of sediment), low values of total hydrocarbons (340 to 1000 ppm). The lipid compounds vary between 2 and 6% of TOC, these values characterize an organic matter inherited from the original biomass. In fact, in the sediments where the organic matter is still immature, lipid fraction does not exceed, in general, 1 to 3 % of the TOC (2). The saturated fraction (Fig. 2) represents less than 10% of the total lipid content. N-alkanes have a bimodal distribution with light n-alkanes ranging from n-C_{15}, to n-C_{19} characteristic of benthic algae (5, 6, 7), and long chains (n-C_{25} to n-C_{31}) having an odd/even predominance corresponding to n-alkanes from high vascular plants (8, 7, 2).

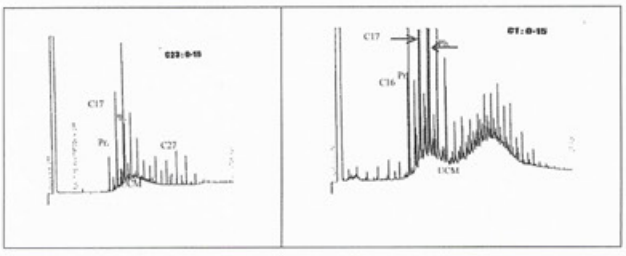


Fig. 2. Gas chromatograms of the aliphatic fraction. Pr=pristane, Ph=phytane, numbers refer to n-alkane chain length.

With these results, we can estimate the consequences of biogeochemical processes on the hydrocarbon composition of the lake and evaluate the impact of human and in particular harbour activity on the organic contents of the sediments.

References

1 - Eganhouse, R.P., and I.R. Kaplan, 1982. Extractable organic matter in municipal wastewaters. 2. Hydrocarbons: molecular characterization. *Environ. Sci. Technol.,* 16:541-551.

2 - Tissot B.P., et Welte D.H., 1984. Petroleum Formation and Occurrence. 2ème édition : Berlin, Springer-Verlag, 538 p.

3 - Zheng G.J., Richardson B.J., 1999. Petroleum hydrocarbons and polycyclic aromatic hydrocarbons in Hong Kong marine sediments. *Chemosphere*, Vol. 38. N°11: 2625-2632.

4 - Benalioulhaj S., Trichet J., Benalioulhaj N., Lucas J., Schreiber B.C., et Philp R.P., 2000. Black shales and phosphorites, results of differential diagenetic evolution of organic matter in the Oulad Abdoun-Timahdit sedimentary basin (MOROCCO). Marine Authigenesis: From Global to Microbial, SEPM Special Publication No. 66: 427-444.

5 - Lytle, J.S., T.F. Lytle, J.N. Gearing, and P.J. Gearing, 1979. Hydrocarbons on benthic algae from the Eastern Gulf of Mexico. *Mar. Biol.,* 51: 279-288.

6 - Youngblood, W.W., M. Blumer, R.L. Guillard, and F. Fiore, 1971. Saturated and unsaturated hydrocarbons in marine benthic algae. *Mar. Biol.,* 8: 190-201

7 - Farrington, J.W., and B.W. Tripp, 1977. Hydrocarbons in western North Atlantic surface sediments. *Geochim. Cosmochim. Acta,* 41: 1627-1641.

8 - Blumer, M, Guillard R.R.L., and Chase, T., 1971. Hydrocarbons of marine phytoplankton. *Mar. Biol.*, 8: 183-189.

RESPIRATION AND VERTICAL CARBON FLUX FROM WATER COLUMN ETS ACTIVITY

T.T. Packard [1] * and J.P. Christensen [2]

[1] Institut de Ciències del Mar; Pg. Marítim Barceloneta, 37-49; 08003 Barcelona, Spain -* ted@icm.csic.es
[2] Bigelow Laboratory, W. Boothbay Harbor, ME 04575, USA - jchristensen@bigelow.org

Abstract

Carbon fluxes were calculated by integrating water column respiration from 30, 50 and 100 m to the bottom in the Gulf of Maine. These fluxes were 3, 2, and 1 μ mol C min^{-1} m^{-2}. Profiles of respiration ranging from 10 to 680 p mol O_2 L^{-1} min^{-1} over water columns as deep as 275 m were best described by power functions. Respiration correlated well with seawater turbidity and chlorophyll.

Keywords: electron transport, CO2 production, O2 consumption, metabolism

Carbon flux in the ocean can be calculated directly from sediment trap measurements and indirectly from models, the $^{234}Th/^{238}U$ method, and the vertical profile of plankton respiration (R). We integrate respiration depth profiles (R = f (z)) to calculate carbon flux (F). $F = \int R\,dz = \int f(z)\,dz$. The calculations do not include benthic respiration, benthic carbon burial, or the respiration of large plankton and nekton. Nevertheless, they represent 90% of the total carbon flux. Here we use Gulf of Maine ETS activity measurements to calculate vertical profiles of the oxygen utilization rate and vertical carbon fluxes from 30, 50, and 100 m depth.

ETS activity was measured by tetrazolium reduction in cell-free extracts from ocean particulate matter (1). Respiration (p mol O_2 $h^{-1}L^{-1}$) was calculated from the relationship between the ETS activity and seawater respiration for the euphotic zone of the Gulf of Maine. This unitless ratio of R-ETS activity is 0.260. Respiration increased from the surface to some subsurface maximum near the chlorophyll maximum (Fig. 1). Then it decreased by a factor of 20-50 as an inverse power function through the thermocline. Below it decreased more gradually and near the bottom it tended to increase.

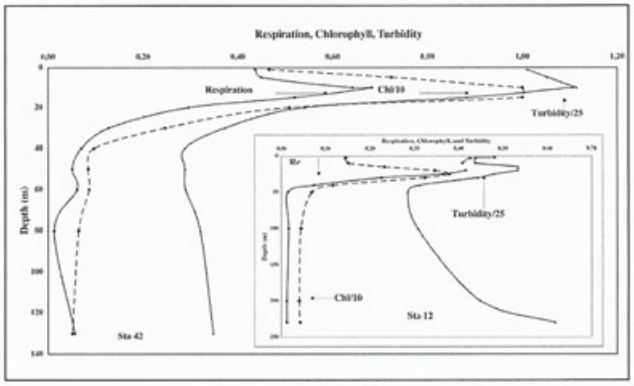


Fig. 1. Co-varying profiles of respiration, turbidity, and chlorophyll at Scotia shelf station 42. The units of respiration are n mol O2 L^{-1} min^{-1}, and for chlorophyll they are mg L^{-1}, turbidity is unitless. However, for scaling purposes, chlorophyll values have been divided by ten, and those for turbidity divided by 25. Inset: Profiles of respiration turbidity, and chlorophyll at Chattam Shelf station 14. The scaling factors and the units are the same as in the surrounding figure for station 42.

Carbon flux was calculated in three ways. (1) We integrated respiratory CO_2 production rates from either 30, 50, or 100 m to the bottom by trapezoidal approximation (F_{trap}). (2) We integrated the respiration-depth function as a definite integral from the upper depth (i.e. 30m) to infinity as the bottom depth. (3) We used the depth of the bottom as the lower boundary for the definite integral. The carbon fluxes from the 30 m level average 3.55 μ mol C min^{-1} m^{-2} by trapezoidal approximation, 2.62 μ mol C min^{-1} m^{-2} by integrating equation 1 to the bottom, and, 3.12 μ mol C min^{-1} m^{-2} by solving equation 2 for s= ∞. Other integrations are presented in Table 1.

By the ^{238}U / ^{234}Th method, carbon fluxes from the 50, and 100 m levels in the Gulf of Maine range from 0.2-25 (2), and 1.4-17 (3) μ mol C min^{-1} m^{-2}. Our fluxes from the 50 m and the 100m level range from 1.3 to 2.2 and 0.38 to 1.53 μ mol C min^{-1} m^{-2} (Table 1). These fall in at the low end of wide range of fluxes from the ^{238}U / ^{234}Th method. Note that the time scale inherent to each method is different. Fluxes from ETS activities and ^{238}U to ^{234}Th decay are based on minute-scale changes, fluxes from ^{3}He-^{3}H method are based on annual-scale changes, and fluxes from sediment traps are based on day-to-month scale changes. Thus, to compare the short-time-scale methods with the long-time-scale ones, time-series data for the short-time-scale methods is needed.

Table 1. Carbon flux (F_c) from 30, 50,and 100 m (z_t) in the Gulf of Maine. Mean values from 5 stations are presented.

CARBON FLUX from 30 m.			
	F_{trap}	$F_{t\text{-}s}$	F_{∞}
Mean	3.55	2.62	3.12
St. Deviation	1.24	1.51	2.00
CARBON FLUX from 50 m.			
	F_{trap}	$F_{t\text{-}s}$	F_{∞}
Mean	2.20	1.30	1.81
St. Deviation	0.54	0.76	1.31
CARBON FLUX from 100 m.			
	F_{trap}	$F_{t\text{-}s}$	F_{∞}
Mean	1.53	0.38	0.88
St. Deviation	0.23	0.23	0.81

(1) F_{trap}, is F_c from the upper boundary (z_t) calculated by trapezoidal approximation. The bottom respiration value used in this calculation was the same as the minimum measured value at each station. (2) $F_{t\text{-}s}$ is the integration of the normalized power function, $R_z = R_c(z/z_t)^b$ between z_t and the bottom depth (z_s). $F_{t\text{-}s} = [R_c /((1+b)(z_t)^b)]\,[(z_s^{1+b}) - (z_t^{1+b})]$. (3) F_{∞} is the integration of the same equation between the z_t and infinity. All three calculations represent the portion of the F_c that is oxidized in the water column below z_t. All F_c values are given in m mol C min^{-1} m^{-2}.

References

1 - Packard, T.T. and Williams, P.L.B. 1981. Rates of respiratory oxygen consumption and electron transport in surface seawater from the northwest Atlantic Ocean. *Oceanologica Acta,* 4: 351-358.

2 - Benitez-Nelson, C., Buesseler, K.O. and Grossin, G. 2000. Upper ocean carbon export, horizontal transport, and vertical eddy diffusivity in the southwestern Gulf of Maine. *Continental Shelf Res.,* 20: 707-736.

3 - Charette, M.A., Moran, S.B., Pike, S.M. and Smith, J.N. 2001. Investigating the carbon cycle in the Gulf of Maine using the natural tracer thorium-234. *J. Geophysical Res.,* 109: 11,553-11,579.

TROPHIC CONDITIONS AND TRENDS IN NUTRIENT CONCENTRATIONS IN THESSALONIKI BAY

A. Pavlidou *, R. Psyllidou-Giouranovits

Hellenic Center for Marine Research, PO Box 712, GR 190 13, Anavyssos, Attica, Greece - *aleka@ncmr.gr

Abstract

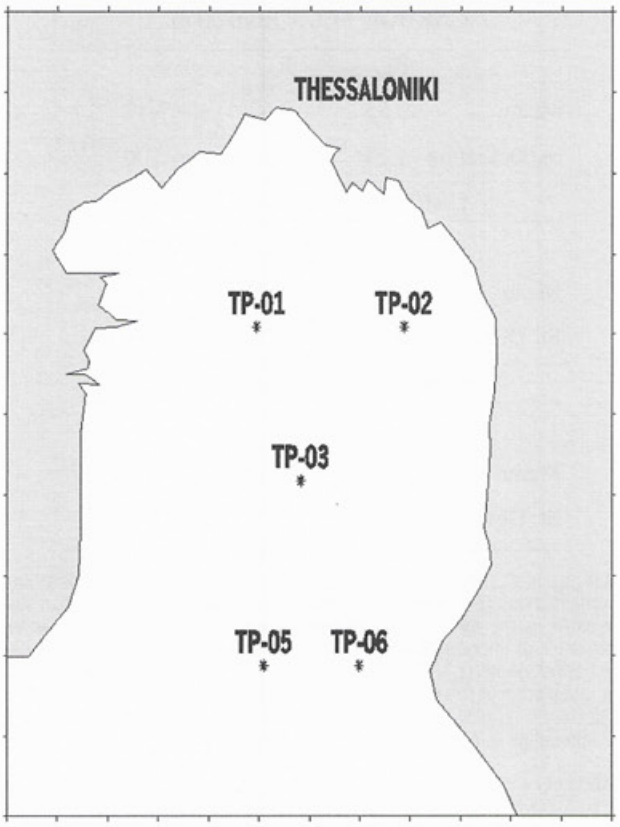
In this paper we present the results of nutrient measurements during the period 1995-2002, in order to define the ecological status of Thessaloniki Bay ecosystem.

This work contains an assessment of the eutrophication of coastal waters influenced by a sewage outfall in Thessaloniki Bay, for the period 1995-2002. A eurtophication scale has been applied for indicating four trophic levels in the marine environment (oligotrophic, lower mesotrophic, upper mesotrophic, eutrophic).

Keywords: Thessaloniki Bay, Eutrophication, Trophic Status.

Introduction

The study area is mainly affected by aquaculture activities, agriculture activities in the coastal zone and pollutants from the domestic and industrial effluents of Thessaloniki (partly treated). Sampling sites are shown in Figure 1.



Materials and methods

Nutrient data (nitrate, nitrite, silicate, ammonium and phosphate) have been collected during the period 1995-2002 (1,2).

The samples for the determination of nutrients were collected in 100 ml polyethylene bottles and kept continuously under deep freeze (-20 °C), until their analysis in the laboratory by a nutrient autoanalyser (3,4,5,6).

Results and discussion

During the period 1995-2002 the mean integrated nutrient concentrations in Thessaloniki Bay ranged as follows: Phosphate: 0.09 – 1.23 μmol/L; Silicate: 0.54 – 9.17 μmol/L; Nitrite: 0.04 – 1.55 μmol/L; Nitrate: 0.20 – 2.87 μmol/L; Ammonium: 0.08 - 4.14 μmol/L.

The temporal variability of nutrient concentrations in the study area is related with the Thessaloniki municipal sewage outfall, the agriculture and aquacultute activities in the area, the existence of the thermocline during the warm period, the enhanced anthropogenic activities and the various point sources, which enrich the study area in pollutants, as well as the fluctuation of the flow rate of the main rivers affecting the study area.

The characterisation of the trophic level of the Thessaloniki bay is based on nutrient concentration scales evaluated for the greek coastal ecosystems (7). According to the mean integrated values of nutrients for the period 1995-2002, Thessaloniki Bay is characterised as an *upper mesotrophic* area.

Additionally, the stoichiometric balance criterion in the selected stations confirmed that the mean ratio for the nutrients calculated does not reach the Redfield ratio ΣN:P of 16:1. The development of the ΣN:P ratio indicates that during the last ten years nitrogen was developed towards the limiting nutrient in the area studied.

References

1 - Pavlidou, A., 2001. Dissolved Oxygen and nutrients in the inner Thermaikos Gulf. December 1999-November 2000. Proccedings of the 7th Conference of Chemistry Greece-Cyprus, pp. 49-51, Lefkosia, Cyprus.

2 - Pavlidou, A. and Psilldou-Giouranovits, R., 2003. Monitoring of the temporal and spartial distribution of dissolved oxygen and nutrients in the Thermaikos Gulf". Proceedings of the 7th Hellenic Conference in Oceanography and Fishing, p. 252, Chersonissos, Krete, Greece.

3 - Koroleff, F., 1970. Revised version of "Direct determination of ammonia in natural waters as indophenol blue". Int. Con. Explor. Sea C. M. 1969/ C:9 ICES information on techniques and methods for sea water analysis. Interlab. Rep., 3: 19-22.

4 - Mullin, J.B., Riley, J.P., 1955. The colorimetric determination of silicate with special reference to sea and natural waters. *Anal. Chim. Acta,* 12: 162-176.

5 - Murphy, J., Riley, J. P. (1962). A modified single solution method for phosphate in natural waters. *Anal. Chim. Acta.,* 1: 162-176.

6 - Strickland, J.D.H., Parsons, T.R., 1968. A practical handbook of sea water analysis. *Bull. Fish. Res. Bd. Canada,* 167: 310.

7 - Karydis, M., 1999. Evaluation of the trophic levels in greek coastal ecosystems. Scientific Report, Univ. of Aegean, Lesvos Island, February 1999.

IMPOSEX IN *H. TRUNCULUS* IN THE LAGOON OF VENICE: ROLE OF TBT AND OTHER ENDOCRINE DISRUPTORS

Pavoni B., Pellizzato F., Centanni E.*, Maran C., De Bona S.

University of Venice, Dept. Environmental Sciences, Calle Larga S. Marta 2137, 30123, Venice, Italy

Abstract

The imposex occurrence in population of the gastropod *H. trunculus* has been investigated in the Lagoon of Venice. The morphological modifications in the organisms were related to levels of different endocrine disruptors, such as butyltin and phenyltin compounds, PCBs, PAHs, organochlorine pesticides, in the animal tissues, both in the visceral coils and the rest of the soft body. A good correlation was found between the biological response and the concentrations of xenobiotics.

Key words: Imposex, endocrine disruptors, Hexaplex trunculus, Lagoon of Venice

A wide variety of xenobiotic compounds of anthropogenic origins released in the environment by numerous applications, have been reported to be able to affect aquatic organisms at different levels of the biological organization (molecular, cellular, systemic or individual) and in the long term to threaten the population, community or ecosystem levels. It is the case of substances suspected to act as endocrine disruptors [1] such as Organotin Compounds (OTCs), Polychlorinated Biphenyls (PCBs), Organochlorine Pesticides and Polycyclic Aromatic Hydrocarbons (PAHs). Interacting with the endocrine system of the organism, they can reduce the reproductive capacities and damage the population survival. A well known example is the appearance of male sexual characteristics (namely a penis and a vas deferens) on females of gastropods in response to tributyltin (TBT) exposure. This phenomenon, known as imposex [2], caused the sterilisation of females of the whelk *Nucella lapillus*, leading to the decline of populations of the mollusc in the southwest coasts of England [3]. It is reported to affect more than 150 species of gastropods [5] world-wide [4].

With the aim of studying the occurrence of the imposex phenomenon in the Lagoon of Venice, populations of at least 40 individuals of the common Mediterranean gastropod *H. trunculus* (Neogastropoda: Muricidae) were collected in 5 sites and morphologically inspected to assess the level of the biological modification in the 8-stages scale of the Vas Deferens Sequence (VDS). The content of organotin compounds, both butyltins and phenyltins (TBT, TPhT and their metabolites, DBT, MBT, DPhT and MPhT, respectively) was determined in pooled tissues of the same stages of imposex, using a liquid-liquid extraction, the derivatization with the Grignard reagent and the determination with GC-MS after purification of the extract with Florisil. Both the visceral coils and the rest of the soft tissues were analysed.

A good agreement was found between the biological and the chemical results in the examined stations, confirming the effective role of this species as a bioindicator of organotin contamination and its high sensitivity. No stages lower than 3 were found and even in the station supposed to be the least contaminated the level of imposex in this gastropod was unexpectedly high. A significant correlation ($r=0.917$, $p<0.05$) was found between the butyltin content in the entire organism and one of the morphological modifications induced, the length of the penis in females, in the form of a dose-response curve. An even better correlation was found using the sum ob butyltin and phenyltin compounds ($r=0.982$, $p<0.05$).

The same samples were also analysed for the PCBs, PAHs and organochlorine pesticides to establish, beside the undoubtable role of TBT, a possible synergistic or antagonistic role of this endocrine disruptors in the induction of the abnormalities. The PLS method (Partial Least squares regression in latent variables) was applied to relate the imposex response (Y) to the concentrations of the four classes of compounds (X block) analysed in this study. The chemometric model shows, with a good predictive capacity of the dependent variable, that the concentrations of PCBs and pesticides positively contribute to the explanation of the imposex effect. On the contrary, a negative effect seems to characterise PAHs in respect to PCBs, pesticides and OTCs.

References

1 - Sonnenschein C., and Soto, A.M. 1998. An updated review of environmental estrogen and androgen mimics and antagonists. *J. Steroid Biochem. Molec. Biol.* 65(1-6): 143-150.

2 - Smith B.S. 1971. Sexuality in the American mud snail, *Nassarius obsoletus* Say. Proceeding of the Malacological Society of London, 39: 377-381.

3 - Bryan G. W., Gibbs P. E., Burt G. R., Hummerstone L. G. 1986. The decline of the gastropod *Nucella lapillus* around South-West England: evidence for the effects of tributyltin from anti-fouling paints. *J. Mar. Biol. Assoc. UK.*, 66: 611-640.

4 - Ellis D. V., Pattisina L. A. 1990. Widespread neogastropod imposex: a biological indicator of global TBT contamination? *Mar. Poll. Bull.*, 21: 248-253.

5 - Schulte-Oehlmann U., Tillmann M, Markert B, Oehlmann J, Watermann B, Scherf S. 2000. Effects of endocrine disruptors on prosobranch snails (Mollusca: Gastropoda) in the Laboratory. Part II: Triphenyltin as a Xeno-Androgen. *Ecotoxicology,* 9: 399-412.

LONG-TERM CHANGES OF THE NORTHERN ADRIATIC TROPHIC CONDITIONS

Osvin Pečar * and Robert Precali
Center for Marine Research, Rudjer Bošković Institute, Rovinj, Croatia

Abstract
Trophic index and Secchi depth data were used to assess trophic conditions along the Po River delta – Rovinj profile in the last 30 years. A marked gradient in trophic condition was observed along the profile. A decrease in the trophic index was identified only in the most western part and could be related to the change of nutrients composition of the Po River waters during the early eighties.

Keywords: TRIX, Transparency, Northern Adriatic

Introduction

Trophic conditions of the shallow northern Adriatic are heavily influenced by the Po River flow (1). It is the main reason for the eutrophication and Secchi depth gradient between the Po Delta and the opposite Istrian coast. Eutrophication is a significant environmental problem in areas with seasonally limited exchange of water such as the northern Adriatic. Trophic index (TRIX) was calculated using 30 years data of oxygen saturation, chlorophyll *a* and nutrients, with the aim to numerically describe the trophic state in the studied region.

Materials and methods

The data were collected at 5 stations along the Po River delta – Rovinj profile during the period 1972-2002. The profile is delimited by stations SJ108, 12 Nm off the Po River delta (44° 45,4' N; 12° 45,0' E), and SJ107, 13 Nm from Rovinj, western Istria coast, Croatia (45° 2,8' N; 13° 19,0' E). The water was collected with 5 L Niskin (dissolved oxygen and nutrients) and 6 L VanDorn (chlorophyll *a*) samplers. Dissolved oxygen was determined by Winkler titration. Nutrient analyses were performed aboard immediately after sample collection with spectrophotometric methods widely used in oceanography (2). The chlorophyll *a* was determined fluorimetrically after acetone extraction (2). Statistical analysis of the data was performed for the first 5 m were the eutrophication processes are more marked.

Results and discussion

This is the first evaluation concerning the trophic conditions of the northern Adriatic open waters using TRIX. The overall 30 years data (Fig. 1) clearly demonstrate a sharp trophic gradient from west to east that can be attributed mainly to the Po River, the major nutrients source in the area (1), with more than 75% of the total input. The least squares means indicate that over the entire investigated area the ecological status can be classified as high. The transparency of the water column also shows this gradient and it is also more pronounced than for TRIX. This difference may be attributed mainly to organic and inorganic suspended matter content of the Po waters.

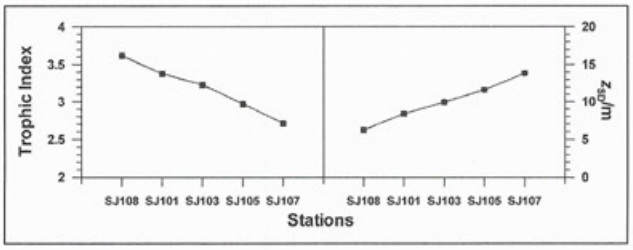


Fig. 1. Least squared means and standard errors for trophic index and transparency (Secchi depth, z_{SD}) at stations SJ108 and SJ107 for the period 1973-2002.

Long-term changes of TRIX for the western and eastern stations bounding the profile (SJ108 and SJ107 respectively) show a significant change in trophic conditions at the beginning of the eighties. A slight decrease is evident and can be related to the change in the nutrient composition of the Po River waters. The phosphorous load of the waters was halved due to the replacement of polyphosphates with other compounds in detergents, and other sanitations measures within the watershed (3).

Data related to Secchi depth measurement do not show significant changes for the past 30 years. The oscillations between years are related to changes in the hydrological regime of the Po River, more evident at the stations closer to the delta (Fig. 2).

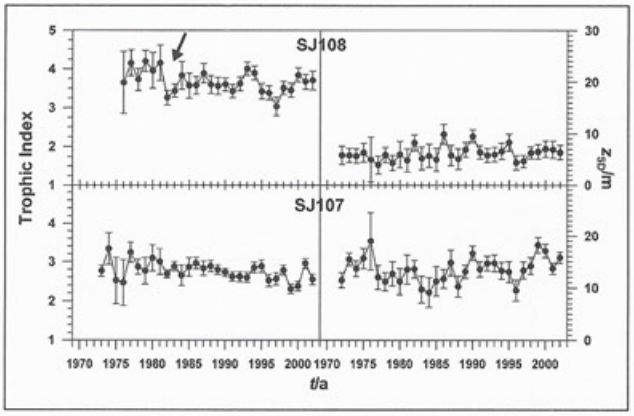


Fig. 2. Least squared means and standard errors for trophic index and transparency (Secchi depth, z_{SD}) at stations on the Po River delta – Rovinj profile in the period 1973-2002.

Classification of waters that have great variability of environmental conditions (nutrient inputs, hydrodynamic and meteorological fluctuations) using only TRIX may underestimate the real trophic state. Additional parameters, including transparency and biological observations (phytoplankton population densities) should significantly improve the trophic classification of waters.

References

1 - Degobbis D., Precali R., Ivančić I., Smodlaka N., Fuks D. and Kveder S., , 2000. Long-term changes in the northern Adriatic ecosystem related to anthropogenic eutrophication. *Int. J. Environment & Pollution*, 13: 495-533.
2 - Strickland J.D.H. and Parsons T.R., 1972. A practical handbook of seawater analysis. *Bull. Fish. Res. Bd Canada*, Ottawa 167: 310.
3 - Pagnotta R., Caggiati G., Piazza D., Ferrari F., 1995. Il controllo della qualità delle acque superficiali del bacino padano. *Inquinamento*, 4: 8-14.

DETERMINATION OF ZN- PYRITHIONE IN ADRIATIC COASTAL SEAWATER SAMPLES BY CATHODIC STRIPPING VOLTAMMETRY

Marta Plavšić [1*] and Constant M.G. van den Berg [2]

[1] Rudjer Boskovic Institute, Center for Marine and Environmental Research, POBox 180, 10002 Zagreb, Croatia - * plavsic@rudjer.irb.hr

[2] Oceanography Laboratories, Earth Sciences Department, Liverpool L69 7ZL, UK - Vandenberg@liverpool.ac.uk

Abstract

A method was adapted here to determine the anti-foulant pyrithione in natural waters. The method is based on cathodic stripping voltammetry (CSV) in the presence of Triton-X-100 to separate the pyrithione peak from interfering thiol compounds. The detection limit in UV-digested seawater was 1.5 nM for a deposition time of 60s. The method is applied for the determination of Zn- pyrithione in coastal samples of the Adriatic sea.

Key words: Zn-pyrithione, electrochemistry, Adriatic sea, anti-foulant

Introduction

Zinc pyrithione, ZPT, (zinc-2-pyridinethiol-N-oxide (IUPAC), CAS [13463-41-7]), belongs to a group of antifouling paint booster biocides which are added to antifouling paints to improve their efficacy. These biocides have become prevalent , followed a ban on the use of triorganotin biocides in antifouling paints for small boats in the late 1980's[1]. ZPT is used extensively also an antiseborrehic agent in hair care [2]. Both of these commercial applications made ZPT an analyte of interest . Several studies of the fate of pyrithione in the environment and its toxicity to aquatic life have been made [2,3]. Goka [2] showed on Zebrafish and Japanese Medaka that ZPT induces significant teretogenic effects on larvae of both species. Kobayashi and Okamura [3] found ZPT much more toxic to sea urchins than tributyltin oxide (TBTO). Assessment of the impact of pyrithiones (PT) has been complicated by lack of a sensitive and reproducible method of analysis. Methods developed for detection of ZPT in hair care and cosmetic products (HPLC and polarography) [4,5] could in principle be used for natural waters but they require a very large preconcentration step suffering from poor recovery and reproducibility. The method developed recently [6], for analytical determination of ZPT in natural waters in the presence of Triton-X-100, has good reproducibility, sensitivity and can alleviate the influence of other S - containing compounds which are present in natural waters. This newly developed method is applied here for the determination of ZPT in samples from the coastal area of the Adriatic sea, Mersey river estuary and marinas.

Experimental

Instrumentation and reagents

The voltammetric system comprised a μAutolab voltammeter (Ecochemie) and a static mercury drop electrode (Metrohm 663VA), PC-controlled using GPES 4.8 Windows software (Ecochemie). The reference electrode was double junction Ag/saturated AgCl with a salt bridge filled with 3M KCl. The counter electrode was a glassy carbon rod, and the voltammetric cell was glass. A 1 mM stock solution of zinc pyrithione (SIGMA) was prepared weekly. A potential of -0.1 V was applied to adsorb the pyrithione using an adsorption time of typically 60 s. Then an equilibration time of 10 s was allowed, and the potential was scanned in the differential-pulse mode from -0.05 to -1.2 V. (modulation time 0.01 s, interval 0.1 s, step height 0.010 V and pulse amplitude 0.050 V).

Results and discussion

Pyrithione gives a peak at -0.3 V in the presence of Triton-X-100 (2-4ppm), when added to pH 9 (ammonia buffer) seawater sample. Cyclic voltammetry (CV) across a long potential range (-0.05V to -1.2V) showed that the voltammetric peaks for ZPT and glutathione are well separated , even in the presence of 1000nM of glutathione. The first peak appears at a potential E = -0.3 V and is due to the reduction of mercury in an adsorbed complex with pyrithione, while the second peak appears at E = -0.5 V and is due to the presence of glutathione in the sample .

The height and potential of the ZPT peak are affected by variations in the pH and electrochemical parameters (adsorption time, potential, etc), and by the concentration of Triton-X-100 which is used for much improved sensitivity.

It has been reported that low water solubility and rapid photodegradation are probably significant factors in the removal of ZPT from surface waters, with a half-life of 4 hours under ambient room light [7]. The pyrithione is indeed readily broken down by ambient UV light, but it is likely that such UV is much reduced in estuarine waters , marinas and in waste water outfalls, so it is not known whether the photolytic process is important in nature. Samples stored under ambient conditions appeared stable. After 8 hours standing under ambient conditions in a translucent polyethylene bottle on the lab bench, the remains of the bulk solution containing 200 nM of ZPT were analysed and produced peaks of equal height to the original measurements made with fresh sample[6]. Localized high concentrations of pyrithione could be expected due to the reduced UV light , embayment of high concentration waters in marinas or at waste water outfalls.

The marina sample (within a docks complex off the River Mersey ; UK) was determined to contain 105 ± 5 nM pyrithione [6]. A sample from the marine Rogoznica lake (Croatia, in the vicinity of marina Frapa) was found to contain 120 ± 5 nM pyrithione. Seawater samples from other coastal areas of the north Adriatic sea were analysed as well. The concentrations in these samples were 24-44 nM of pyrithione.

Conclusion

These preliminary measurements indicate that pyrithione may well occur widespread in the environment, and it will be interesting to investigate its source and fate (anti-fouling agent, shampoos, or other) in different coastal waters.

Acknowledgements

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References

1 - Thomas K.V., 2001. The environmental fate and behaviour of antifouling paintbooster biocides: a review. *Biofouling* ,17 : 73-86 .

2 - Goka K., 1999. Embryotoxicity of Zn- pyrithione, an antidandruff chemical, in fish, *Environ.Res.* , 81 : 81- 83.

3 - Kobayashi N., Okamura H., 2002. Effect of new antifouling compounds on the development of sea urchins. *Mar. Pollut. Bull.*, 44 : 748 -751.

4 - Voulvoulis N., Scrimshaw M.D., Lester J.N.,1999. Analytical methods for the determination of 9 antifouling paint booster biocides in estuarine water samples. *Chemosphere*, 38: 3503-3516.

5 - Wang L.H., 2000. Determination of zinc pyrithione in hair care products on metal oxides modified carbon paste electrode. *Electroanalysis*, 12 : 227- 232.

6 - Mackie D.S., van den Berg C.M.G., Readman J., 2003 .Determination of pyrithione in natural waters by cathodic stripping voltammetry. *Anal. Chim Acta.*, submitted.

7 - Thomas K.V., 1999.Determination of the antifouling agent zinc pyrithione in water samples by copper chelate formation and high – performance liquid chromatography atmospheric pressure chemical ionisation mass spectrometry. *J. Chromatogr. A.*, 833(1):105-109.

MUCILAGE EVENTS (2000-2002) IN THE NORTHERN ADRIATIC AND THE N/P RATIO

Robert Precali [1] *, Danilo Degobbis [1], Tamara Dakovac [1] and Carla Rita Ferrari [2]

[1] Center for Marine Research, Rudjer Bošković Institute, Rovinj, Croatia
[2] ARPA Emilia Romagna, Struttura Oceanografica Daphne, Cesenatico, Italia

Abstract

DIN/PO_4 ratio changes were investigated (1999-2002) in the northern Adriatic waters, influenced by riverine inputs, were mucilaginous aggregates preferably form. It was not evidenced that much higher DIN/PO_4 ratio than the Redfield value (16:1) contributed to the mucilage events.

Keywords: Mucilage events, N/P ratio, Po River influence, Northern Adriatic

Introduction

In the last 15 years mucilage events occurred with a much higher frequency (1988, 1989, 1991, 1997, 2000-2002) than in the previous several decades (1). These events coincided with a considerable reduction of the phosphorus load in the Po River waters, with a significant increase in the DIN/PO_4 ratio. Laboratory experiments proved that high values of this ratio can increase the phytoplankton extracellular release of compounds that are assumed to represent the matrix of mucilaginous aggregates (1).

The aim of the research was to investigate a possible role of changes in the DIN/PO_4 ratio in the northern Adriatic surface layer during the period 1999-2002, when mucilage events occurred with varying intensity and duration.

Materials and methods

Data were collected approximately monthly from June 1999-July 2002 at 20 stations along three transects, northerly of the line Senigallia–Susak Island. The water samples were collected with 5 L Niskin samplers. Nutrient analyses were performed aboard immediately after sample collection with spectrophotometric methods widely used in oceanography (2).

Waters (type 1) with salinity range $32 \leq S \leq 37$, oxygen saturation ratio $O_{2sat} \geq 105\%$, and depths <10 m were analysed. Visual observations suggested that the most part of mucilaginous material forms in these waters. Nutrients concentration and DIN/PO_4 ratio in type 1 water were grouped in two categories: before (March-June) and during or after (June-August) the mucilage event. The data were presented as Box and Whisker graphs for every year.

Results and discussion

Riverine nutrients can substantially modify the nutrient ratios of the upper water column of the northern Adriatic during the spring freshets. During the investigated period the DIN/PO_4 ratio in the Po River water were much higher than the optimal Redfield ratio (16:1) and ranged from 50:1-150:1, depending on the flow dynamic (Fig. 1). The values of this ratio were even higher before the mucilage events (Fig. 2) in 2000, but particularly in 2001, when the freshwater influence was more marked (lower surface salinities, higher DIN concentrations; Fig. 2). Interestingly, in those years the mucilage events were time limited (1-2 weeks). In contrast, in 2002, when the DIN/PO_4 ratios were much lower (Fig. 2), the event lasted for more than two months.

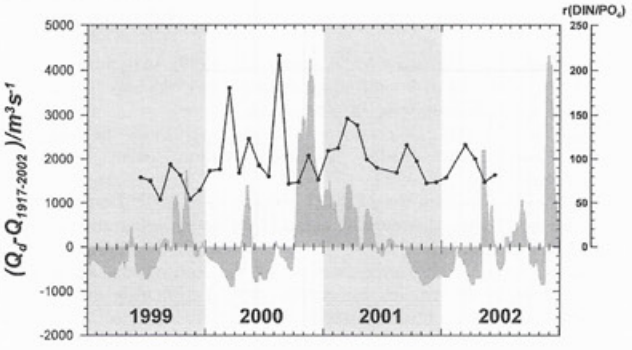


Fig. 1. Differences of the Po River daily flows from model values (1917-2002), and DIN/PO_4 ratio (*r*) in its waters in the period 1999-2002.

In summer the DIN/PO_4 ratios were markedly decreased, approaching the Redfield ratio. But, this decrease was observed in all the investigated years, independently on the intensity of the mucilage events, or even if the event did not occur (in 1999).

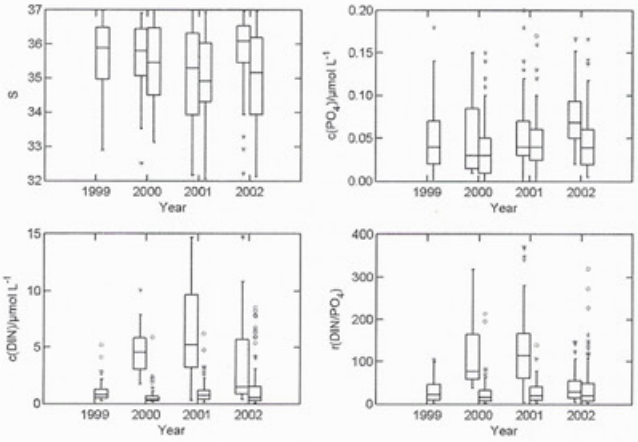


Fig. 2. Box and Whiskers graphs of salinity, dissolved inorganic nitrogen (DIN) and orthophosphate (PO_4) concentrations (*c*), and DIN/PO_4 ratio (*r*) in waters of type 1 before (Marc-June, left) and during (July-August, right) appearance of mucilage in the period 1999-2002.

The DIN/PO_4 ratio changes obviously do not trigger mucilage events, but they probably have an important role, influencing chronically the excretion mechanisms of the northern Adriatic phytoplankton, and, thus, synergically contributing with several other factors (biological, physical).

References

1 - Degobbis D., Malej A. & Fonda-Umani S. 1999. The mucilage phenomenon in the northern Adriatic. A critical review of the present scientific hypotheses. *Ann. Ist. Super. Sanità*, 35: 373-381.

2 - Strickland J.D.H. and Parsons T.R., 1972. A practical handbook of seawater analysis. *Bull. Fish. Res. Bd Canada*, Ottawa 167: 310 p.

EFFECTS OF OLIGOTROPHY GRADIENTS ON PELAGIC PRIMARY PRODUCTION IN THE AEGEAN SEA (EASTERN MEDITERRANEAN)

S. Psarra [1] *, L. Ignatiades [2], K.Pagou [3], G. Assimakopoulou [3], O. Gotsis-Skretas [3], A. Tselepides [1] & P. Raimbault [4]

[1] Institute of Marine Biology of Crete (IMBC), POB 2214 Iraklio 71003, Crete, Greece - *spsarra@imbc.gr,
[2] Institute of Biology, National Research Centre Democritos, POB 60228, 15310 Ag. Paraskevi, Athens, Greece
[3] Institute of Oceanography, National Centre for Marine Research, POB 712, 190 13 Anavissos Attikis, Greece
[4] Laboratoire d'Océanographie et de Biogeochimie (UMR CNRS 6535), Centre d'Océanologie de Marseille, Campus de Luminy, F-13288 Marseille cedex, France

Keywords : Primary production – Phytoplankton - Oligotrophy – Aegean Sea -Eastern Mediterranean

Primary production was measured on a north-south oligotrophy gradient in the Aegean Sea* (1). Hydrological characteristics revealed a permanently stratified system in the North, influenced by Black Sea Waters (BSW) whereas the South alternated from highly stratified to well-mixed conditions in summer and winter, respectively (2). Despite the lack of important differences in nutrient concentrations, chlorophyll and primary production during the spring bloom were higher in the North (Fig. 1), based mainly on picoplankton and regenerated nitrogen forms, while diatoms were absent. Thus, the high primary production rates could be supported by the high organic matter inputs of BSW origin through regeneration processes (3).

* This work was integrated in the EU project MATER.

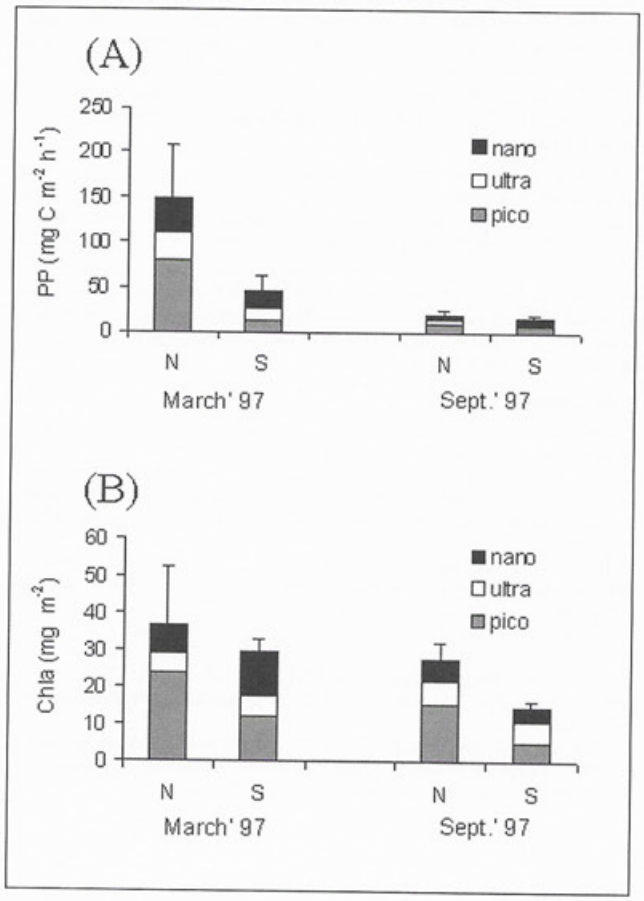


Fig. 1. Primary production (A) and chlorophyll-a (B) size-fractionated measurements, in the North (N) and the South (S) Aegean Sea, during March and September '07. Size fractions correspond to 0.2-1.2μm, 1.2-3μm and > 3μm, representing pico-, ultra- and nano-phytoplankton, respectively. Error bars represent the SD of total primary production and total chla between the stations in the two basins.

References

1 - Ignatiades, L. Psarra, S., Zervakis, V., Pagou, K., Souvermezoglou, E., Assimakopoulou, G. and Gotsis-Skretas, O., 2002. Phytoplankton size-based dynamics in the Aegean Sea (Eastern Mediterranean). *J. Mar. Sys.*, 36: 11-28.

2 - Lykousis, V. Chronis, G., Tselepides, A., Price, B., Theocharis, A., Siokou-Frangou, I., Van Wambeke, F., Danovaro, R., Stavrakakis, S., Duineveld, G., Georgopoulos, D., Ignatiades, L., Souvermezoglou, A. and Voutsinou-Taliadouri, F., 2002. Major outputs of the recent multidisciplinary biogeochemical researches undertaken in the Aegean Sea. *J. Mar. Sys.*, 33-34: 313-334.

3 - Siokou-Frangou, I., Bianchi, M., Christaki, U., Christou, E., Giannakourou, A., Gotsis, O., Ignatiades, L., Pagou, K., Pitta, P., Psarra, S., Souvermezoglou, E., Van Wambeke, F. and Zervakis, V., 2002. Organic carbon partitioning and carbon flow along a gradient of oligotrophy in the Aegean Sea (Mediterranean Sea). *J. Mar. Sys.*, 33-34: 335-353.

SEASONAL VARIATIONS OF THE NO3:PO4 RATIOS IN THE NORTHWESTERN ALBORAN SEA

T. Ramírez *, D. Cortés, J. Mercado, M. Vargas-Yáñez and M. Sebastián

Instituto Español de Oceanografía. Centro Oceanográfico de Málaga. Puerto pesquero s/n, Apdo. 285, 29640 Fuengirola, Malaga, Spain
* teodoro.ramirez@ma.ieo.es

Abstract

Seasonal variations of nutrient concentrations were studied in the northwestern Alboran Sea during 2002. On overall, the average NO_3^-: PO_4^{3-} ratios in the upper layers were lower than the Redfield ratio throughout all the year, indicating a NO_3^- deficiency relative to PO_4^{3-}. NO_3^- was removed to undetectable levels, particularly in summer and autumn, while PO_4^{3-} concentrations of ~0.15 µM remained unutilised. In contrast, in the deeper layers the N:P ratio was on average higher than 16:1, indicating a PO4 deficiency relative to NO_3^-. The mean N:P ratio for all data from the slope of NO_3^- vs. PO_4^{3-} was 23.78.

Key words: nutrients; ratio NO_3^-: PO_4^{3-}; Alboran Sea.

Introduction

The Alboran Sea has been object of a great number of studies on physical oceanography and mesoscale processes, however the number of works dealing with nutrients is scarce, particularly in the continental margin. In addition most of these studies has been carried out during spring or summer, when the weather conditions are more favourable. Therefore there is a lack of information about the seasonal cycles of nutrients in this area and their role on primary production. In a very simple approach the Alboran Sea could be considered as a two layer system, with the upper layer being occupied by the Atlantic Waters AW (more and less modified). Below this layer saltier Mediterranean waters flow towards the Gibraltar Strait (1). The Atlantic Water entering the Alboran Sea is depleted in nutrients (2), and the molar proportions of N:P are considered to be similar to that of Redfield (3) in the Atlantic side of Gibraltar, while they are lower than 16:1 in the layer of Atlantic water in the Alboran Sea (2). However, a recent study indicated that the N:P ratio in the Atlantic layer on the western side of Gibraltar was lower than 16:1 (4), indicating a deficiency of NO_3^- relative to PO_4^{3-}, while the in the eastern side of Gibraltar the AW were deficient in PO_4^{3-} (4) as occur in other areas in the Eastern Basin and in the NW Mediterranean (5).

The aim of this study is to analyse the seasonal variations of nutrient concentrations in the continental margin of the northwestern Alboran Sea, analysing the seasonal variations of the N:P ratios and their departures from the theoretical ratio of Redfield N:P (16:1). The sampling was carried out in February, April, July and October 2002, at 24 stations situated in six transects off the coast of Málaga (South of Spain). Seawater samples were taken at different depths with Niskin bottles, down to a maximum depth of 300 m. Nutrient analysis were carried out in a Bran-Luebbe AA3 autoanalyser.

Results

On overall, the highest concentrations of nutrients in the surface layers were found during the April cruise, coinciding with a generalised increase of salinity that was caused by upwelling events. During this season the mean concentrations in the top 20 m were 2.54 µM NO_3^-±1.98 (SD) and 0.21 µM PO_4^{3-}±0.76 (SD). In contrast, the lowest concentrations in the upper layers were found during the summer cruise. During this season a strong pycnocline was developed due to the combined effect of the seasonal thermocline and a marked halocline, the latter due to the intrusion of fresh Atlantic Waters (AW) with salinities lower than 36.5 psu. Thus, in most of the stations NO_3^- concentrations were below the detection limit (<0.05 µM). At those stations where NO_3^- was detected, the mean concentration in the upper 20 m was 0.24 µM±0.36 (SD). The mean PO_4^{3-} concentration in the top 20 m during this season was 0.13 µM±0.04(SD). In the deeper waters, 100-300 m, the lowest nutrient concentrations were observed in spring, while the higher concentrations were found in autumn. The vertical profile of nutrient concentrations suggested the occurrence of intense remineralisation processes in the water column during summer and autumn, leading to a relative maximum of PO_4^{3-} at 75 m and an increase of nutrient concentrations below the thermocline.

The mean N:P ratios in the upper layers (top 20 m), during all the cruises, were lower than the classical Redfield ratio of 16:1, indicating that there was a deficiency of NO_3^- relative to PO_4^{3-}. The lowest N:P ratios were detected during the summer, ranging from<0.32 to 5.15, with a mean of 1.28±1.51 (SD). During the summer and autumn cruises PO_4^{3-} concentrations ~0.15 µM were detected whereas NO_3^- levels dropped below the detection limit. In contrast, during the spring cruise the N:P ratios were closer to the Redfield ratio, due to the upwelling of deeper waters, with a higher N:P ratio. The N:P ratios in the top 20 m during the spring ranged from <0.32 to 16.69, with a mean of 9.19±5.87.

The N:P ratio increased with depth, reaching in general a maximum value at 200 m. In general, the N:P ratios of the deeper waters (200-300 m) were higher than 16:1, indicating a PO_4^{3-} deficiency relative to NO_3^-. The plot of NO_3^- vs. PO_4^{3-} concentrations for all the data gives a slope of 23.78, while the mean N:P ratio at 200-300 m was 18.99±2.32 (SD), which is slightly lower than the mean N:P ratios reported for the deep Mediterranean waters ~22-24 (3). The higher N:P ratios in the deep waters were found in spring 20.49±0.97 (SD), while the lowest values were found in autumn 17.63±1.41(SD). The low values of the N:P ratio found during the autumn cruise was due to the increase in PO_4^{3-} caused by remineralisation processes in the water column.

In general, the low NO_3^- concentrations observed during winter, summer and autumn, together with the low N:P ratios during all the cruises suggest that new primary production, in the northwestern Alboran Sea, could be potentially limited by NO_3^-. This NO_3^- deficiency would favour the development of phytoplankton communities based on recycled nutrients within the photic layer. This is consistent with a change in the phytoplankton community assemblages in the Northwestern Alboran Sea that has been observed to occur from 1994 to 2001 (6).

References

1 - Parrilla G., and Kinder T., 1987. Oceanografía física del Mar de Alboran. *Bol. Inst. Esp. Oceanogr.*, 4(1): 133-166.

2 - Minas H.J., Coste B., Le Corre P., Minas M., and Raimbault P., 1991. Biological and geochemical signatures associated with the water circulation through the Strait of Gibraltar and in the Western Alboran Sea. *J. Geophys. Res.*, 96(C5): 8755-8771.

3 - Bethoux J.P., Morin P., and Ruiz-Pino D., 2002. Temporal trends in nutrient ratios: chemical evidence of Mediterranean ecosystem changes driven by human activity. *Deep Sea Res.*, II, 49: 2007-2016.

4 - Dafner E.V., Boscolo R., and Bryden H.L., 2003. The N:Si:P molar ratio in the Strait of Gibraltar. *Geophys. Res. Lett.*, 30(10): 1506

5 - Krom M.D., Kress N., and Gordon L.I., 1991. Phosphorus limitation of primary productivity in the eastern Mediterranean Sea. *Limnol. Oceanogr.*, 36(3): 424-432.

6 - Mercado J.M., Ramírez T., Cortés D., Sebastián M., and Vargas-Yañez M., 2003. Temporal changes in phytoplankton communities in a upwelling area of the Alboran Sea. *J. Plankton Res. (submitted)*

LEAD, ZINC, COPPER AND IRON PARTITIONING SPATIAL DISTRIBUTION IN LAVRIO PORT SEDIMENTS

F. Sakellariadou * and L. Haralambides

Dept of Maritime Studies, University of Piraeus, 40 Karaoli & Dimitriou st, 185 32 Piraeus, GR - * fsakelar@unipi.gr

Abstract

The recently renovated port of Lavrio accommodates bulk cargo ships and coastal ferries. In the coastal area there is a mineralization of mixed sulphides and oxidized ores of lead, zinc and iron. In the present paper, the spatial distribution of Pb, Zn, Cu and Fe partitioning in Lavrio port sediments is studied. It is concluded that the geology of the inland coastal area, the metallurgical activities and the inappropriate material used for maritime constructions have affected dramatically the metal partitioning distribution. There is a need for the appropriate high quality port management.

Keywords: metal, partitioning, pollution, port, sediments.

Introduction

Ports accommodate various polluting activities and are considered as effective natural traps. Port sediment study allows pollution sources comparison, feasible transport pathways investigation, geochemical changes identification, presence and mobility of potential pollutants indication. Metal partitioning among sediment geochemical phases provides information about the source, mode of occurrence, biological and physicochemical availability, mobilization and uptake. In Lavrio, there is a mineralization of mixed sulphides and oxidized ores of Pb, Zn and Fe, at the contact between schists and marbles. The intensive mining and metallurgical activities have resulted in the formation of huge spoils of wastes (1). The recently renovated port of Lavrio accommodates bulk cargo ships and coastal ferries. It acts as metal source (2, 3) for the neighboring coastal zone.

Methodology

In 1999 surface sediment samples were collected from Lavrio port. They were analysed for total metal content (treatment by mixture of conc. HNO_3, $HClO_4$, HF at high T) (4) and metal partitioning (5 with some modifications, 6). The five fractions examined are the exchangeable (Exch), carbonate associated (Car), reducible (Red), organic matter-sulphide bound (Or+Sul), and residual (Res). All metal concentrations were measured by AAS. The relative standard deviation of the measurements was <5%. The spatial distribution was achieved by using the program Surfer®, version 7, 1999 edition (Golden Software Inc.). The distributions are expressed in ppm (μg/g).

Results

Figure 1 shows the spatial distribution of Cu (Exch). It shows enrichment near the loading facilities and the old pier (left side of the map). This distribution is similar with that of Pb (Exch) with the exception of enrichment in the south side of the map. Figure 2 shows the spatial distribution of Zn (Car), Zn (Red), Fe (Red), Zn (Or+Sul). Enrichment is found at the vicinity of the new pier (under construction at the time of sampling). This pattern is almost identical with that of Fe (Car) while it has many similarities with those of Cu (Car) and Pb (Or+Sul). Figure 3 shows the spatial distribution of Cu (Or+Sul) and Pb (Red). Enrichments are found near the loading facilities and the new pier.

Conclusions

The exchangeable metal enrichment, representing the most easily released fraction, indicates man-made pollution and the possibility for metal biological uptake. Metal partitioning enrichment near loading facilities shows the influence of the mineralization and the metallurgical activities on the coastal area. Metal partitioning enrichment at the vicinity of the new pier indicates that it has been constructed with material coming from the area of the old mining and the smelter wastes deposits. Lavrio port, due to coastal geology and human activities, like metallurgical works in past and maritime constructions at present, acts as a metal source for the neighboring coastal area. There is an urgent need for a high quality port management.

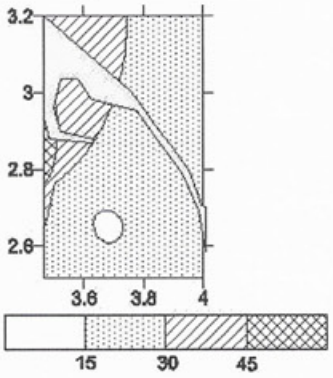


Fig. 1.
Cu (exch) distribution (ppm).

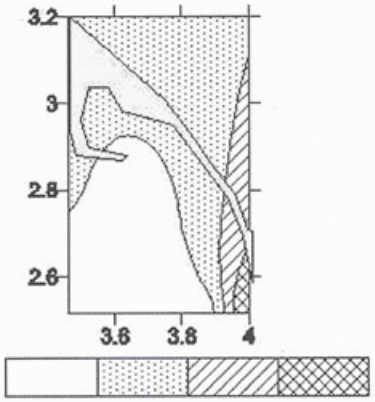


Fig. 2.
Zn (Car), Zn (Red), Zn(or+sul) and Fe (Red) distributions (ppm).

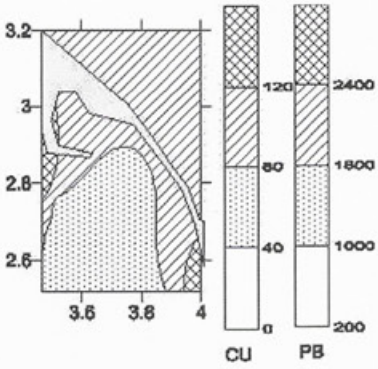


Fig. 3.
Cu (or + sil) and Pb (Red) distribution (ppm)

References

1 - National Technical University of Athens, 1999. Chapter 2: Evaluation of the Environmental Problem. *In*: Vol. 3: Environmental Characterization of Lavrion Site – Development of Remediation Techniques, Soil Rehabilization in the Municipality of Lavrion, LIFE Project, Contract No: 93/GR/A/GR/4567, 1999.

2 - Sakellariadou, F., Haralambides, L. and Maroulakou, M., 2000. Geochemical investigations in sediment samples collected from the ports of Lavrio and Rafina, East Attiki, Proc. of the 5th International Conference on Environmental Pollution, Thessaloniki-Greece, 741-748.

3 - Sakellariadou, F., Haralambides, L., 2003. Metal partitioning in Rafina and Lavrio Port Sediments. *The Cyprus Journal of Science and Technology*.

4 - UNEP, 1985. Reference Methods for Marine Pollution Studies, No 31-39.

5 - Tessier, A., Campbell, P.G.C. and Bisson, M., 1979. Sequential extraction procedure of the speciation of particulate trace metals. *Anal. Chem.*, 51 (7): 844-850.

6 - Sakellariadou, F., 1987. Geochemistry of near shore sediments from the North Aegean Sea, Greece. Ph.D. Thesis, Imperial College, London, p. 376.

ORGANIC CARBON BALANCE ON A NORTH-SOUTH TRANSECT ACROSS THE EASTERN ALBORAN SEA

A. Sanchez-Vidal *, A. Calafat, M. Canals, J. Frigola, J. Fabres

GRC Geociències Marines, Dept. d'Estratigrafia, Paleontologia i Geociències Marines, Universitat de Barcelona, Barcelona, Spain - tonim@natura.geo.ub.es.

Abstract

Our study provides the first estimates of particulate organic carbon export in the Alboran Sea. A vertical organic carbon balance has been estimated using satellite-derived primary production, organic carbon fluxes down the water column, and mean accumulation rates in bottom sediments. Results suggest that less than 1% of the carbon fixed during photosynthesis in surface waters is vertically transferred and finally buried in deep sediments. A large portion is supplied by lateral advection and by shelf-derived benthic nepheloid supply.

Keywords: sediment traps, organic carbon, Alboran Sea

To know the transport of particulate organic carbon (POC) in the oceans is crucial for the understanding of the global carbon cycle and its response to climate change. Only a small fraction of the organic carbon produced in the euphotic zone sinks out, reaches the deep-sea floor and is buried forming the sedimentary record.

We have attempted to constrain the production, transfer and burial of POC in the Eastern Alboran Sea. Particle flux data were obtained from three mooring arrays deployed during one year, from June 1997 to May 1998, following a north to south transect along 1°30' W in the Eastern Alboran Sea [1]. Each mooring line was equipped with three sediment traps at 500-700 m depth, 1000-1200 m depth, and 30 m above the sea floor. The study was part of the European MTPII-MATER multidisciplinary project.

By combining measurements of primary production data from [2], algorithm-generated POC fluxes with an adapted version of Martin's et al. (1987) equation, POC fluxes measured at three sediment trap-depths [1], and mean accumulation rates measured from sediment cores [3], balances of carbon are presented in Figure 1.

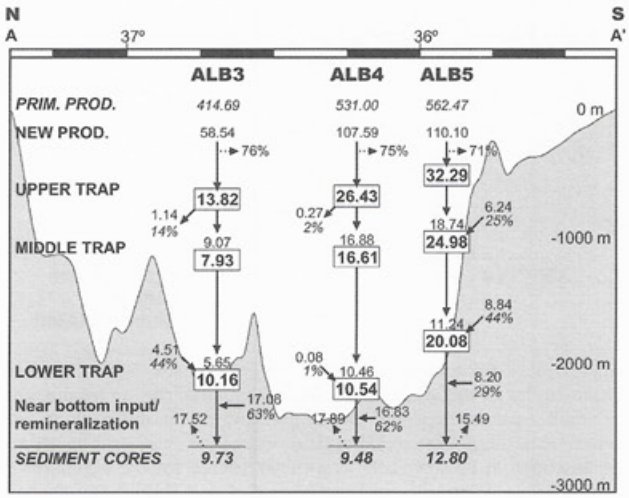


Fig. 1. Organic carbon flux balance across the Eastern Alboran Sea following a North-South transect along 1°30' W. Bold data within rectangles represent measured organic carbon fluxes by the sediment traps; data among arrows represent inferred lateral organic carbon fluxes. All POC fluxes are in mg $m^{-2}d^{-1}$.

Data reveal that a 14-21% of the primary production in surface waters is exported through the euphotic zone. There is, however, a northwards decrease of export fluxes that likely reflects the advection to the east and to the south of phytoplankton-rich water by the Atlantic jet, as depicted by SeaWiFS images [1]. Vertical POC fluxes down the water column are largest in the southern site. Lateral POC fluxes are also higher, where inputs represent 25% and 44% of the total POC flux at middle and lower depths, respectively. In the northern site ALB3 a loss that accounts for 14% of the POC is observed between upper and middle depths, and lateral input reappears between the middle and lower traps with an input of 44% of the organic carbon. A strong input of POC is supposed to occur below 30 meters above bottom at the three stations to account for the difference between what is accumulated [3] plus remineralized [4] and what is collected at the lower bottom trap. This accounts for up to 63% of total POC reaching the sea floor. The three sediment cores below the moorings have similar organic carbon accumulation rate, a situation that has been attributed to the spatial homogenisation capacity of near bottom transport [3].

Computation of the total export ratio, which is the proportion of primary production exported from the surface layer and buried in the sediments after arriving at the sea floor either vertically or advectively, yields the following values of 2.35% (ALB3), 1.79% (ALB4) and 2.28% (ALB5). However, the primary export ratio, which is the proportion of primary production arriving at the sea floor vertically, is only 0.48%, 0.68% and 0.89% for ALB3, ALB4 and ALB5, respectively. Therefore, only 0.5-0.9% of the carbon fixed during photosynthesis in surface waters of the Eastern Alboran Sea is vertically transferred and buried into the deep sediments to form the sedimentary record. A larger carbon portion is supplied by lateral advection at intermediate depths and by benthic nepheloid layers, probably derived from the continental margin, which in consequence would constitute a significant source of organic carbon to the deep Eastern Alboran Sea.

References

[1] - Sanchez-Vidal, A., Calafat, A., Fabres, J., Canals, M., 2003. Mesoscale circulation-controlled particle and organic carbon fluxes below the Almeria-Oran Front (Alboran Sea, SW Mediterranean Sea). *J. Mar. Syst.* (Submitted for publication)

[2] - Garcia-Gorriz, E., Carr, M.E., 2001. Physical control of phytoplankton distributions in the Alboran Sea: A numerical and satellite approach. *J. Geophys. Res.*, 106 (C8): 16795-16805.

[3] - Masqué, P., Fabres, J., Canals, M., Sanchez-Cabeza, J.A., Sanchez-Vidal, A., Cacho, I., Calafat, A., Bruach, J.M., 2003. Accumulation rates of major constituents of hemipelagic sediments in the deep Alboran Sea: a centennial perspective of sedimentary dynamics. *Mar. Geol.*, 193: 207-233.

[4] - Bianchi, A., Calafat, A., De Wit, R., Garcin, J., Tholosan, O., Cacho, I., Canals, M., Fabres, J., Grout, H., Masqué, P., Sanchez-Cabeza, J.A., Sempéré, R., 2003. Microbial activity at the deep water sediment boundary layer in two highly productive systems in the Western Mediterranean: the Almeria-Oran front and the Malaga upwelling. *Oceanol. Acta*, 25 (6): 315-324.

DISSOLVED ORGANIC CARBON IN THE IONIAN SEA AS FUNCTION OF WATER MASS CIRCULATION

C. Santinelli [1], B. Manca [2], L. Nannicini1 and A. Seritti [1] *

[1] CNR Istituto di Biofisica, Area della Ricerca di Pisa, Via Moruzzi, 1 – 56124 Pisa, Italy - alfredo.seritti@ib.pi.cnr.it
[2] Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS, Borgo Grotta Gigante 42/C, 34010 Sgonico (Trieste), Italy

Abstract

Dissolved Organic Carbon (DOC) in the Ionian Sea was investigated during two surveys carried out in January 1999 and April 2002. The highest values (50-89 µM) were found in the upper layers (0-100 m). In the intermediate layer DOC concentration was of 40-58 µM in 1999 and 48-58 µM in 2002; the lowest values were found in the LIW during the first survey. In the deep layer the DOC ranged from 46 to 57 µM in 1999 and 2002, respectively. In 2002 the Adriatic Sea regains the main role as principal source of deep waters for the Eastern Mediterranean.

Keywords: DOC, water masses, Ionian Sea.

In the early 1990s, the hydrological characteristics of intermediate and deep waters of the Eastern Mediterranean (EM) were affected by substantial changes as a consequence of the major climatic event named Eastern Mediterranean Transient (EMT) [1]. This important event also influenced the biogeochemistry of the water column [2]. The Ionian sea is an area where the thermohaline circulation has an effect on the whole EM [1].

Figure 1 shows the study area and DOC vertical profiles in two stations (A01 and G99) investigated both in 1999 and 2002. DOC in the surface waters (0-100 m) ranged from 50 to 89 µM in all the stations, without any connection with the time of survey. On the contrary, different DOC values were observed in the intermediate and deep waters in the two periods. In winter 1999, the Levantine Intermediate Water (LIW) exhibited very low DOC values (40-42 µM), because of the reduction of this water mass that was prevalently constrained to re-circulate in the Levantine basin; in the meanwhile, the new Cretan Intermediate Water (CIW) occupied the intermediate layer mostly in the eastern portion of the Ionian sea exhibiting larger DOC values (54-62 µM). In 1999, the LIW was particularly old indicating that a large part of DOC was probably already mineralised, therefore the remaining part should be mainly constituted by the "refractory" fraction [3]. In contrast, the CIW in the first survey exhibited DOC values relatively high because of its young age, being very close to the source. The deep layer in the 1999 was occupied by both the new Cretan Deep Water (CDW) and the Eastern Mediterranean Deep Water (EMDW) of Adriatic origin. The latter was elevated at shallower depth, because of the intrusion in the bottom layer of the much more dense CDW. Therefore, the DOC exhibited values ranging from 43 to 47 µM in the CDW and 44-48 µM in the EMDW.

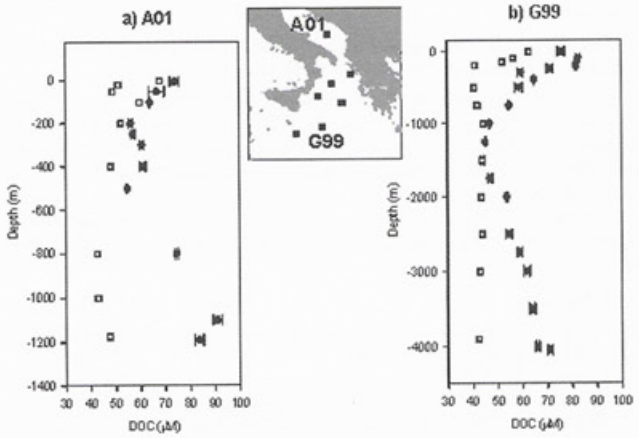


Fig. 1. Comparison between DOC vertical profiles in 1999 (γ) and 2002 (•) in the stations: A01, located in the Southern Adriatic Sea and G99, located in the Central Ionian, as shown in the inserted map.

A rather different situation was observed during the second survey carried out, in the same area of the Ionian sea, in spring 2002. The LIW circulates more abundant from east to west, as it was the case before the EMT; and the Adriatic Deep Water (ADW) returned to be the main source of deep waters for the whole EM. Therefore, DOC in the LIW has shown concentrations (48-59 µM) much higher than those observed in 1999, whilst the CIW exhibited values (mean value 58 µM) similar to those found in the 1999, although its contribution was restricted to a smaller area. Concerning the deep waters, the ADW at its source region (station A1 located in the southern part of the Adriatic sea at the interior of the gyre) exhibited DOC concentrations of 74 µM. Then, during its route towards the south into the Ionian, it mixes with the surrounding "older" EMDW to give a "new" product, with DOC values ranging from 57 to 75 µM, which are, however, higher than those observed in 1999. In the station A1 (Fig. 1a), the DOC concentration is higher (≈ 74 µM) in 600-1000 m depth range; it may be attributed to the deep convective movements of surface waters in the interior of the southern cyclonic gyre; whilst DOC values of 80-90 µM were observed in the bottom layer below 1000 m, presumably because of the arrival of much more dense waters formed in the northern shelf region. In the station G99 (Fig. 1b), the increase of DOC to values >50 µM in the layer below 2000 m, may be connected to the arrival of "new" EMDW; therefore, the moderate increase of DOC may be the result of a mixing between the recent ventilated ADW, rich of DOC, and the resident EMDW.

In conclusion, the DOC behaviour in the water column, monitored in different periods, confirms the strict correlation occurring between DOC and physical characteristics of the different water masses.

References

1 - Klein, B., W. Roether, B.B.Manca, D.Bregant, V.Beitzel, V.Kovacevich, and A.Luchetta, The large deep water transient in the Eastern Mediterranean, *Deep Sea Research I, 46,* 371-414, 1999.

2 - Seritti, A., Manca, B. B., Santinelli, C., Murru, E., Boldrin, A., and Nannicini, L. 2003. Relationships between hydrological properties and dissolved organic carbon (DOC) in the Ionian Sea (winter 1999). *Journal of Geophysical Research,* Vol. 108, C9, 8112, doi: 10.1029/2002JC001345.

3 - Carlson C.A., 2002. Production and removal processes. Pp. 91-151. *In*: Hansell D.A. and Carlson C.A. (eds.), Biogeochemistry of marine dissolved organic matter. Elsevier Academic press, San Diego, USA.

CHEMISTRY OF THE SEA SURFACE MICROLAYER IN THE BLACK SEA

G. Shtereva *, B. Dzhurova, O. Hristova
Institute of Oceanology, BAS, PO Box 152, 9000Varna, Bulgaria - * chem@io-bas.bg

Abstract
The study is based on bi-monthly monitoring in Varna Bay, which is affected by anthropogenic pressure. Nutrients (TP, IP, N_{NO2}, N_{NO3}, Si), suspended matter, oxidizability, metals (Fe, Mn) were measured in both layers: SL and SML. A maximum accumulation for most of investigated parameters in Summer-Autumn period was observed. The highest coefficient of accumulation for nitrate N was established.

Keywords: Black Sea, nutrients, oxidizability, surface microlayer

As an area of exchange of matter and energy, the sea surface microlayer (SML) is an important boundary that either affected by global change. The sea SML has unique chemical and biological characteristics very different from those of underlying water. This thin sea-surface film receives material input from atmospheric, terrigeneous and marine sources, leading to elevated concentrations of both natural compounds and anthropogenic contaminants (1). There is still a lack of knowledge about phisico-chemical processes governing the formation and properties of SML and. The aim of the study is to assess the capacity of SML to accumulate nutrients and organic matter.

The study is based on bi-monthly monitoring at one station in Varna Bay, one of the most affected by anthropogenic pressure regions along the Bulgarian Black Sea coast. The following parameters: total phosphorus (TP), inorganic phosphorus (IP), nitrite and nitrate nitrogen (N_{NO2}, N_{NO3}), silica (Si), suspended matter (SM), oxidizability Fe and Mn were determined by standard methods. The accumulation in SML is presented by ratio between concentration in SML and surface (SL): $Ka=C_{SML}/C_{SL}$.

The data reveal that sea SML is enriched in organic and inorganic substances relative to the surface water. The nutrients distribution in SML follows that in SL (Figs. 1, 2). Their microlayer concentrations occasionally exceed the permissible limits (Water quality criteria for the coastal sea water). The comparison of nutrients distribution in SL

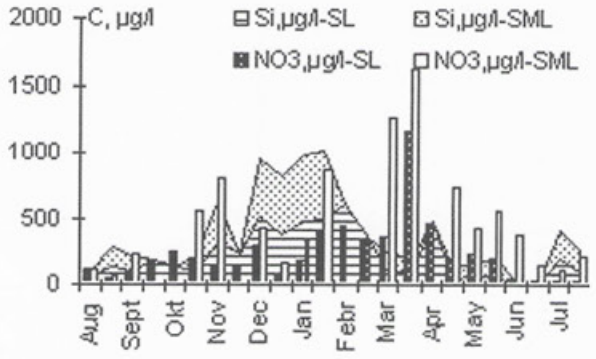


Fig. 1. Silica and nitrate N in the surface microlayer (SML) and surface layer (SL).

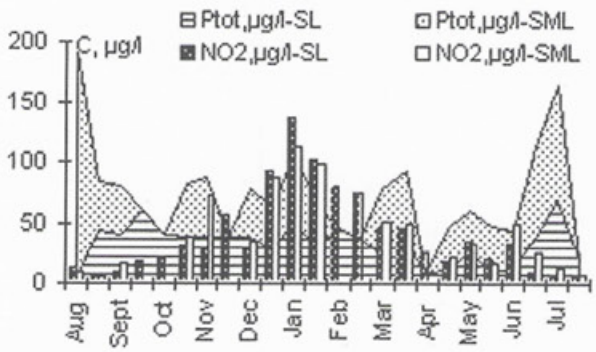


Fig. 2. Total P and nitrite N in the surface microlayer (SML) and surface layer (SL).

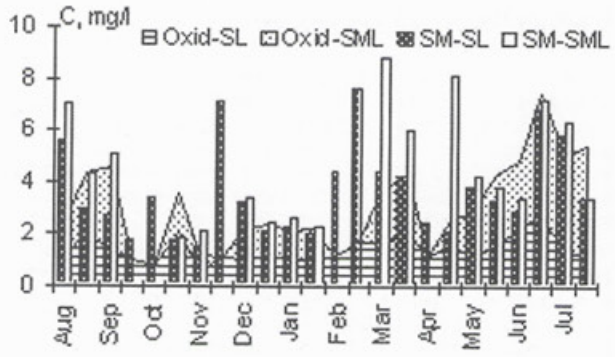


Fig. 3. Oxidizability and SM in the surface microlayer (SML) and surface layer (SL).

and SML shows a good correlation for N (r^2=0.47). A similar situation is observed for SM (r^2=0.45). According to the coefficient of accumulation (K_a) the microlayer enrichment for N during all seasons is the highest. Maximum of K_a for the whole period of investigation is as follows: 8 for N_{NO3}; 2.8 for N_{NO2}; 4 for TP and oxidizability; 3 for IT; 2 for SM, 5 for Fe and 9 for Mn). The coefficient of accumulation for metals, phosphorus and SM is comparable with those found in other area, where similar investigations were carried out (2,3). Concerning inner annual distribution, we can note, that the more significant enrichment of the SML (with exception of phosphorus) was established during the summer–autumn period (Figs. 1, 2, 3). The calculated N/P ratio is the highest in both layers in March, when maximum N-content was detected. Analogously, maximum Si/P ratio was in January, in relation to Si content, respectively.

The data presented suggest the following conclusions, which at the stage of investigation should be considered preliminary:

A microlayer enrichment for all parameters (nutrients and organic matter) is observed. The capacity of SML accumulation for N is the highest in comparison with the other nutrients. The seasonal distribution is characterized with maximum accumulation for most of investigated parameters in Summer-Autumn period. These preliminary results could be used for subsequent investigations to improve our understanding of the processes at natural phase boundaries.

References

1 - Hardy, J. 1999. Biolody, contamination and toxicity of the sea surface. *CIESM Workshop Series,* 9: 41-44.
2 - Shtereva, G. 1998. Total and organic suspended matter in the Black Sea water of the thin surface microlayer. *Proceedings of IO,* 2: 27-31.
3 - Shtereva, G. 2000. Contaminant accumulation in the sea surface microlayer, *J. of Balkan Ecology,* v.5, 2:196-200.

MERCURY SPECIATION IN SEDIMENTS FROM A SEWAGE-SLUDGE MARINE DISPOSAL SITE

Efrat Shoam-Frider [1], Gedalia Shelef [2] and Nurit Kress [1*]

[1] Israel Oceanographic & Limnological Res., The National Institute of Oceanography, PO. Box 8030, Tel Shikmona, Haifa, Israel 31080 - efrat@ocean.org.il - * nurit@ocean.org.il

[2] Division of Environmental Engineering and Water Resources, Faculty of Civil Engineering, Technion - Israel Institute of Technology, Technion City, Haifa 32000 Israel - Shelef@tx.technion.ac.il

Abstract

Mercury speciation in marine sediments collected at a sewage sludge disposal site showed it to be associated mainly with the organic matter fraction (amorphous organic sulfur compounds and humic acid), reducing it's availability to the marine environment. The third most prominent fraction was cinnabar. Methylmercury, the most deleterious species to human health consisted only of 0.1-0.5 % of the total mercury in the sediment sample, compared to 2.6% of the total mercury in the sewage sludge.

Keywords : mercury, speciation, sediment, sewage sludge, marine environment

Background

Mercury is a naturally occurring element that enters the environment as a result of natural (e.g., volcanoes, fires, surface emissions) and anthropogenic sources (e.g., combustion, commercial products). The biogeochemical cycle of mercury is complex and it can be found, among others, as elemental mercury vapor, gas-phase and dissolved ionic mercury, particulate bound, in organic forms and as cinnabar. Mercury is bioaccumulative and toxic impacting the environment and man (1). Of all the mercury species, methylmercury is the one that poses the higher risk to human health.

Although most of the introduction of mercury is via the atmospheric pathway, land based sources can cause local problems or "hot spots". Along the Israeli Mediterranean coast there are two areas with increased mercury in the sediments: in the northern coast, opposite a chlor alkali plant and in the southern coast, at the marine disposal site of excess (16,000 m^3 day^{-1}) sewage sludge from the Dan Region Wastewater treatment plant (2). The outfall operates since 1987 and is located 5 km offshore, at a water depth of ca. 38 m. About 60 Kg mercury $year^{-1}$ enters the marine environment with the sewage sludge (3). To date, only total mercury concentrations were measured in the area's sediments. This study aimed to determine the mercury speciation in the sediments of the outfall area to assess the possibility of mercury accumulation in the food web.

Experimental

Sediments were sampled in October 2002. The methods of sediment sampling, preservation and preparation are thoroughly described elsewhere (1). Speciation was performed using selective extractions of biogeochemically relevant fractions (4). Briefly, five fractions were determined: F1(water soluble), F2 ('human stomach acid' soluble), F3 (organic, humic acid chelated), F4 (elemental mercury and amorphous organic sulfur compounds), F5 (mercury sulfide, cinnabar). Methylmercury was determined in a separate aliquot of the sediment. Sediments cores of three stations were analyzed: one station at the outfall, one station located 1.5 km northward of the outfall and a non affected station located 5.5 km northwards of the outfall. Fresh sewage sludge was sampled from the treatment plant, dried and analyzed in the same manner as the sediment samples. QA/QC of the results was performed with certified international standards.

Results and discussion

Total mercury, methyl mercury and mercury speciation in the sediment samples and in fresh sewage sludge results are presented in Table 1. Total mercury concentration was the lowest at the natural station. At the affected stations, total mercury concentrations decreased with increased depth of the sediment. The highest total mercury concentration was found at the sewage sludge sample. Methyl mercury in the sewage sludge was 2.6% of the total mercury while in the sediment samples the percentage of methylmercury was much lower, in the range of 0.1-0.5%. Most of the mercury was found in the F4 fraction followed by the F3 fraction, ie, the mercury was associated with the organic matter fraction: amorphous organic sulfur compounds (F4) and humic acid (F3). The presence of elemental mercury in the F4 fraction was ruled out by pyrolisis analysis. The third most prominent fraction was F5, cinnabar. There was almost no mercury associated with the F1 and F2 fractions, the most accessible and bioavailable, neither in the sludge nor in the sediments. The distribution of mercury among the different fractions in the two stations affected by the sewage sludge was similar to that in the original sludge. The mercury species distribution in the natural station was slightly different with and higher relative contribution of the F3 fraction compared to the F4 fraction. This may be due to the association of mercury with natural humic acids. These results indicate that the mercury introduced to the marine environment with the sewage sludge is mainly associated with the most stable complexes of mercury, reducing it's availability in the environment.

Table 1. Total mercury, methyl mercury and speciation of mercury (in % from total mercury) in activated sewage sludge and in marine sediments at the disposal site.

Station	Sed. depth	Total Hg	Methyl Hg	% Methyl Hg
	cm	ppb	ppb	
outfall	-3	366.2	0.99	0.27
	-5	347.9	0.71	0.20
	-7	216	0.43	0.20
	-9	202.4	0.50	0.25
1.5 km N	-3	936	1.56	0.17
	-6	1274	1.20	0.09
	-8.5	403.6	1.19	0.29
	-12.5	501.7	0.72	0.14
Natural	0	34.36	0.19	0.54
Sewage sludge		1532	39.7	2.59

Station	Sed. depth	F1	F2	F3	F4	F5
	cm	%	%	%	%	%
outfall	-3	0	0	34.8	61.9	3.25
	-5	0.2	0	25.6	62.6	11.6
	-7	0.3	0	11.2	74.0	14.5
	-9	2.9	0	17.1	75.3	4.7
1.5 km N	-3	0.0	0	20.8	76.2	3.0
	-6	0.1	0	30.4	62.5	7.1
	-8.5	0.0	0	11.4	65.0	23.5
	-12.5	0.0	0	7.8	87.1	5.1
Natural	0	1.1	0	40.8	40.4	17.6
Sewage sludge		0	2.4	18.7	74.1	4.7

References

[1] - U.S. Environmental Protection Agency (EPA), 2000. Mercury research strategy. Office of Research and Development. EPA/600/R-00/073.

[2] - Kress, N, Herut, B. and B.S. Galil, 2003. Sewage sludge impact on sediment quality and benthic assemblages off the Mediterranean coast of Israel – a long-term study. *Marine Environmental Research*, 57(3): 213-233.

[3] - UNEP/WHO (1999). Identification of Priority Hot Spots and Sensitive Areas in the Mediterranean. MAP Technical Reports Series No. 124. UNEP, Athens. 102 p.

[4] - Bloom, Nicolas S.; Preus, Eve; Katon, Jodie; Hiltner, Misti, 2003. Selective extractions to assess the biogeochemically relevant fractionation of inorganic mercury in sediments and soils. *Analytica Chimica Acta*, 479(2): 233-248.

DISTRIBUTION AND ORIGIN OF HYDROCARBONS IN SEDIMENTS FROM ELEFSIS BAY, GREECE (EASTERN MEDITERRANEAN)

E. Sklivagou [1*], I. Hatzianestis [1], N. Rori [2], F. Rigas [2]

[1] Hellenic Centre for Marine Research, Mavro Lithari, 190 13 Anavyssos, Greece - * jenny@ncmr.gr
2. School of Chemical Engineering, National Technical University of Athens. 15700 Athens, Greece.

Abstract

Hydrocarbons were studied in surface sediments and sediment cores collected from the Elefsis Bay. Aliphatic hydrocarbon concentrations (AHC) in surface sediments ranged from 170 to 753 μg/g, while polycyclic aromatic hydrocarbon (PAH) values varied between 981 and 7255 ng/g. Concentrations in the western core remained high for both AHC and PAH till to 10 cm depth. In the eastern core, the high hydrocarbon values persist to 19 cm depth.

Keywords: sediments, petroleum, PAH

Introduction

Elefsis Bay is an almost enclosed embayment, which is situated in the northern Saronikos gulf, in central Greece. The Bay receives industrial effluents and domestic wastes, which generate severe ecological stresses in the area, resulting in almost anoxic conditions during summer.

The aim of this work is to study the horizontal and vertical profiles of AHC and PAH in Elefsis Bay sediments, in order to assess their levels and sources and to investigate the history of their inputs.

Materials and methods

Surface sediment samples (0-2 cm) were collected from three stations during June 1995 and June 2000. In addition, two sediment cores were collected in December 2001 (Fig. 1). The AHC and PAH were determined by gas chromatography / mass spectrometry [1].

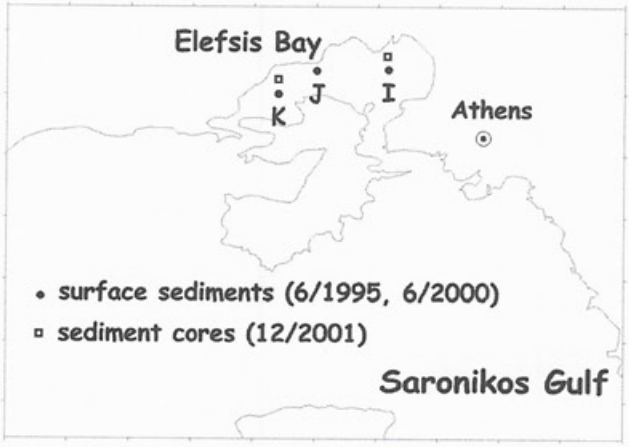


Fig. 1. The sediment sampling locations.

Results and discussion

Surface sediments

The concentrations of aliphatic hydrocarbons (AHC) found in Elefsis Bay sediments during the two sampling periods ranged between 170 and 753 μg/g (Fig. 2). These AHC values clearly indicate that the area suffers from substantial petroleum contamination [2].

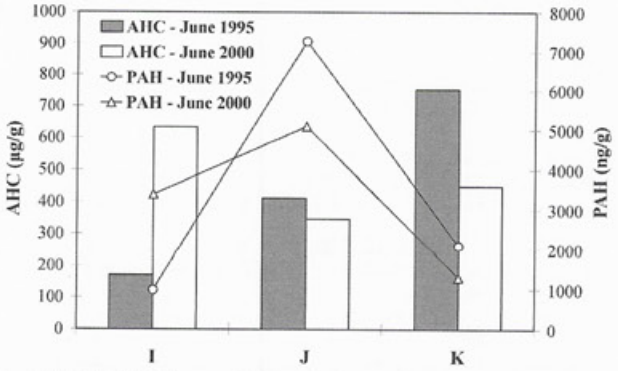


Fig. 2. AHC and PAH concentrations in the surface sediments.

Furthermore, the ratio unresolved/resolved compounds (U/R), which is widely used in order to identify the origin of the hydrocarbons, gave values indicative of significant petroleum contamination (U/R= 17-46).

Twenty-four PAH compounds were determined in this study, comprising parent compounds with two to six aromatic rings, dibenzothiophene, retene and the alkylated products of phenanthrene and dibenzothiophene. Total PAH concentrations in Elefsis Bay sediments ranged between 981 and 7255 ng/g (Fig. 2), indicating a high degree of pollution in comparison with other Greek areas [2]. In the PAH mixture, the compounds with four or more aromatic rings and mainly, fluoranthene and pyrene, were dominant in all cases. These compounds are known to be of pyrolytic origin.

Sediment cores

AHC concentrations in the western core (K core) ranged between 4 and 805 μg/g (Fig. 3). The high AHC values remained almost constant down to 10 cm depth and the maximum value was recorded in the 8-9 cm layer. On the other hand, PAH concentrations ranged from 79 to 3536 ng/g (Fig. 3). The vertical profile of PAH values showed pronounced maxima in the layers 6-7 and 7-8 cm.

In the eastern core (I core), AHC concentrations were observed in the range of 18 – 551 μg/g, while PAH values varied between 44 and 2259 ng/g (Fig. 3). The vertical distribution for both parameters was relatively uniform till to 19 cm depth and the maximum values were recorded in the 2-3 cm layer.

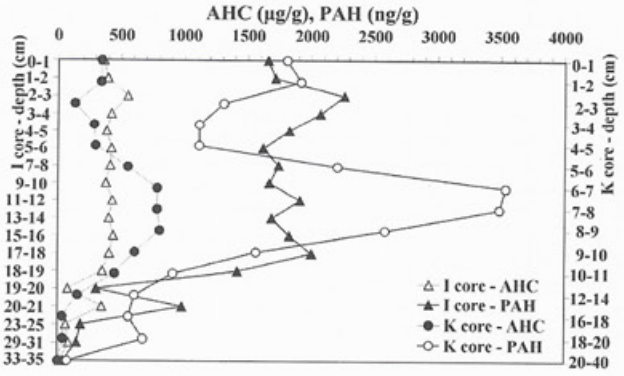


Fig. 3. Vertical profiles of AHC and PAH in the two sediment cores.

References

1 - UNEP/IOC/IAEA, 1992. Determination of petroleum hydrocarbons in sediments. Reference Methods for Marine Pollution Studies, No 20, UNEP

2 - Hatzianestis I., Sklivagou E. and Georgakopoulou E., 2001. Hydrocarbons, pesticides and PCBs in sediments from Thermaikos gulf. *Fres. Environ. Bull.*, 10(1): 63-68.

THE BIOACCUMULATION OF ^{210}PO IN PLANKTON AND ITS POTENTIAL USE AS AN ORGANIC CARBON TRACER AT THE DYFAMED SITE IN THE NORTHWESTERN MEDITERRANEAN

Gillian Stewart [1]*, Nicholas Fisher [1], J. Kirk Cochran [1], Scott Fowler [2], Pere Masqué [3]

[1] Marine Sciences Research Center, Stony Brook University, USA - * gstewart@ic.sunysb.edu, nfisher@notes.cc.sunysb.edu, kcochran@notes.cc.sunysb.edu

[2] IAEA, Marine Environment Laboratory, Monaco - S.Fowler@iaea.org

[3] Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Bellaterra, Spain - Pere.Masque@uab.es

Abstract

The natural radionuclide polonium-210 becomes concentrated in marine biota and may be an excellent tracer for the export of particulate organic matter from the sea surface to depth. Based on laboratory experiments, ^{210}Po's distribution inside plankton is similar to that of protein, and the radionuclide is lost from decomposing marine particles as organic carbon is lost. Preliminary profiles of particulate polonium at the DYFAMED site correspond well to particulate organic carbon (POC) profiles. Results from controlled laboratory uptake, trophic transfer, desorption, and decomposition experiments will be used to interpret field data.

Keywords: Polonium, Bioaccumulation, Organic Carbon Flux, DYFAMED

Polonium-210 (half-life = 138 d), the final alpha-emitting product of the ^{238}U decay series, is produced in seawater from the decay of its grandparent ^{210}Pb. ^{210}Po is found at sub-trace concentrations in seawater (10^{-20} M) and displays a nutrient-like profile with depth, partly as a result of the distribution of ^{210}Pb (1). ^{210}Po becomes highly concentrated in marine organisms and can contribute significantly to human radioactivity exposure through seafood consumption (2). In addition, due to its high particle reactivity, polonium has been used to trace the vertical flux of particulate matter in the ocean (3,4). Unlike thorium-234, which is a well-documented particle surface area tracer (5), ^{210}Po has a high specific affinity for organic matter and protein (3) and may provide more information about the organic carbon content of sinking particles.

In order to understand more about the behavior of this element in the marine environment, we have developed a model for the biological accumulation of ^{210}Po from the dissolved phase in which the surface area and protein content of phytoplankton cells can be used to consistently predict the cellular concentration of polonium:

$$Po_{cell} = [Po_{water}] \{K_{SA} * SA + K_P * P_{cell}\}$$

where Po_{cell} is cellular ^{210}Po, Po_{water} is the ambient concentration of polonium in the water, K_{SA} and K_P are the surface area and protein uptake coefficients, SA is surface area, and P_{cell} is cellular protein (6). Further, the assimilation of polonium by zooplankton grazers directly reflects the partitioning of cellular polonium in the phytoplankton food, as seen in Figure 1, consistent with our findings for other elements (7). In other words, if 30% of cellular ^{210}Po is found in the cytoplasm of a phytoplankton cell, a grazer will effectively assimilate 30% of the polonium in its gut.

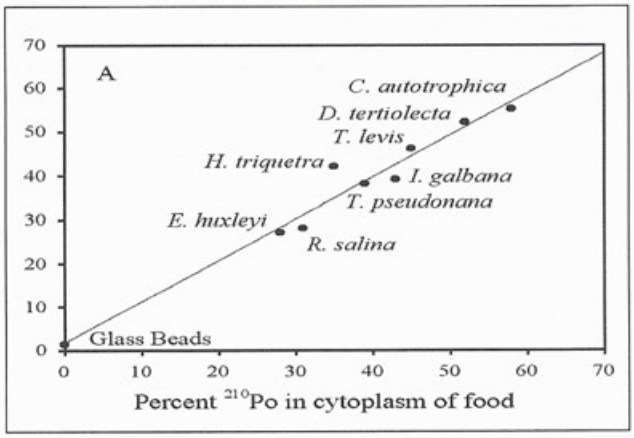


Fig. 1. The assimilation of ^{210}Po by copepods corresponds to the percentage of ^{210}Po in 8 species of phytoplankton food cells and control glass beads. Regression line is not statistically different from 1:1.

These two pieces of information allow us to predict the concentration of polonium in phytoplankton, zooplankton and their fecal pellets, all of which can be a driving force behind sinking flux (8). With the predictable uptake and retention of ^{210}Po, and our knowledge of the loss of polonium with decomposition we may be able to interpret radionuclide field data with more confidence.

Preliminary results from the DYFAMED site indicate that the depth profile of particulate ^{210}Po matches the profile of particulate organic carbon (POC). In contrast, the disequilibrium between ^{238}U and ^{234}Th may be more indicative of total mass flux. This difference may be due to polonium's greater affinity for organic matter and its incorporation into biological material. Thorium, on the other hand, is found primarily bound to the surfaces of cells and organisms (8). This study may be the first time that laboratory results describing ^{210}Po's behavior have been compared to field data. We propose that the use of polonium, along with its grandparent ^{210}Pb and/or ^{234}Th, may answer some of the questions about currently used techniques for the estimation of POC flux (9).

References

1 - Cochran J.K., M.P. Bacon, S. Krishnaswami, and K.K. Turekian, 1983. ^{210}Po and ^{210}Pb distributions in the central and eastern Indian Ocean. *Earth and Planetary Science Letters*, 65: 433-452.

2 - Bulman R.A., L.W. Ewers, and K.Matsumoto, 1995. Investigation of the the potential bioavailability of ^{210}Po in some foodstuffs. *Science of the Total Environment*, 173/174 : 151-158.

3 - Nozaki Y., J. Zhang, and A. Takeda, 1997. 210Pb and 210Po in the equatorial Pacific and the Bering Sea: The effects of biological productivity and boundary scavenging. *Deep Sea Research*, 44: 2203-2220.

4 - Friedrich J. and M.M. Rutgers van der Loeff, 2002. A two tracer (^{210}Po-^{234}Th) approach to distinguish organic carbon and biogenic silica export flux in the Antarctic Circumpolar Current. *Deep Sea Research*, 49: 339-354.

5 - Coale K.H. and K.W. Bruland, 1985. Th-234 – U-238 Disequilibrium within the California Current. *Limnology and Oceanography*, 30(1) 22-33.

6 - Stewart G.M. and N.S. Fisher, 2003a. Experimental Studies on the accumulation of polonium-210 by marine phytoplankton. *Limnology and Oceanography*, 48(3): 1193-1201.

7 - Stewart G.M. and N.S. Fisher, 2003b. Bioaccumulation of polonium-210 in marine copepods. *Limnology and Oceanography*, 48(5): 2011-2019.

8 - Fisher N.S. J.-L. Teyssie, S. Krishnaswami, and M. Baskaran, 1987. Accumulation of Th, Pb, U, and Ra in marine phytoplankton and its geochemical significance. *Limnology and Oceanography*, 32: 131-142.

9 - Cochran J.K. and P. Masque. 2003. Short-lived U-Th series radionuclides in the ocean: Tracers for scavenging rates, export fluxes and particle dynamics. Uranium Series Geochemistry: *Reviews in Minerology and Geochemistry*. 52: 461-492.

^{210}PO AND ^{210}PB CONCENTRATIONS, FLUXES, PARTICLE SETTLING VELOCITIES, AND ORGANIC CARBON AT THE DYFAMED SITE, NORTHWESTERN MEDITERRANEAN

Gillian Stewart [1*], J. Kirk Cochran [1], Pere Masqué [2], Robert Armstrong [1], Juan-Carlos Miquel [3, 4], Alessia Rodriguez, Scott Fowler [3], Michael Peterson [5], Nicholas Fisher [1]

[1] Marine Sciences Research Center, Stony Brook University, USA - * gstewart@ic.sunysb.edu, kcochran@notes.cc.sunysb.edu, nfisher@notes.cc.sunysb.edu rarmstrong@notes.cc.sunysb.edu

[2] Institut de Ciència i Tecnologia Ambientals, Universitat Autònoma de Barcelona, Bellaterra, Spain - Pere.Masque@uab.es

[3] IAEA Marine Environment Laboratory, Monaco - J.C.Miquel@iaea.org, S.Fowler@iaea.org

[4] Dipartimento per lo Studio del Territorio e delle sue Risorse, University of Genoa, Italy and IAEA, Monaco - A.M.Rodriguez@iaea.org

[5] University of Washington, USA - mlpmlp@u.washington.edu

Abstract

Novel settling-velocity sediment traps and an elutriator were employed along with traditional techniques to explore the characteristics of sinking and suspended material at the DYFAMED site. This is the first time that ^{210}Po, ^{210}Pb, and other characteristics have been examined in particulate samples separated by sinking velocity and may further elucidate the composition of particulate flux. Preliminary results suggest that ^{210}Po activities differ among particles sinking at different rates. These measurements will allow us to compare the efficiency of ^{210}Po and ^{234}Th as flux tracers, with an emphasis on the potential usefulness of ^{210}Po as a POC flux tracer.

Keywords: Polonium-210, Lead-210, Flux, Organic Carbon, Thorium

Traditionally, sinking and suspended particles in the ocean have been separated by size fractions using filters and meshes (e.g. 1). Size alone, however, does not determine the rate at which particles sink. Equally important are the composition of the material and its density. In an attempt to establish some relationship between composition and sinking velocity, we collected particles at the DYFAMED site and separated them based solely on their settling rates. The samples were divided using an elutriator and a specially designed sediment trap into six sinking velocity ranges between <10 and >230m per day; each fraction was analyzed for total and organic carbon, ballast minerals, protein, lipids, pigments, and the radionuclides ^{210}Po, ^{210}Pb, and ^{234}Th.

Previously, the ratio of polonium to thorium has been used to decipher the organic and biogenic silica content of particles in the Southern Ocean (2). In the context of MEDFLUX, we are interested in the relationship between organic content, ballast content, and sinking flux. Potentially the amount of ballast, or dense mineral content, in a particle may determine not only the sinking rate, but also the extent to which organic matter is preserved as it is transported to depth (3,4). The preservation of organic carbon by ballast below the mixed layer may successfully sequester carbon for thousands of years, and thus warrants further investigation for the accurate modeling of the global carbon cycle and the biological pump.

Specifically, we are looking for a correlation between the ^{210}Po/^{210}Pb or the ^{210}Po/^{234}Th ratio and the organic content of sinking matter. We predict that the ratio of polonium to lead and/or thorium will reflect the ratio of organic matter to ballast as ^{210}Po is known to associate with labile cellular material (5) and ^{210}Pb and ^{234}Th are linked with more refractory organic material or inorganic substances such as sediment, atmospheric dust, and biogenic minerals (6,7).

Preliminary data suggest that the polonium activity differs in particles with differing sinking velocities (Fig 1). Over 52% of the total polonium flux was found within the fastest sinking particles but, when normalized to mass, the particles sinking between 29 and 58 m/day had the highest ^{210}Po activity. This result indicates that these particles contain either the highest organic content, highest protein content, or concentrate polonium for some other reason. The nature of these particles will be more fully known when the other analyses (total and organic carbon, Al, Ti, Si, etc.) are complete. Results of these investigations as well as the lead and thorium activities will be presented.

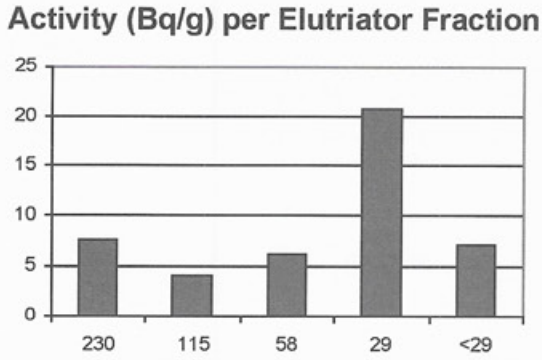


Fig. 1. The preliminary ^{210}Po activity (Bq/g) in each of the elutriator fractions. The numbers below each column represent the minimum settling velocity in meters per day of particles in that fraction. The first column includes particles sinking faster than 230 m/day while the final column includes all particles that sink slower than 29 m/day.

References

1 - Harvey H.R. and J.R. Johnston, 1995. Lipid-composition and flux of sinking and size-fractionated particles in Chesapeake-Bay. *Organic Geochemistry*, 23: 751-764.

2 - Friedrich J. and M.M. Rutgers van der Loeff, 2002. A two tracer (^{210}Po-^{234}Th) approach to distinguish organic carbon and biogenic silica export flux in the Antarctic Circumpolar Current. *Deep Sea Research*, 49: 339-354.

3 - Mayer, L.M., 1994. Surface area control of organic carbon accumulation in continental shelf sediment. *Geochimica Cosmochimica Acta*, 58: 1271-1284.

4 - Armstrong, R.A., C. Lee, J.I. Hedges, S. Honjo, and S. Wakeham, 2002. A new, mechanistic model for organic carbon fluxes in the ocean based on the quantitative association of POC with ballast minerals. *Deep Sea Research*, 49: 219-236.

5 - Stewart G.M. and N.S. Fisher, 2003a. Experimental Studies on the accumulation of polonium-210 by marine phytoplankton. *Limnology and Oceanography*, 48(3): 1193-1201.

6 - Nozaki, Y., F. Dobashi, Y.Kato, Y. Yamamoto, 1998. Distribution of Ra isotopes and the 210Pb and 210Po balance in surface waters of the mid Northern Hemisphere. *Deep Sea Research*, 45: 1263-1284.

7 - Bacon M.P. and R.F. Anderson, 1982. Distribution of thorium isotopes between dissolved and particulate forms in the deep sea. *Journal of Geophysical Research*, 46: 1293-1299.

HEAVY METAL MONITORING IN RED MULLET *MULLUS BARBATUS* (L.1758) FROM IZMIR BAY (EASTERN AEGEAN SEA-TURKIYE) 1999-2001.

Ugur Sunlu

Ege University, Faculty of Fisheries, Dept. of Hydrobiology, 35100 Bornova Izmir, Turkiye - sunlu@sufak.ege.edu.tr

Abstract

Bio-monitoring of heavy metal levels in edible parts of *Mullus barbatus* (L.1758) was conducted in Izmir bay during two years period. Moreover, some physico-chemical parameters, also have been analysed in the same region. The levels of trace elements in edible parts of demersal finfish *M. barbatus* (L.1758), sampled from Izmir bay have ranged between; 0.14-0.55 µg Cd/g wet weight, 0.80-2.60 µg Pb/g w.w., 0.11-0.50 Cu/g w.w., 6.59-11.21 µg Zn/g w.w., 2.12-13.25 µg Fe/g w.w. Generally heavy metal levels are lower than the results in fish tissues reported from Mediterranean regions.

Key words; Bio-monitoring, Heavy metals, Mullus barbatus, Izmir bay.

Introduction

Heavy metals are a major anthropogenic contaminant of estuarine and coastal waters. Their inputs include urban run-off, industrial effluents, mining operations and atmospheric depositions, and may be in particulate or dissolved forms. Although many are essential biological elements, all have the potential to be toxic to organisms above certain threshold concentrations, and for the protection of aquatic biota it is important that these limits not be exceeded in aquatic environments.

Determination of heavy metal levels in marine organisms are usually preferred than the measuring of the metal concentrations in seawater and sediment samples. Metal concentrations in seawater are very low and show wide fluctuations. Marine organisms can be used as monitors to give information on concentrations of heavy metal or changes in metal availabilities in the surrounding environment (1, 3).

Red mullets, being bottom dwellers to a certain extent, are species that tend to concentrate contaminants to a higher degree than other species due to high mobility. For this reason it was recommended by as monitoring species. A number of studies have determined the trace metal concentrations in Izmir Bay and Eastern part of the Aegean Sea (2).

The aim of this study was to determine the trace metal concentrations (Cd, Pb, Zn, Cu, Fe) in edible tissues of the demersal finfish *M. barbatus* caught from Izmir Bay during two years period. Further more the present study, discusses the temporal variations of the heavy metals.

Study Area;

The Bay of Izmir extends about 24 km in the East-West direction and its average width is about 5 km. It is roughly L-shaped. From the standpoint of its topographical and hydrographical characteristics, the Bay consists of three sections: the Inner, Middle and the Outer Bay (Fig. 1).

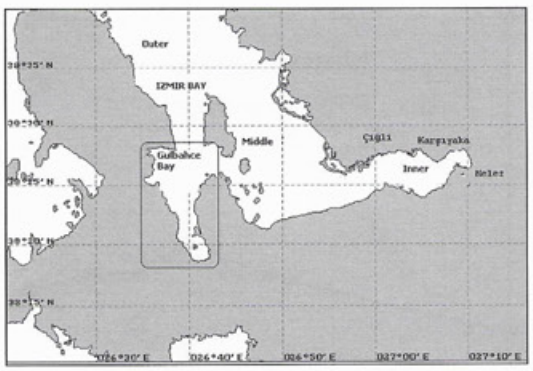


Fig.1. Map of Sampling Area.

Izmir Bay receives pollutants from direct urban effluents, industrial activities and the sewage of 3 million inhabitants of City. For this reason Izmir Municipality decided to construct "Izmir Big Channel" Waste-Water Project in 1969. But unfortunately Water treatment Construction could not be completed until the end of 2002. In 2000-January half of the water treatment plant opened and 65% of the sewage water started to treat until January 2000. At the end of the plant construction in 2002, the pollutant levels of the Inner Bay water decreased slowly and remediation period began (3).

Methodology

During the period November1999-October 2001 *M. barbatus* were caught by trawl from Gulbahce Area which is located in middle part of Izmir Bay (Fig. 1). At the same time some physico-chemical environmental parameters has been measured. Deep sea water temperature has been measured by 0.1°C sensitive thermometer, dissolved oxygen (Winkler method) were measured on board ship whereas salinity was determined with Harvey method and the pH values were measured by pH Electronic Papier Hanna Instrument.

Dorsal muscle of Red mullet were taken from similar size speciemens. Tissues were homogenised with blender; approximately 5-7 g of homogenate was then digested with 5:1 HNO_3:$HClO_4$ under reflux, filtered and diluted with double distilled water. Metal samples were measured by a PYE Unicam SP-9 AAS. Metal values were determined by direct aspiration using air-acetylene flame. Intercalibration fish muscle homogenate samples (IAEA-142/TM) were used as a quality control sample (4).

Results and discussion

The variability in metal concentrations of marine finfish depends on many factors, either environmental (metal concentrations in sea water, temperature, salinity, dissolved oxygen, pH, etc.) or purely biological (species, tissues, organs, feeding conditions, etc.).

Minimum, maximum and average values of some physico-chemical environmental parameters which are related to trace metal accumulation in deep waters of Gulbahce area were changed in; 11.0-26.4, 19.8° C for temperature, 33.76-39.21, 36.58 for psu, 7.15-8.20, 7.60 for pH and 5.20-8.50, 7.40 mg/l for dissolved oxygen.

The levels of trace elements in edible parts of demersal finfish *M. barbatus* (L.1758), sampled from Izmir bay have ranged between; 0.14-0.55, 0.19 µg Cd/g wet weight, 0.80-2.60,1.40 µg Pb/g wet weight, 0.11-0.50, 0.27 µg Cu/g wet weight, 6.59-11.21, 7.60 µg Zn/g wet weight, 2.12-13.25, 8.05 µg Fe/g wet weight .

Conclusions

In conclusion, we have carried out analyses on the levels of trace metals in the muscle tissues of *M. barbatus* from middle part of Izmir Bay. Lead concentrations are similar to those reported in fish from Mediterranean countries. Cadmium, iron, zinc and copper levels are lower than the results in fish tissues reported from Mediterranean regions. Some generalizations can be inferred from the mean trace metal levels in fish. The order of the metal concentrations found in *M. barbatus* was **Fe>Zn>Pb>Cu>Cd**.

Generally, the Inner Bay which is a shallow water body having a limited water exchange with the Outer bay and the open sea. According to metal results, a dominant source of metal contamination from urban and industrial activities and less important inputs from continental and agricultural orgins. Metal concentrations distribution in biota indicate higher levels in inner parts of Izmir Bay. Pollution of the Inner Bay is effected on biodiversity very negatively. Only indicator marine organisms can live in inner part of Izmir bay for recent years.

The Middle Bay is a transition zone, and with such characteristics it must be monitored very carefully in the future phases of the monitoring programme. This area relatively far from anthropogenic sources so that these site was affected very little by chemical contamination.

References

1 - Brown, M.T., Depledge, M.H., 1998. Determinants of trace metal concentrations in marine organisms. In: Langston & Bebianno (eds.), Metal Metabolism in Aquatic Environments. Chapman & Hall.

2 - UNEP, 1996. The state of the marine & coastal environment in the Mediterranean Region. MAP Technical Reports No100, 142 p.

3 - Sunlu, U, Egemen, Ö, Basaran, A. 2001. The Red Mullet *Mullus barbatus* (L.1758) as an indicator for heavy metal pollution in Izmir Bay (Turkiye). *Rapp. Comm. Int. Mer Médit.*, 36:166.

4 - Bernhard, M., 1976. Manual of methods in aquatic environment research. *FAO Fisheries Technical Paper* No158 FIRI/T 158.

THE IMPACT OF THE 1999 SPRING BLOOMS ON CARBOHYDRATE LEVELS IN THE NORTHERN ADRIATIC

Natasa Tepic *, Senka Terzic and Marijan Ahel

Center for Marine and Environmental Research, Rudjer Boskovic Institute, 10000 Zagreb, Croatia - *tepic@irb.hr

Abstract

Dissolved (DTCHO) and particulate (PTCHO) carbohydrates were measured in the Northern Adriatic in the period from February to June 1999 in order to determine their relationship with the phytoplankton dynamics during typical spring blooms. A concurrent correlation of PTCHO with fucoxanthin and chlorophyllide *a* indicated that senscent diatom blooms were an important source of carbohydrates in the basin. The maximum concentration of DTCHO was observed in May, suggesting a gradual transition of PTCHO into DTCHO after the diatom bloom.

Key words: carbohydrates, organic matter, Adriatic Sea, phytoplankton bloom

Introduction

During the last two decades organic macroaggregates in the northern Adriatic seemed to occur more often than in the past [1]. Carbohydrates represent the major constituents of the northern Adriatic mucilage. Consequently, to understand the mucilage phenomenon, it is necessary elucidate seasonal and spatial patterns of carbohydrates. Several studies were reported addressing the distribution of carbohydrates in the northern Adriatic [2-3], but only one [4] provided some insight into the seasonal variability of PTCHO and DTCHO over the entire annual cycle and indicated the possible impact of major phytoplankton blooms on the carbohydrate levels.

Methods

Study area and sampling: Samples were collected in the central part of the northern Adriatic at several stations along the transect Po River mouth – Rovinj.

Determination of carbohydrates: Dissolved and particulate carbohydrates were determined by MBTH method [5], which was modified by including a hydrolysis step with 1.7 M HCl.

Results and discussion

The hydrological regime of the Po River during 1999 was rather regular with two characteristic maxima in spring and autumn. As a consequence of spring freshets, two major phytoplankton blooms occured in April and June (Fig. 1A). Both blooms were confined to the surface layer, while the concentration in the bottom layer remained low. The bloom in April was strongly dominated by diatoms (fucoxanthin, Fig. 1B), whereas the bloom in June was rather mixed with predominance of primnesiophytes. A significantly enhanced concentration of chlorophyllide *a* during the diatom bloom (Fig. 1B) indicated that this bloom was in the senescent phase. In contrast, the pheopigment levels in June were relatively low. The temporal distribution of PTCHO (Fig. 1C) was closely related to the described phytoplankton dynamics, showing maximum during the April bloom. Despite the fact that the concentration of phytoplankton biomass in June was very similar to that in April, the concentration of PTCHO was several times lower. This suggested that senescent diatoms should be regarded as an important source of carbohydrates. The temporal distribution of DTCHO shows a different pattern from PTCHO (Fig. 1C). The maximum of DTCHO ocurred in May (596 mg C/L), indicating a gradual transition of PTCHO into DTCHO after the diatom bloom.

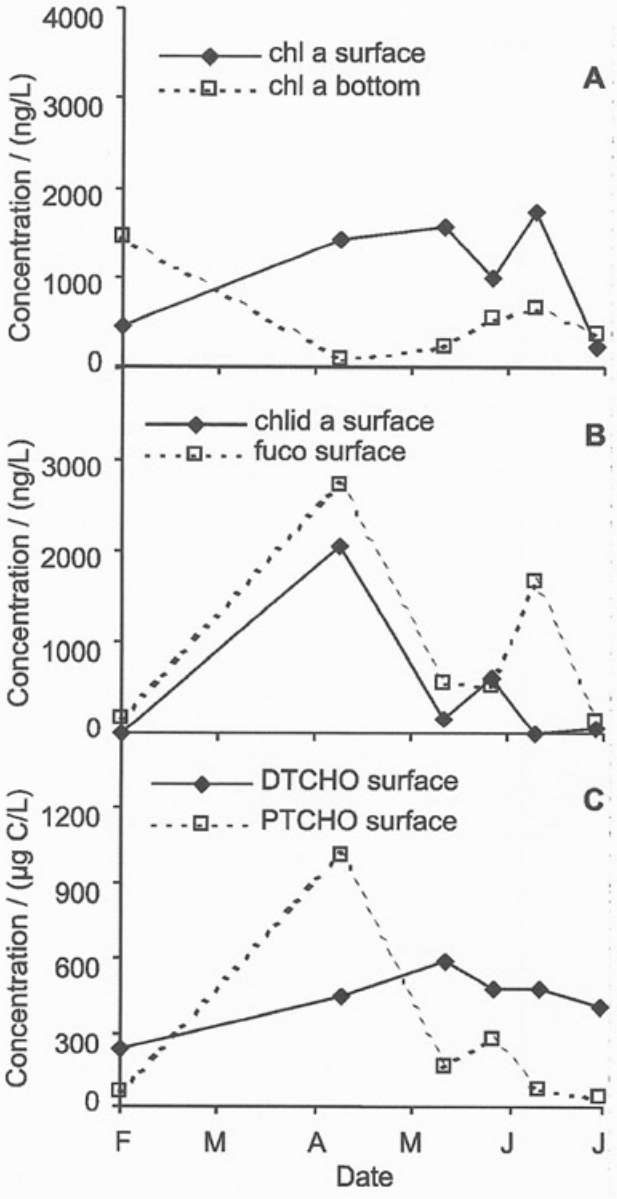


Fig. 1. Temporal distribution of (A) chlorophyll *a* (chl *a*), (B) fucoxanthin (fuco) and chlorophyllide *a* (chlid *a*) and (C) particulate (PTCHO) and dissolved (DTCHO) carbohydrates in the surface (0 m) and bottom (30 m) layers of the station SJ108 during the period February-July 1999.

References

1 - D. Degobbis, S. Fonda-Umani, P. Franco, A. Malej, R. Precali and N. Smodlaka, 1995. Changes in the Northern Adriatic ecosystem and the hypertrophic appearance of gelatinous aggregates. *Sci. Total Environ.*, 165: 43-58.

2 - M. Pettine, L. Patrolecco, M. Manganelli, S. Capri and M. G. Farrace, 1999. Seasonal variations of dissolved organic matter in the Northern Adriatic Sea. *Mar. Chem.*, 64: 153-169.

3 - N. Tepic, S. Terzic and M. Ahel, 2000. Distribution of dissolved and particulate carbohydrates in the Northern Adriatic during the 1997 mucilage event. *Period. Biol.*, 102: 179-187.

4 - N. Tepic, S. Terzic, N. Muhin and M. Ahel, 2001. Seasonal variability of particulate and dissolved carbohydrates in the Northern Adriatic. *Rapp. Comm. int. Mer Médit.*, Monaco, 36: 167.

5 - K.M. Johnson and J.M. Sieburth, 1977. Dissolved carbohydrates in seawater. Part I. A precise spectrophotometric method for monosaccharides. *Mar. Chem.*, 5: 1-13.

DISTRIBUTION OF CHLOROPHYLL *a* AND PHEOPIGMENTS IN THE NORTHERN ADRIATIC

Senka Terzic, Iva Mikac*, Milos-Sasa Grubesic and Marijan Ahel
Center for Marine and Environmental Research, Rudjer Boskovic Institute, 10000 Zagreb, Croatia

Abstract
Chlorophyll *a* (chl *a*) and its breakdown products were determined in the northern Adriatic over the whole annual cycle of 2000 using reverse-phase high-performance liquid chromatography (HPLC). Distribution of chl *a* was characterised by a typical seasonal pattern with pronounced maxima in spring and autumn, coinciding with phytoplankton blooms that developed in the surface layer after the major freshwater inputs by the North Italian rivers. The composition of pheopigments as well as their percentage in the total concentration of chlorophyll *a* strongly varied, depending on the season and location. The highest levels were observed during major diatom blooms.

Key words: chlorophyll a, phytoplankton, pheopigments, northern Adriatic

Introduction

The northern Adriatic receives large amounts of freshwater from the North Italian rivers and represents one of the most eutrophic areas of the Mediterranean Sea. Numerous investigations have been carried out in order to assess the eutrophication and related phenomena in this basin [1]. The impact of the Po River discharges on the phytoplankton dynamics in the northern Adriatic is well documented, but, until recently, a very limited number of reports have been published on the spatial and seasonal distribution of photosynthetic pigments and their break-down products [2].

Methods

Study area and sampling

Samples were collected at several stations in the central part of the Northern Adriatic along a transect extending from the city of Rovinj to the mouth of the Po River. Sampling was performed in approximately monthly intervals, from January to December 2000.

Analysis

Chlorophyll a and its breakdown products, including chlorophyllide, pheophorbide, pyropheophorbide and 2 pheophytins, were determined using a HPLC-method with serially coupled UV and fluorescence detection [3].

Results and discussion

The seasonal distribution of chl *a* in the northern Adriatic during 2000 (Fig. 1A) showed some typical features, which are characteristic for this basin. The maxima observed in the surface layer (0-5 m) were strongly correlated with the freshwater pulses of the Po River, while chl *a* levels in the bottom layer were less variable and can be linked mainly to regeneration processes. The decoupling between the two layers was more pronounced in the western part of the basin (station SJ108), while in the eastern part (RV001) the surface peak of chl *a* is often missing (Fig. 1B). The ratio between chl *a* and pheopigments is highly variable. The most abundant breakdown product of chl *a* was chlorophyllide *a*, followed by pheophorbides and pheophytins. This indicated enzymatic cleavage as the key mechanism of chlorophyll *a* degradation. The concentration of those pheopigments, which were suggested to be indicators of grazing, such as pyropheophorbide *a*, was relatively low. Spatial distribution of pheopigments revealed an increase of their absolute concentrations as well as their relative contributions to the total chl *a* in the western part of the basin (Fig. 1C), especially during diatom blooms in February and October.

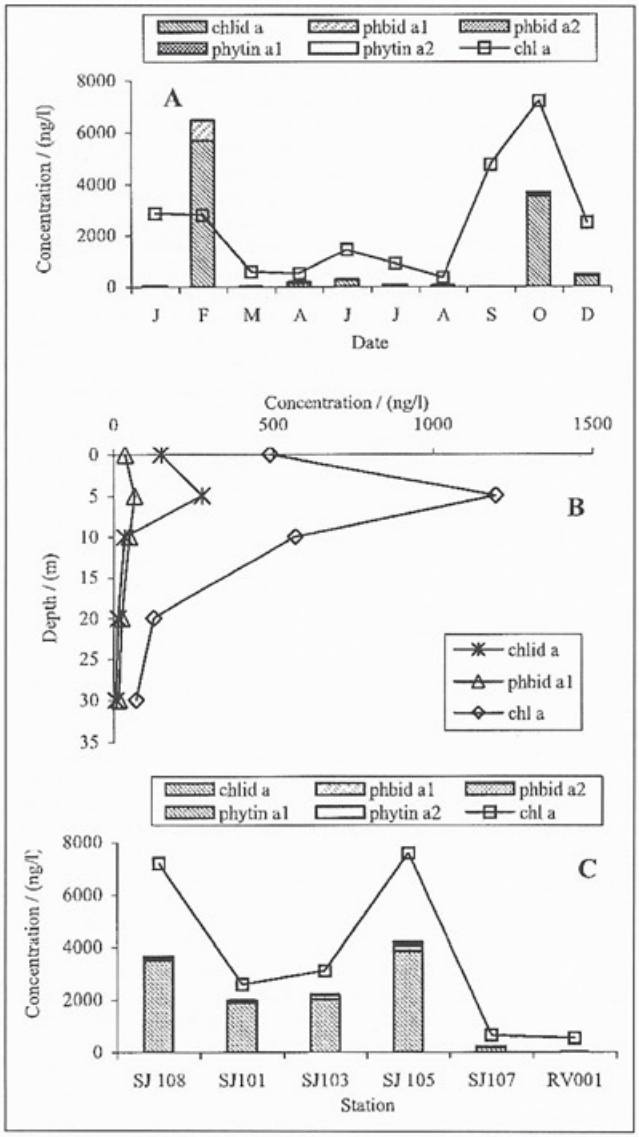


Fig. 1. Distribution of chlorophyll *a* (chl a) and selected pheopigments in the northern Adriatic: (A) seasonal distribution in the surface layer of the western part of the basin (station SJ108), (B) vertical distribution in the water column at the station SJ108 and (C) spatial distribution along the transect Po River mouth – Rovinj (October 2000); chlid = chlorophyllide *a*, phbid = pheophorbide *a*, phytin = pheophytin *a*.

References

1 - D. Degobbis, R. Precali, I. Ivancic, N. Smodlaka, D. Fuks and S. Kveder, 2000. Long-term changes in the Northern Adriatic ecosystem related to anthropogenic eutrophication. *Int. J. Environ. Pollut.*, 13: 495-533.

2 - M. Ahel and S. Terzic, 1998. Pigment signatures of phytoplankton dynamics in the northern Adriatic. *Croat. Chem. Acta*, 71: 199-215.

3 - R.F.C. Mantoura and C.A. Llewellyn, 1983. The rapid determination of algal chlorophyll and carotenoid pigments and their breakdown products in natural waters by reverse-phase high-performance liquid chromatography. *Anal. Chim. Acta*, 151: 297-314.

HEAVY METAL AND RADIOACTIVITY IN BIOTA AND SEDIMENT SAMPLES COLLECTED FROM ÜNYE IN THE EASTERN BLACK SEA

Sayhan Topcuoglu*, Emine Ölmez, Çiğdem Kırbasoğlu, Y. Ziya Yılmaz, Neslihan Saygın
Çekmece Nuclear Research and Training Center, Istanbul, Turkey- stopcuoglu@superonline.com

Abstract

The heavy metal (Cd, Co, Cr, Cu, Ni, Pb, Zn, Fe and Mn) and radionuclide (^{137}Cs, ^{238}U, ^{232}Th, and ^{40}K) concentrations were determined in macroalgae, mussel, sea snail, fish and sediment samples collected from Ünye region at the eastern Turkish coast of the Black Sea. In general, as regards the influence of the collection site on the whole metal accumulation, Ünye is considered to be more polluted than other region of the Black Sea. The measured radionuclide concentrations are within the range of the values cited in previous work concerning the Turkish Black Sea coast.

Key-words: radioactivity, heavy metal, Black Sea

Introduction

The coastal area of Ünye in the eastern Black Sea is nearly 35 km long. The famous beaches of the Black Sea were located in this area. Since 2000, nutrients exceeded the algae requirements that caused eutrophication. In this area, insufficiently treated sewage, municipal waste combustion and agricultural runoffs are the main sources of the chemical pollution. At the same time, a fertilizer plant and a coper smelter located 50 km west of Ünye. Several papers have been published concerning heavy metal levels in biota and sediment samples of Turkish Black Sea coast (1-4). It is well known that many anthropogenic radionuclides entered into the Black Sea after Chernobyl accident. Nowadays, the anthropogenic radionuclide in the Black Sea marine environment originated from rivers of the Chernobyl contaminated regions and from nuclear power plants in countries around the Black Sea. Of late, the study of natural radionuclides in the Black Sea has received increasing attention. Some papers have been published concerning anthropogenic and natural radionuclides in biota and sediment samples collected from Turkish Black Sea coast (3,5-6). However, no data on the heavy metal and radioactivity levels of biota and sediment samples in Ünye area have been published. The objectives of this study are to examine the concentrations of selected heavy metals (Cd, Co, Cr, Cu, Ni, Pb, Zn, Fe and Mn) and ^{137}Cs, ^{238}U, ^{232}Th and ^{40}K radionuclides in biota and sediment samples collected from Ünye coastal area in 2001.

Materials and methods

The macroalgae species (*Cystoseira barbata, Ulva lactuca*) were harvested from the sea at low tide. The algae samples were washed in seawater at the sampling station and transfered to the laboratory. In the laboratory, they were rinsed in sea water to remove contaminating materials. Lastly, algae were rinsed in distilled water. Then they were dried at 85 °C to constant weight and homogenized. The mussel (*Mytillus galloprovincialis, Venus gallina*) and sea snail (*Rapan venosa*) and fish (*Trahurus trahurus, Sarda sarda, Psetta ssp.*) samples were stored on ice in an insulated box and transferred to the laboratory. Prior to metal analysis, all the soft part and muscle tissue for each sea snail and all the soft part of each mussel was dissected. The muscle samples of the fish were prepared from the tail part of the fish. The samples were pooled and freeze-dried for 10 days to a constant weight. About 4 cm of the top of sediment samples collected within the same 3-5 m reach at each sampling site using a Lenz Bottom Sampler. The collected sediment was sieved in the field and the <63 and <500 µm size fractions were kept for heavy metals anaysis.The heavy metal concentrations were determined by atomic absorption spectrophotometer (Varian, Model Spectra AA 100/200). The collected sediments were sieved and the <500 µm size fraction was kept for radionuclide analysis. The gamma isotopic analyses were carried out using a Canberra S-45 4K MCA spectrometer. Other procedures of the two methods were similar to that previously described (3,6).

Results and discussion

The range of the heavy metal concentrations in biota and sediment samples are shown in Table 1. In present study, Cu in macroalgae, Pb in mussel and Zn in sea snail samples are higher than were found in the same species collected from the other coastal parts of the Black Sea. At the same time,Co, Cr, Cu, Ni, Pb, Fe and Mn concentrations in the sediment samples at the present study were higher than other areas of the Turkish Black Sea coast (3). The radionuclide levels in the tested biota and sediment samples are shown in Table 2. The ^{137}Cs concentrations in the biota samples were found to be below the lower limit of detection. The ^{137}Cs and natural radionuclide concentrations in the sediment samples are lower when compared with the result of the other parts of the eastern Black Sea (6).

Table 1. The range of the heavy metal concentrations in biota and sediment samples (µg g^{-1} dry weight).

Metal	Algae	Mussel	Sea snail	Fish	Sediment
Cd	0.8-2.7	2.5-5.8	0.5-12.3	<0.02	<0.02
Co	<0.5	3.0-3.2	<0.5	<0.05	22.5-86.2
Cr	1.1-2.4	4.1-4.7	<0.06-1.8	<0.06	39-245
Cu	19.-26	12-29	67-70	4-6	47-111
Ni	4.2-6.7	4.9-7.8	<0.1	<0.1	36.5-79.2
Pb	<0.1	4.5-7.9	3.5-6.7	<0.1	<0.1-52.9
Zn	76-350	98-255	53-147	21-34	68-148
Fe%	0.1-0.2	01-04	0.1-0.2	0.03	4.2-29.6
Mn	30-80	63-65	7-14	2-3	907-2830

Table 2. Radionuclide concentrations in biota and sediment samples (Bq kg^{-1} dry weight).

	^{137}Cs	^{238}U	^{232}Th	^{40}K
Macroalgae	<3	<13	<7	543±297
Mussel	<3	<13	<7	<170
Sea snail	<3	<13	<7	<170
Turbot	<3	<13	<7	655±353
Bonito	<3	<13	<7	280±162
Sediment-1	22±7	39±21	47±16	686±128
Sediment-2	17±7	56±17	39±14	530±118
Sediment-3	9±6	33±13	35±13	599±100

References

1 - Topcuoğlu, S., Güven, K.C., Kırbaşoğlu, Ç., Ünlü, S., Yılmaz, Y.Z., 2001. Heavy metals in Marine Algae from Şile in the Black Sea. *Bull. Environ. Contam. Toxicol.*, 67:288-294.

2 - Topcuoğlu, S., Kırbaşoğlu, Ç., Güngör, N., 2002. Heavy metals in organisms and sediments from Turkish Coast of the Black Sea, 1997-1998. *Environ. Int.*, 27:521-526.

3 - Topcuoğlu, S., Ergül, H.A., Baysal, A., Ölmez, E., Kut, D., 2003. Determination of radionuclide and heavy metal concentrations in biota and sediment samples from Pazar and Rize stations in the eastern Black Sea. *Fresenius Environ. Bull.*, 12 (7):695-699.

4 - Topcuoğlu, S., Güven, K.C., Balkıs, S., Kırbaşoğlu, Ç., 2003. Heavy metal monitoring marine algae from the Turkish Coast of the Black Sea, 1998-2000. *Chemosphere*, 52:1683-1688.

5 - Topcuoğlu, S., 2000. Black Sea Ecology, Pollution research in Turkey of the marine environment. *IAEA Bull*, .42 (4): 12-14.

6 - Topcuoğlu, S., Kut, D., Esen, N., Güngör, N., Ölmez (Eğilli), E., Kırbaşoğlu, Ç., 2001. ^{137}Cs in biota and sediment samples from Turkish coast of the Black Sea, 1997-1998. *J. Radioanal. Nucl. Chem,*. 250 (2): 381-384.

METAL CYCLING THROUGH PLANKTON COMMUNITIES: A SINGLE-CELL APPROACH USING SYNCHROTRON-BASED X-RAY FLUORESCENCE

Benjamin S. Twining†, Stephen B. Baines, and Nicholas S. Fisher*

Marine Sciences Research Center, State University of New York, Stony Brook, NY 11794-5000 USA - * nfisher@notes.cc.sunysb.edu
†Present address: Yale School of Forestry and Environmental Studies,
Environmental Science Center, PO Box 208105, New Haven, CT 06520

Abstract

We have applied a synchrotron-based x-ray fluorescence microprobe to analyze the concentrations and cytological distributions of trace elements in autotrophic and heterotrophic protists from remote waters. Using this approach it is now possible to discern different elemental stoichiometries exhibited by different types of co-occurring protists. This technique, combined with other geochemical measurements, should enable important new advances in our understanding of the marine biogeochemistry of trace elements.

Keywords: x-ray fluorescence, microprobe, microbial loop, trace metals

Introduction

The elemental composition of marine protists is of great interest to oceanographers. The elemental stoichiometries of plankton simultaneously reflect the nutrient ratios of the aquatic environment and control the input of recycled elements through remineralization of plankton (1). While most attention has been focused on the C, N, and P content of plankton, several early studies determined the trace metal composition of plankton as well (2, 3). More recent evidence that trace metal nutrients such as iron can limit primary production in both open-ocean and coastal environments (4, 5) has spurred researchers to further study the trace metal contents of plankton.

Bioactive trace metals such as Mn, Fe, Co, Ni, Cu, and Zn are typically measured in plankton by first concentrating cells onto filter membranes and then digesting the filters and analyzing the resulting solution with atomic absorption spectrometry or inductively-coupled plasma mass spectrometry. This approach requires concentrating large amounts of similarly sized cellular and abiotic material on membranes of various pore-size. Thus co-occurring plankton with overlapping size ranges cannot be separated, and the potentially contaminating influence of suspended abiotic particles cannot be eliminated.

We have developed a new approach to the analysis of trace elements in marine protists that utilizes the unique sensitivity of synchrotron x-ray radiation to measure trace metals in individual nanoplankton cells. Further, the synchrotron x-ray fluorescence (SXRF) technique produces a two-dimensional map of the metals in each cell, providing additional information on the co-localization of elements. Here we present an example of the information that can be collected using this technique for cells collected from the Southern Ocean during a recent mesoscale iron enrichment experiment (SOFeX).

Materials and methods

Complete descriptions of the sample preparation and analysis protocols are presented elsewhere (6). Briefly, cells were collected with trace-metal 'clean' techniques from the Southern Ocean, before and after Fe fertilization, and immediately centrifuged onto gold electron microscopy grids following fixation with Chelexed glutaraldehyde. The mounted cells were briefly rinsed with Milli-Q deionized water and then dried in a Class 100 laminar flow hood. Light and epifluorescence micrographs of the dried cells were taken on-board the ship, and the cells stored in a plastic dessicator until analysis. SXRF analyses were performed at the 2-ID-E beamline of the Advanced Photon Source, Argonne National Laboratory, Argonne, IL. Each cell was raster scanned across a highly focused x-ray spot, and the excited x-ray fluorescence spectra were recorded at each pixel with a 3-element germanium detector. Spectra were averaged over the cell, corrected for fluorescence from nearby background regions, and the peak areas modeled. Peak areas were converted to element concentration with NIST thin-film standards. Trace element contents were normalized to cellular P, which was measured directly with SXRF.

Results and discussion

SXRF enables the identification of different trace metal compositions of co-occurring protists cells. Table 1 presents an example of SXRF data collected from the Southern Ocean, which are compared to data from bulk analyses of collected plankton from other waters. There are notable differences in the metal contents of diatoms and flagellated cells that cannot be detected with bulk analyses. Flagellated cells were significantly more enriched in P and diatoms more enriched in Mn, Ni, and Zn. Iron fertilization resulted in sharp increases in cellular concentrations of Mn, Ni, and Zn and smaller increases in P. Generally, P, Fe, and Zn were found distributed within cells and Si in the frustules of diatoms. Adsorbed Fe, localized in high concentrations attached to some cells in a way that doesn't correspond to any cellular feature, can be identified and removed from the elemental analysis with SXRF. Explanations for varying elemental stoichiometries in different co-occurring taxa remain to be discovered. Stoichiometric variations among different taxa suggest that the concept of a constant Redfield-type elemental ratio may not extend to trace metals. Application of SXRF analyses to protists in other waters, such as P-limited waters of the eastern Mediterranean, may reveal different stoichiometric relationships and may help explain the distribution of plankton in those waters.

Table 1. Elemental composition (ratios normalized to cellular P, mmol mol^{-1}) of natural plankton assemblages as measured with bulk analysis and SXRF.

	Martin & Knauer (2)	Collier & Edmond (3)	Cullen et al. (10)	This study					
				Low Fe			*High Fe*		
				Diatom	A flag	H flag	Diatom	A flag	H flag
Elements normalized to P									
Mn	0.39	0.34	1.7	0.42	0.16	0.14	0.28	0.22	0.17
Fe	5.2	4.6	--	0.71	0.54	0.63	1.9	1.9	0.94
Ni	0.21	0.86	--	1.2	0.16	0.22	0.73	0.21	0.20
Zn	0.84	3.0	11.1	8.1	1.4	2.1	6.2	1.8	2.6

Shown are geometric mean stoichiometries for three cell types (diatoms, autotrophic flagellated cells—A flag, heterotrophic flagellated cells—H flag) collected from either low Fe (unenriched) or high Fe (enriched) stations. The Martin and Knauer (2) and Collier and Edmond (3) data are shown as selected by Bruland *et al.* (7). The SXRF Fe data are from Twining *et al.* (8, 9).

References

1 - Redfield A.C., Ketchum B.H. and Richards F.A., 1963. The influence of organisms on the composition of seawater. Pp. 26-77. *In:* M. N. Hill (ed.), Comparative and Descriptive Oceanography. Wiley, New York.

2 - Martin J.H. and Knauer G.A., 1973. The elemental composition of plankton. *Geochim. Cosmochim. Acta*, 37: 1639-1653.

3. Collier R. and Edmond J., 1984. The trace-element geochemistry of marine biogenic particulate matter. *Prog. Oceanogr.*, 13: 113-199.

4 - Martin J.H., Gordon R.M. and Fitzwater S.E., 1991. The case for iron. *Limnol. Oceanogr.*, 36: 1793-1802.

5 - Hutchins D.A. and Bruland K.W., 1998. Iron-limited diatom growth and Si:N uptake ratios in a coastal upwelling regime. *Nature*, 393: 561-564.

6 - Twining B.S., Baines S.B., Fisher N.S., Maser J., Vogt S., Jacobsen C., Tovar-Sanchez A. and Sanudo-Wilhelmy S.A., 2003. Quantifying trace elements in individual aquatic protist cells with a synchrotron x-ray fluorescence microprobe. *Anal. Chem.*, 75: 3806-3816.

7 - Bruland K.W., Donat J.R. and Hutchins D.A., 1991. Interactive influences of bioactive trace-metals on biological production in oceanic waters. *Limnol. Oceanogr.*, 36: 1555-1577.

8 - Twining B.S., Baines S.B. and Fisher N.S., 2004. Trace element composition of individual plankton cells collected during the Southern Ocean Iron Experiment (SOFeX). *Limnol. Oceanogr.*, Submitted.

9 - Twining B.S., Baines S.B., Fisher N.S. and Landry M.R., 2004. Cellular iron contents of plankton during the Southern Ocean Iron Experiment (SOFeX). *Deep-Sea Res. I*, Submitted.

10 - Cullen J.T., Chase Z., Coale K.H., Fitzwater S.E. and Sherrell R.M., 2003. Effect of iron limitation on the cadmium to phosphorus ratio of natural phytoplankton assemblages from the Southern Ocean. *Limnol. Oceanogr.*, 48: 1079-1087.

DISTRIBUTION PATTERN OF TRACE METAL CONCENTRATIONS, CONTROLLED BY MULTI-SOURCE FACTORS: NORTH AEGEAN SEA (EASTERN MEDITERRANEAN).

F. Voutsinou-Taliadouri * and C. Zeri

Hellenic Centre for Marine Research, Institute of Oceanography, P.O. Box 712, 19013 Anavyssos, Hellas - *fvouts@ncmr.gr

Abstract

Dissolved Cd, Cu, Ni and Mn were measured in North Aegean seawater in order to evaluate the influences controlling their concentrations. The study area is subjected to certain factors both natural and anthropogenic: Black Sea- Levantine water outflows, river- atmospheric inputs, trawling activities, resuspension processes, etc. In general, the increased fresh and brackish water inputs in the North Aegean plateaus result in elevated trace metal levels in the surface layer, while the bottom nepheloid layer depicts a clear trend of increased concentrations in the Thermaikos Gulf.

Keywords Trace metals (Cd, Cu, Ni, Mn), freshwater inputs, sediment resuspension, Aegean Sea, Eastern Mediterranean

Introduction

The present work is a summary of recently collected data concerning trace metal concentrations in seawater within the framework of E.U. Projects: MATER, INTERREG and INTERPOL. The study area includes the North Aegean plateaus and deep basins from the Dardanelles Straits to the east to the Sporades basin to the west as well as the Thermaikos Gulf to the northwest. Water depths reach 1550 m in the basins whereas on the plateaus never exceed 200 m and especially in the Thermaikos shelf area do not exceed 100 m. The shelf area receives freshwater inputs from many rivers (Evros, Nestos, Strymon, Axios, Aliakmon, Penios, Loudias) draining the Balkan Peninsula with estimated annual water discharge 11 km^3 yr^{-1}. Also, it receives surface brackish Black Sea waters outflowing from the Dardanelles Straits varying from 100 to 1200 km^3yr^{-1}. Moreover it is known that the shelf area is subjected to increased trawling activities, which result in sediment resuspension.

The aim of this work is to compile previous works in the area and summarize briefly the most important input sources and processes, which affect dissolved trace metal distribution in the Thermaikos Gulf-North Aegean Sea system.

Methods

The data under consideration have been produced within the framework of three European research programmes, namely MATER-MTP II, INTERREG and INTERPOL, conducted in the area from 1997 to 2004. A total of 600 seawater samples have been collected during 9 cruises and were analysed for dissolved Cd, Cu, Ni and Mn. Detailed description of sampling and analytical protocols is given elsewhere (1).

Results

The mean concentrations of the metals measured in the different water layers during all seasons are presented in Table I.

		Cd (nM)	Mn (nM)	Ni (nM)	Cu (nM)
	Depth layers				
Thermaikos Gulf	0-20 m (n=109)	0.089	23.68	5.60	2.14
	20-70 m (n=64)	0.094	51.92	5.99	2.31
N. Aegean Plateaus & basins.	0-50 m (n= 100)	0.110	9.50	8.66	3.34
	50 – 450 m (n= 156)	0.089	3.26	5.66	2.26
	450 – 1200 m (n= 146)	0.093	1.13	5.43	2.04

It has been well documented (1) that in the North Aegean inflowing low salinity waters carrying increased amounts of trace metals mix with high salinity low metal content intermediate waters of Levantine origin and result in trace metal enrichments in the surface open waters. This is particularly true for Cu, Ni and Mn as it is shown from the near-linear relationship with salinity. (Fig. 1).

The specific topography of the area, e.g. coexistence of extensive shelf-slope areas and deep basins favours sediment transport from rivers and the coastal zone towards the deeper parts of the system. The presence of benthic nepheloid layer (BNL) in the Thermaikos Gulf and over the outer shelf and shelf break has been reported by many authors (2,3). Especially in the Thermaikos Gulf the presence of a BNL is a constant feature. Increases in dissolved trace metal concentrations have been observed occasionally near the sea -bed along the slope or in the deep basins. Moreover, in the Thermaikos Gulf dissolved trace metal concentrations and especially Mn are constantly elevated in the BNL layer, and near the river mouths, a feature clearly depicted in North – South transect of the Thermaikos gulf (Fig. 2).

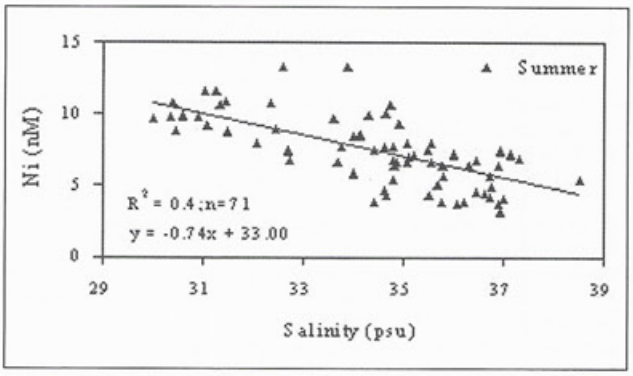


Fig. 1. Salinity vs Ni in the North Aegean.

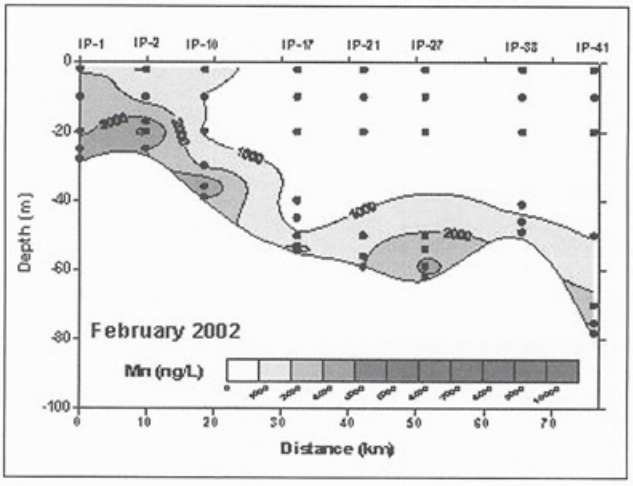


Fig. 2. Dissolved Mn distribution in the Thermaikos Gulf north-south transect.

References

(1) - Zeri C., F. Voutsinou-Taliadouri, 2003. Processes affecting the distribution of dissolved trace metals in the North Aegean Sea (Eastern Mediterranean), *Continental Shelf Research*, 23: 919-934.

(2) - Karageorgis, A., Anagnostou Ch., 2001. Particulate matter spatial-temporal distribution and associated surface sediment properties: Thermaikos Gulf and Sporades Basin, NW Aegean Sea. *Cont. Shelf Res.*, 21: 2141-2153.

(3) - Lykoussis, V., Collins, M.B., Ferentinos, G., 1981. Modern sedimentation in the NW Aegean Sea, Greece. *Mar. Geol.*, 43: 111-130.

PRESENT WATER QUALITY OF KASTELA BAY (ADRIATIC SEA) AND SOME PROPOSALS FOR ITS PROTECTION AND IMPROVEMENT

Ilija Vukadin * and Lambe Stojanoski
Intitute of Oceanography and Fisheries (IOF)- Split, Croatia - * Vukadin@izor.hr

Abstract

The research of the physical-chemical properties of the Kastela Bay waters carried up to now (1952-2002) showed it to be a highly eutrophic area and one among the most polluted along the eastern Adriatic coast. Frequent anoxia in the bottom layer along with microbiological pollution often cause mass mortality of marine organisms in its eastern part of the Bay.

Key words: Kastela Bay, nutrients, eutrophication, pollution, remedial measures.

Introduction

The number of urban inhabitans in cities is rapidly growing, producing further increase of amount of waste: bacterial/viral pollutants acting as potential disease pointer, and nutrient generating severe eutrophication of coastal waters. The eutrophication has become an acute environmental problem especially in semi-enclosed areas and gulfs with small exchanges of water with surrounded areas, like the Kastela Bay (Split area). The excessive level of organic matter and nutrients (P and N-salts) affects water quality by contributing to algal bloom every summer, in eastern part of the Bay (1). Unfortunately, there is no federal agency (in the town or in the country) with overriding responsibility for nonpoint source pollution control.

Study area

The Kastela Bay is 14.8 km long, about 6 km wide and, on the average, 23 m deep. The eastern part of the bay also receives large quantities of untreated municipal and industrial effluents. Water exchange and changes in the current field are mostly induced by local winds related to the passing of mid-latitude cyclones over the area. The Bay is particularly threatened by the organic matter and nutrients input causing an extreme phytoplankton bloom each summer.

Results and discussion

The long-term studies of chemical and biological parameters in the Kastela Bay area point to the fact that, during the past decade, an increase in the eutrophication level has persisted in all the areas of the eastern Adriatic coast (2). Different types of pollution produce different forms of water degradation. The source of water pollution provides the key to its control. Most people still believe that the industry-big industry-is the problem. They come into the Bay ecosystem from diffuse or "non-point" source such as runoff from stormwater and from atmosphere (Fig. 1). Stormwater runoff also delivers a certain quantity of nutrients, motor oils, cleaning fluids and assorted contaminants from roadways and parking lots. Nonpoint sources of pollution include all other discharges and involve urban and agricultural runoff, leaches and runoff from individual disposal systems such as septic tanks and marine sanitation device, runoff from construction sites and forest harvest areas. These sources of contaminants are becoming more important all over the Bay, and these sources remain more difficult to quantify as well as to control.

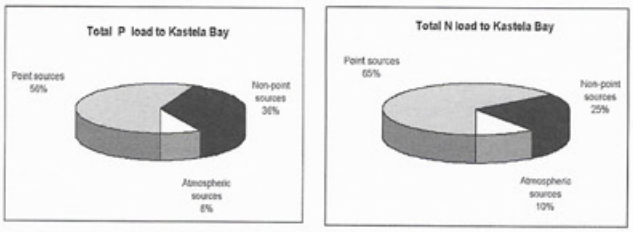


Fig. 1. Source of nutrients in the Kastela Bay

Statistical analyses of 20-50 years trends of selected water quality parameters showed declining water quality conditions in the all areas of the Bay. Nutrients, suspended matter, pesticides, heavy metals and bacteria are the five major causes of severe water quality problems in the Kastela Bay (3, 4).

Long-term studies of heavy metal concentrations (Zn, Cu, Cd and Hg) in seawater, sediments and some marine organisms in coastal area of the middle Adriatic have shown that the Kastela Bay is one of the most threatened areas along the eastern coast, as shown in Table 1(5). Nowadays we know a fear amount about inputs of toxic metals into the Bay, we are still just learning how to measure the effect of those contaminants on the Bay organisms, and on the Bay ecosystem itself. Exposure to trace metals and other contaminants can effect on phytoplankton population, for example, causing shifts in species composition, and these changes could have significant impact throughout the ecosystem (6).

Table 1. Mean values of heavy metals in water (ng dm^{-3}) sediments (mg kg^{-1} DW) and marine organisms (*Mytilus galloprovincialis*, (mg kg^{-1} FW) in the open sea stations (*a*) and in the Kastela Bay (*b*). b* Station just near CAP (chlor-alkali plant)

	Seawater		Sediments		*M.galloprovincialis*	
Metal	(a)	(b)	(a)	(b)	(b)	(b*)
Zn	234	2170	29	342	16.5	29.4
Cu	112	196	8.6	27.6	0.66	1.65
Cd	21	48	0.1	0.37	0.08	0.15
Hg	10	52	0.02	1.86	0.3	3.32

Conclusion

The following points are among the significant conclusions resulting from this paper in order to minimizing pollutant fluxes from land-based sources:

- Many existing industries represent pollution hot spots in coast of the Bay. Old and abandoned industrial plant have had in the past contamined land and water of the Bay.
- To reduce the flux of water-polluting elements and compounds from point and non-points sources, as well as from agricultural sources and deposits of urban sludges.
- Reducing the emission from trafic sources, (especially in summer period), mining activities and cement industry.
- The planing of waste water treatment plants needs to include many low-cost plant serving large population, to reduce their discharges of toxic materials to a minimum level.
- " Environmental education "program for young people and adults. These program can prepare better tomorrow's generation as informed stewards for our threatened coastal seas and their irreplaceable living resources.
- Monitoring program. These programs include monitor level of conventional pollutants and some toxic elements and compounds in water, sediments and marine organisms as well. Monitoring program also include the bacterial quality of waters phitoplankton communities, as well as, monitoring of benthic macroinvertebrate and fisheries assessments.

References

1 - Ninčević Ž., and Marasović I., , 1998. Chlorophyl *a* and primary production of size fractionated phytoplankton in the middle Adriatic Sea. *Rapp. Comm. int. Mer Médit.* 35: (2), 472-473

2 - Vukadin I., 1998. Transport and budget of nutrients in Kaštela Bay (Adriatic Sea). *Rapp. Comm. Int. Mer Médit.* 35: (1) 306-308.

3 - Šolić M., Krstulović N., Marasović I., Baranović A., Pucher-Petković T., and Vučetić T., 1994. Analyses of time series of planktonic communities in the Adriatic Sea: distinguishing between natural and men-induced changes. *Oceanol. Acta*, 20(1): 131-143.

4 - Vukadin I., Zvonarić T., and Odžak N., 1995. Fate and distribution of toxic heavy metals in some marine organisms from the eastern Adriatic coast. *Helgolandder Meeresunters.* 49: 679-688.

5 - Zvonarić T., and Odžak N., 1998. Distribution of Hg, Cu, Zn and Pb in surface sediments from the coastal region of the central Adriatic. *Rapp. Comm. int. Mer Médit.* 35(1): 312-313.

6 - Greer J.,1996. The trouble with toxics in the Bay. *Maryland Marine notes*, 6: 1-6.

DISSOLVED INORGANIC IODINE IN THE ROGOZNICA LAKE (EASTERN ADRIATIC COAST)

Vesna Žic * and Marko Branica

Center for Marine and Environmental Research, Rudjer Bošković Institute, Zagreb 10000, Croatia - * vzic@rudjer.irb.hr, branica@rudjer.irb.hr

Abstract

The speciation of iodine in the water column of the Rogoznica Lake was studied during the period 1998-2000. This small, eutrophicated salt lake, where anoxic conditions mostly prevail only in the deeper layers, has undergone a complete anoxia in September 1997. Elevated concentrations of iodide in the deeper layers (up to 2.4 μmol L^{-1}), and iodate in the oxic part of the water column (up to 0.53 μmol L^{-1}), were maintained for almost two years. The biogeochemical renewal processes that affect the concentration of both iodate and iodide within the water column seem to be slow in comparison to those that govern the speciation of iodine.

Key words: iodate, iodide, anoxia

Results

As a result of the geomorphologic isolation, higher biological activity and a stable conditions within the stratificated water column, the processes affecting the distribution of the dissolved iodine in natural waters, where the hypoxic and anoxic conditions are intermittently or permanently present, are found to be more intensive as compared to those occurring in the oceans. The Rogoznica Lake, situated at the Gradina Peninsula, in the eastern part of the Adriatic coast (43°32' N, 15°58' E), belongs to such a marine sub-environment. The lake water is enriched with nutrients [1, 2], inorganic and organic iodine species [3], dissolved organic carbon, surface-active substances and phytoplankton biomass [4]. The hypoxic and anoxic conditions are induced by a high primary production and consequent oxygen depletion. These are accompanied with the formation of a reduced sulphur species that are found to be present in significant quantities[1, 5].

In October 1997, complete oxygen depletion and the presence of the hydrogen sulphide were obtained within the entire water column of the Rogoznica Lake [2]. Due to the remineralisation processes, the concentrations of nutrients were extremely enhanced along the entire water column and remained high for a few months.

According to the data obtained in our work, and the results that refer to the renewal processes of nutrients, it seems that the nutrient-like behaviour and a biophilic nature of iodine can be confirmed. During the period investigated, the iodate and iodide concentrations (determined by voltammetric methods) varied between <0.025-0.53 μmol L^{-1} and 0.11-2.40 μmol L^{-1}, respectively. The relative ratios of iodate to iodide were significantly lower while the concentrations were higher than those found in seawater.

The average specific inorganic iodine concentrations (a sum of iodate and iodide normalized to salinity 35.00) in the seawater samples from the nearby Soline Bay (0.44 μmol L^{-1}, 1998-1999 and 0.42 μmol L^{-1}, 1993-1994) are comparable to those obtained for the oxic seawater (0.35-0.49 μmol L^{-1}) [6].

According to the concentration range of the specific inorganic iodine in the water samples from the Rogoznica Lake, there is a significant difference between samples collected during 1998-1999, and those collected in 2000. Although the specific inorganic iodine concentrations were high during 2000, varying between 0.46 μmol L^{-1} and 0.76 μmol L^{-1}, these values are low in comparison to the period of 1998-1999 (within the range from 0.56 up to 2.27 μmol L^{-1}). The data of the specific inorganic iodine in 46 water samples collected at various depths in the Rogoznica Lake during 1993-1994 were between 0.44 μmol L^{-1} and 0.78 μmol L^{-1}, which indicates that the period 1998-1999 was exceptional. The data obtained after the acute anoxic event suggest that the sequential processes including the eutrophication, mass mortality of the phyto- and zoo-plankton populations and other organisms (as a result of the oxygen depletion), and the release of bio-accumulated iodine to the water phase via the chemical or remineralisation processes, caused the enhancement of the concentration of iodate and iodide in the water phase. Both iodine vertical profiles, as well as the redox conditions in the deeper layers, suggest that these processes are mainly responsible for the production of iodide. However, assuming that the reducible redox conditions in September 1997 might have caused a complete or at least a partial iodate reduction in the upper layers, and that the results obtained confirmed the enhanced concentration of iodate in July and October 1998, the processes that might produce iodate are relatively fast and worth considering. Whether these processes refer to the photochemical reactions, biologically mediated processes or some alternative mechanism that overcomes the activation energy and the kinetic barrier of the iodide oxidation to iodate, they play a significant role in the speciation of the dissolved inorganic iodine in the Rogoznica Lake.

References

1 - Buljan M., 1956. First findings of hydrogen-sulphide (H2O) in the Adriatic, *Mornarički Glasnik* (Split) 2: 207-214 (in Croatian).

2 - Ciglenečki I, Carić M., Kršinić F., Viličić D. and Ćosović B., 2000. Nutrients recycling in the naturally eutrophicated sea-lake, Rogoznica Lake (Eastern Adriatic Coast, Croatia). Symposium on nutrient over-enrichment of coastal waters: Global Patterns of cause and effect, Washington, DC, SAD.

3 - Stipaničev V. and Branica M., 1996. Iodine speciation in the water column of the Rogoznica Lake (Eastern Adriatic Coast). *Sci. Total. Environ.*, *182*: 1-9.

4 - Ćosović B., Ciglenečki I., Viličić D. and Ahel M., 2000. Distribution and seasonal variability of organic matter in a small eutrophicated salt lake. *Est. Coas. Shelf Sci.*, *51(6)*: 705-715.

5 - Ciglenečki I., Kodba Z., Viličić D. and Ćosović B., 1998. Seasonal Variation of Anoxic Conditions in the Rogoznica Lake. *Croat. Chem. Acta*, *71(2)*: 217-232.

6 - Wong G. T. F., 1991. The Marine Geochemistry of iodine. *Review. in Aquatic Sci.*, *4(1)*: 45-73.

WATER QUALITY OF THE VENICE CANAL NETWORK: RESULTS OF AN INTENSIVE MONITORING

R. Zonta [1] *, M. Scattolin [2], M. Botter [1], F. Collavini [1]

[1] National Research Council – Institute of Marine Science. San Polo, 1364 – 30125 Venice, Italy *roberto.zonta@ismar.cnr.it

[2] Venice City Council – Environment Department. San Marco, 4136 – 30124 Venice, Italy

Abstract

An intensive monitoring activity was performed in spring 2003, to ascertain the water quality of five different zones of the Venice canals network. In consequence of the recent dredging interventions and realisation of sewage purification systems, the results testified acceptable quality conditions in the monitored canals. Further investigations are needed in order to highlight the presence of specific sources, which determine a decrease of the water quality, and to establish suitable methodologies for the future control of the canals network.

Keywords: water quality, pollution, urban wastewater, Venice

In recent years, a series of maintenance and restoration interventions has been started in the about 40 Km-long Venice canals network. They include both the removal of a thick layer of contaminated sediment resulting from more than 30 years of sedimentation, and the reduction of the amount of domestic and commercial wastewaters. As a consequence, a progressive improvement of the water quality in the network is expected, which must be ascertained by means of specific water samplings and analyses. However, due to the complexity and variable characteristics of the network, suitable methodologies for the evaluation of the present situation and the control of the water quality in the future are still to be defined. Different factors induce temporal variability of the water quality in a given site: level variation in different tide phases; meteorological conditions; the strewn wastewater effluents; bottom sediment resuspension due to shear stress and boat traffic; the flow of water masses coming from neighbouring parts of the network. In this picture, an intensive monitoring activity was performed in 28 stations belonging to five different zones of the City (Fig. 1): three marginal areas located in the North (A), South (D) and East (E) respectively, a inner area (B), and the Canal Grande (C), through which a large part of the canals network is fed and drained by tidal currents.

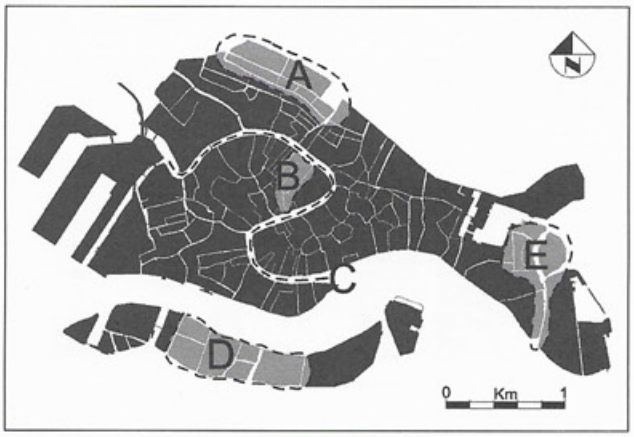


Fig. 1. Map of the City of Venice. The investigated zones are evidenced.

Each station was monitored at least ten times in the period between March 4th and April 16th 2003, collecting more than 300 water samples that were analysed for the following determinants: suspended particulate matter; heavy metals (Fe, Mn, Cd, Cu, Pb, Zn); nitrogen and phosphorous dissolved species; total and fecal coliforms; fecal streptococcus. Samples were mainly collected around the minimum tide, in order to account for the worst quality conditions occurring in the water column. The water sampling was always accompanied by the measurement of water dynamics and phisico-chemical parameters (salinity, temperature, dissolved oxygen, turbidity, pH, redox potential). Data clearly show differences in the quality conditions among the investigated areas. Marginal areas (A, D, E) have a lower contaminants and bacteria content and better physico-chemical characteristics (higher dissolved oxygen concentrations and redox potential values, lower turbidity) with respect to the inner area B. This is ascribed to both a better water renewal and the effectiveness of the interventions already realised in the three marginal areas. The water of the Canal Grande shows intermediate characteristics with respect to marginal and inner areas. Figure 2, for example, shows the average concentrations of dissolved inorganic nitrogen (DIN) measured in the five zones. It is worthwhile to observe that in the majority of the stations belonging to the marginal areas DIN concentration is close to - or even lower than - the imperative values (350 µg/l) established by the Italian law for the water of the lagoon. This feature also holds for dissolved phosphorous, whose imperative value is 25 µg/l. Concentrations of Cu and Pb – as well as those of Fe and Mn - measured in all the 28 stations are, with very few exceptions, lower than the average values that characterise the freshwater discharged into the Venice lagoon from its drainage basin. Zinc concentrations are instead of the same order or even greater. Cadmium always resulted lower than the detection limit (0.1 µg/l). Finally, coliforms show levels lower than the EC imperative values for the bathing waters (Directive 76/160/CEE) in the majority of the stations; the concentration of fecal streptococchi is instead greater than the EC limit. The investigation highlights an acceptable situation for the water quality of the Venice canals network, which is probably better than the expected one on the basis of the number of the planned interventions already performed and the time elapsed. Anyway, the high concentrations of some determinants systematically observed in some of the 28 stations require further investigations, in order to check the eventual presence of specific sources affecting the quality of the water column.

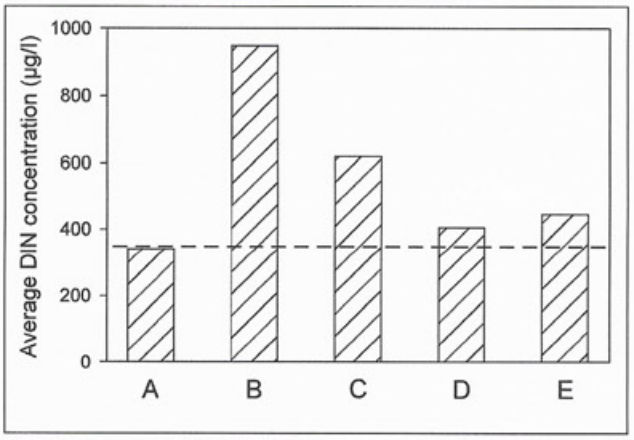


Fig. 2. Average concentration of dissolved inorganic nitrogen in the five zones. The dashed line corresponds to the Italian imperative value (350 µg/l) for the lagoon.

OPTIMISATION DE L'EFFICACITÉ DE LA BIODÉGRADATION D'UN PÉTROLE BRUT DE TYPE ZARZATINE PAR UNE BIOMASSE MIXTE ACCLIMATÉE

I. Zrafi [1], Z. Khedir [1], M. Hammami [2], A. Bakhrouf [1], D. Saidane-Mosbahi [1] *

[1] Laboratoire d'Analyse et de Contrôle des Polluants Chimiques et Microbiologique de l'Environnement, Faculté de Pharmacie de Monastir, Tunisie - * Dalila. Saidane@fphm.rnu.tn
[2] Laboratoire de Biochimie, Faculté de Médecine de Monastir, Tunisie

Résumé

Le but de cette étude est l'optimisation du rendement d'une biomasse marine naturelle existante dans le lieu de rejet de la raffinerie (STIR) à Bizerte, Tunisie. Une acclimatation de cette biomasse à des doses élevées de pétrole a été réalisée. Les paramètres physico-chimiques optimaux de biodégradation seront déterminés et utilisés pour l'amélioration de son rendement. Suite à une extraction le pétrole résiduel sera fractionné par CPL et analysé par CPG. Cette étude a montré que l'acclimatation associée aux paramètres physico-chimiques optimaux permettent une dégradation totale arrivant à 77,8%.

Mots clés: biodégradation, pétrole, biomasse marine.

Introduction

Le devenir des pétroles rejetés en milieu marin est conditionné par les processus de biodégradation (1). Le rendement dépend des capacités dégradantes des bactéries présentes et de l'influence des paramètre physico-chimiques (2). L'objet de cette étude est de réaliser une bioaugmentation associée à une biostimulation *in vitro* pour déterminer les conditions optimales d'une bioremédiation *in situ*.

Matériel et Méthodes

Un échantillonnage d'eau de mer, du lieu de rejet de la raffinerie de Bizerte, Tunisie a été réalisé. Les germes hydrocarbonoclastes ont été isolés et identifiés. La biomasse mixte obtenue est acclimatée à des doses croissantes en pétrole et utilisée pour l'étude de l'influence des paramètres physico-chimiques (température, concentration du pétrole, pH, agitation, composition du milieu d'incubation, aération).

Les échantillons ont été incubés en présence de la biomasse avant de subir l'extraction des quantités résiduelles du pétrole et leur fractionnement par CPL en hydrocarbures non aromatiques (HCS), hydrocarbures aromatiques (HCA) et composés lourds (NSO). Les HCS et les HCA seront analysés qualitativement par CPG.

Résultats et Discussion

L'identification de la flore a montré la prédominance de la famille de *pseudomonadacea* à côté des genres *Acinetobacter, Sphingobacteruims* et *Chryseobacterium.*

L'acclimatation de la biomasse bactérienne à des fortes doses de pétrole a montré qu'aucune dose ne limite son activité, ce qui suggère son adaptation à la présence de ce polluant. L'acclimatation a permis la réduction du temps de latence de l'attaque du pétrole par les bactéries.

La variation de la concentration du pétrole montre que la biodégradation évolue en fonction de la charge pétrolière. La vitesse de biodégradation dépend de la quantité du pétrole. Les pourcentages de biodégradation montrent que l'efficacité des bactéries est importante à toutes les concentrations.

L'eau de mer donne des résultats très satisfaisants par rapport à un milieu minéral (3) et un milieu enrichi en azote et en phosphore.

La variation de la température d'incubation révèle que notre biomasse est active à basse température (4°C) avec dégradation non négligeable touchant même les n-alcanes à nombres de carbone élevés. A 25°C une nette amélioration de la biodégradation est enregistrée (dégradation maximale des n-alcanes). A 37°C la biodégradation est moins favorable, touchant surtout les plus légers.

Les pH basiques sont les mieux tolérés par la biomasse bactérienne, le pH8 qui est celui du milieu naturel donne le maximum de biodégradation.

L'agitation a augmenté énormément le rendement de la biodégradation, elle a permis une émulsification du pétrole et un contact pétrole/ bactéries plus important.

D'après nos résultats, la biodégradation a touché simultanément les HCS et les HCA, avec des pourcentages de biodégradation plus importants pour les HCS. Les chromatogrammes montrent que les n-alcanes sont les plus dégradés en commençant par ceux à nombre de carbone faible (Fig. 1).

La détermination des paramètres physico-chimiques optimaux de la biodégradation a optimisé la durée du traitement tout en augmentant son potentiel et sa qualité. En effet la durée est passé de trois mois avec un rendement plus ou mois important à un mois avec une biodégradation maximale des HCS et importante pour les HCA. Cette biodégradation a touché même les iso-alcanes et les cyclo-alcanes (Fig. 2).

La bioaugmentation associée à la biostimulation peuvent représenter un traitement secondaire efficace pour les rejets de la raffinerie permettant une décontamination importante des rejets; d'ou l'intérêt des germes psychrotrophes dans un traitement *in situ* d'eau de mer (4).

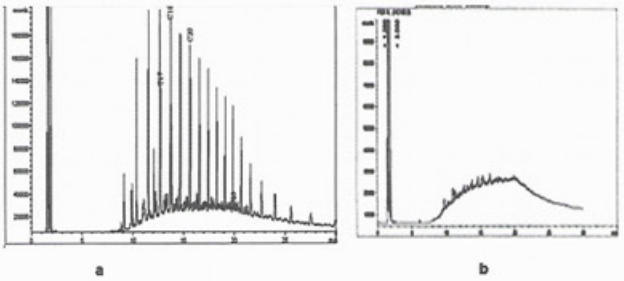


Fig. 1. Exemples de chromatogrammes issus d'un échantillon biodégradé avant optimisation (a) et d'un autre après optimisation de la dégradation (b).

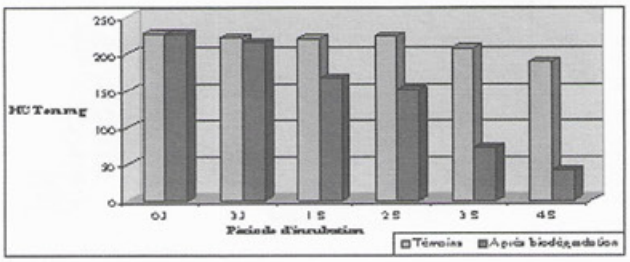


Fig. 2. Evolution des pourcentages pondéraux des HTC après biodégradation par la biomasse bactérienne acclimatée dans les conditions optimales déterminées.

Références

1 - Harayama S., Kishira. H., Kasai. Y, Shutsubo K., 1999. Petroleum biodegradation in marine environments. *J. Mol. Microbiol. Biotechnol.* N° 1(1): 63-70.

2 - Atlas R.M., 1981. Microbiol degradation of petroleum hydrocarbon: an environmental perspective. *Microbiol. Rev.* N° 45: 180-209.

3 - Chaîneau C.H., Moral J., Dupont J., Bury E. Oudot J., 1999. Comparison of the ful oil biodegradation potentiel of hydrocarbon-assimilating microorganisms isolated from a tempereate agricultural soil. *Sci. Total. Environ.* N° 227(2-3): 237-247.

4 - Wyhte L.G., Bourbonniere L., Greer C.W., 1996. Biodegradation potental of psychrotrophic microorganisms. *Can. J. Microbiol.* N° 42: 99-106.

Comité

Microbiologie marine

Président : Gerhard J. Herndl

ETUDE COMPARATIVE DE LA DYNAMIQUE SAISONNIÈRE DES POPULATIONS MICROPLANCTONIQUES DANS LES EAUX CÔTIÈRES LIBANAISES (BATROUN) ET FRANÇAISES (MARSEILLE)

Marie Abboud-Abi Saab [1] *, Beatrice Beker [2], Milad Fakhri [1], Jean-Claude Romano [2]

[1] Conseil National de la Recherche Scientifique, Centre National des Sciences Marines, B.P 543, Batroun, Liban - mabisaab@cnrs.edu.lb

[2] Centre d'Océanologie de Marseille, Université de la Méditerranée, UMR-CNRS 6540, Station Marine d'Endoume, Rue de la Batterie des Lions, 13007 Marseille, France

Résumé

Des échantillons d'eau ont été collectés entre janvier 2001 et décembre 2002, (au moins mensuellement) en deux points de la Méditerranée, l'un dans le bassin oriental (Batroun-Liban) et l'autre dans le bassin occidental (Marseille-France). Les eaux libanaises sont plus chaudes et plus salées, l'amplitude annuelle de température est supérieure et celle de la salinité est inférieure à celle des eaux françaises. Le cycle microphytoplanctonique annuel est comparable aux deux sites avec des différences dans le timing des poussées. Les poussées phytoplanctoniques sont principalement dominées, pour les 2 sites étudiés, par différentes espèces de diatomées. Des différences interannuelles sont notées aux deux sites.

Mots clés: Populations microphytoplanctoniques, côtes libanaises, côtes françaises

Introduction

Les études phytoplanctoniques réalisées dans les eaux côtières françaises méditerranéennes (1; 2) et libanaises (3) sont nombreuses mais rares sont les études comparatives entre ces différentes zones de la Méditerranée. C'est pourquoi, à partir de 1999, dans le cadre du programme de coopération franco-libanais CEDRE, il a été décidé de mener une étude comparative entre les côtes méditerranéennes libanaises et les côtes françaises. Ces deux sites oligotrophes ont l'avantage d'être situés respectivement dans les régions plus chaudes, ou au contraire les plus froides de la Méditerranée. Les résultats (4) issus de cette démarche comparative systématique se sont révélés très instructifs. Le but de cette analyse de deux ans de prélèvements est de comparer l'évolution des populations micro-phytoplanctoniques entre ces 2 sites présentant des spécificités écologiques différentes, et d'en extraire une tendance plus globale.

Matériel et méthodes

Les mesures ont été réalisées en surface dans deux stations, une située au large des eaux libanaises (mensuelle) à Batroun (N 34°14.86 ; E 35°36.07) et l'autre dans les eaux françaises (bimensuelle) près de Marseille (N 43°14,30 et E 5°17,30) entre janvier 2001 et décembre 2002. Un volume de 100 cc est placé en cellules de sédimentation. Les cellules ont été analysées selon la méthode d'Utermöhl (1958).

Résultats et discussion

Durant la période d'échantillonnage, la température de l'eau a suivi le cycle normal connu dans chaque région avec des températures extrêmes variant de 17,4°C à 30°C (ΔT = 12.6°C ; m = 23.39±4.43) au Liban et 12.54 à 23.61°C (ΔT = 11.07°C ; m = 17.72±3.03) en France. La salinité a varié entre 38.867 et 39.652‰ (ΔS = 0.78 ; m = 39.239±0.226) au Liban et 35.145-38.509‰ (ΔS = 3.364; m = 38.097 ± 0.213) en France. Nous constatons que les eaux libanaises sont plus chaudes et plus salées que les eaux françaises, que l'amplitude annuelle de température est supérieure au Liban et que l'amplitude de la salinité est inférieure à celle des eaux françaises. Notons qu'à Batroun la thermocline reste permanente et plus profonde qu'à Marseille où elle disparaît fréquemment en saison chaude lors des refroidissements brusques consécutifs aux vents de NO. Ceci est principalement dû aux différences entre les régimes de vents dominants sur les deux côtes.

Le suivi quantitatif des populations micro-phytoplanctoniques présente une poussée printanière importante et une seconde poussée automnale pour chacun des deux sites.

Des différences sont notées, d'une part, entre les 2 sites étudiés au niveau de la date et de l'importance de chaque poussée et d'autre part chacun des sites présentent des différences interannuelles entre les 2 années de prélèvements.

En effet, au Liban, l'année 2001 présente une poussée de faible intensité en avril (21 x 10^3 cell. L^{-1}), en juin (28 x 10^3 cell. L^{-1}) et une dernière en août (45 x 10^3 cell.L^{-1}). Par contre, en 2002, les eaux libanaises ont présenté une poussée printanière importante avec des maxima en juin et juillet (122 x 10^3 et 119 x 10^3 cell. L^{-1} respectivement) et une autre en septembre (127 x 10^3 cell. L^{-1}). Les eaux méditerranéennes françaises ont présenté, en 2001, une poussée du phytoplancton en mars (65x 10^3 cell. L^{-1}) et une autre plus importante en octobre (122x 10^3 cell. L^{-1}). Par contre, en 2002 une poussée importante a été notée en février-mars (140 x 10^3 cell. L^{-1}) sans noter de poussée automnale comparable à celle de 2001. Il est intéressant de noter que l'année 2002 était presque deux fois plus pluvieuse par rapport à la normale.

Au Liban, ces poussées sont dominées par les diatomées tandis que les dinoflagellés présentent des maxima en juin 2001 (19600 cell. L^{-1}) et pour l'année 2002, les maxima de dinoflagellées apparaissent en avril-mai (15 044 cell. L^{-1}), en juillet et septembre (respectivement 21580 et 20390 cell. L^{-1}).

En France, pendant la période considérée, les floraisons sont également dominées par les diatomées, à l'exception de la poussée automnale de 2002 qui était due à des cryptophycées. Les dinoflagellés n'ont jamais dépassé 3000 cellules par litre durant toute la période considérée ; les cuirassées de grande taille sont souvent présents et diversifiés mais seuls les dinoflagellés nus de petite taille ont présenté des densités supérieures.

L'étude qualitative des poussées phytoplanctoniques a permis de montrer une différence importante concernant la diversité des échantillons au cours de la période d'analyse. Au Liban, les poussées sont l'œuvre d'espèces telles que *Leptocylindrus danicus, L. minimus, Pseudonitzschia pseudodelicatissima, Chaetoceros curvisetus* et *Guinardia delicatula*. En France, les poussées phytoplanctoniques sont dominées par des espèces telles que *Pseudonitzshia delicatissima, Chaetoceros simplex* et *Ch. curvisetus*. La comparaison des listes floristiques montrent que de nombreuses espèces sont communes aux deux sites, cependant elles diffèrent en abondance et par leur période d'apparition.

La communauté phytoplanctonique estivale des eaux libanaises est constituée presque exclusivement des petits dinoflagellés nus très variés (plus de 30 espèces). Durant l'été 2002, les diatomées n'ont cependant pas disparu du milieu comme l'année précédente. Notons à titre indicatif que l'analyse des échantillons de filet qui concentre un grand volume par rapport à la méthode utilisée dans cette étude montre la présence en été de grands dinoflagellés cuirassés, rares et variés et pour la plupart d'origine indo-pacifique.

En conclusion, le cycle annuel est comparable aux deux sites avec des différences dans le timing des poussées, dominées par différentes espèces de diatomées. Des différences interannuelles sont aussi notées dans les deux sites. Cette étude montre l'importance des suivis à long terme pour estimer l'évolution du phytoplancton pour chacune des zones étudiées et la comparaison des 2 sites est nécessaire pour donner aux résultats une dimension plus globale.

Références

1 - Travers M., 1973. Le microplancton du golfe de Marseille: variations de la composition systématique et de la densité des populations. *Téthys*, 5(1): 77-99.

2 - Beker B., Romano J.-C., Arlhac D. 2001. Le suivi de la variabilité des peuplements phytoplanctoniques en milieu marin littoral : le golfe de Marseille en 1996-1997. *Oceanis* 1999, 25(3): 395-415.

3 - Abboud-Abi Saab M., 1985. Etude quantitative du phytoplancton des eaux côtières libanaises. *Leb. Sci. Bull.*, 1(2): 197-222.

4 - Abboud-Abi Saab M., Romano J.-C., Bensoussan N. et Fakhri M. (soumise). Suivis temporels comparés de la structure thermique d'eaux côtières libanaises (Batroun) et françaises (Marseille) entre juin 1999 et octobre 2002.

THE COMPARISON OF BACTERIAL LEVEL IN THE GOLDEN HORN (ISTANBUL, TURKEY) BY USING MICROSCOPIC AND CULTURAL METHODS

Gülsen Altug [1] *, Yunus Bayrak [2]

[1] Istanbul University, Faculty of Fisheries, Istanbul, Turkey - * galtug@istanbul.edu.tr
[2] Ministry of Agriculture and Rural Affairs, Istanbul, Turkey

Abstract

Surface water taken from four different areas in the Golden Horn (Istanbul, Turkey) was analyzed in order to detect levels of bacterial contamination. Bacterial densities enumerated by direct microscopic counts were 2 orders of magnitude higher than plate counts.

Key words: Microscopic Count, Viable Count, Bacterial Contamination

Introduction

Bacteria play a central role in the bio-cycles in aquatic environments (1). Under anthropogenically induced eutrophication, bacterial abundance might increase and pathogenic bacteria might be present as well (2) influencing human health (3).

Instead of conducting separate tests for pathogen bacteria, like *Salmonella, Esherichia coli* 0157, *Vibrio cholera,* determination of indicator bacteria using ordinary analytical methods is a classic approach in aquatic microbiology (4, 5). When we count marine bacteria using either microscopic or ordinary viable counting methods, great differences often occur between direct counts (DC), and viable counts on nutrient rich media such as ZoBell 2216E and VNSS (6).

Golden Horn has been one of the important recreation areas of Istanbul (Turkey) but became heavily polluted in the last half of the 20th century.

Materials and methods

A total of 44 samples of surface water was collected from the coastal area of Alibeykoy, Eyup, Balat and Fener (Golden Horn, Istanbul) and transported to the laboratory between November 2002 and September 2003.

Bacterial counts were made using direct microscopic counting techniques (DC) and the Most Probable Number (MPN) Technique with different media. VNSS agar plates (800 mg C/l), Plate Count Agar (PCA), 0.22 µm Filtered Natural Seawater (FSW), Filtered Seawater with 0.05 µg/l vitamin B_{12} (FSW+B_{12}) were used for viable counts (6; 4). After 24 hours of incubation at 37°C colonies on agar plates were counted.

Results

The results of bacterial counts using DC and cultural methods on surface water samples collected from Golden Horn during the investigation period are given in Tables 1-3. Total Coliform and *E. coli* were highest in samples taken at Alibeykoy (Tables 1, 2). Maximum bacterial abundance was detected by direct microscopic counting. Minimum bacterial numbers were detected using Filtered Seawater as the medium.

Table 1. Analysis for Total Coliforms, *Esherichia coli*, and *Salmonella* spp. in surface waters from Golden Horn, Istanbul, Turkey (MPN/100 mL)

Study Area	Number of the Samples	Total Coliform Max-Min	*Esherichia coli* Max-Min	*Salmonella* spp.
Alibeykoy	11	$11x10^2$-≥$24x10^3$	95x10 -$11x10^2$	One Sample +
Eyup	11	$23x10^2$-$95x10^2$	24x10-95x10	-
Balat	11	95x10-23x10	9.5x10-2.4x10	-
Fener	11	50	<10	-

Discussion

Microscopic counting of bacteria in samples from Alibeykoy yielded $3x10^5$ cells/ml, values of the same samples on Plate Count Agar were $2x10^5$ CFU/ml. Variances in bacterial counts in samples from Alibeykoy were found to be lower as compared to samples collected from Fener (Table 3). Samples from Fener showed that differences between microscopic counts and cultural counts are greater in oligotrophic environments. As can be seen in this study, both the trophic level of the aquatic environment and the different enumeration methods used affect the results of the counts. Thus, studies on transforming unculturable bacteria to culturable forms are important (6; 7; 8). It is assumed that bacteria undergoing sudden exposure to nutrient rich media cannot utilize the substrates (9).

Table 2. Bacterial counts by microscopic and viable counting methods in surface water collected from Alibeykoy (Golden Horn, Istanbul)

Direct Count Cells/ml	*Viable Counting Methods CFU/ ml*			
	Plate Count Agar (PCA)	*Nutrient Rich Media (VNSS)*	*Filtered Seawater (FSW)*	*Filtered Seawater with Vitamin B_{12} (FSW+B_{12})*
$3x10^5$	$2x10^5$	10^5	10^2	10^4

Table 3. Bacterial counts (cells/ml) by microscopic (MC) and viable counting methods in surface water collected from Fener (Golden Horn, Istanbul)

Direct Count cells/ml	*Viable Counting Methods CFU/ ml*			
	Plate Count Agar (PCA)	*Nutrient Rich Media (VNSS)*	*Filtered Seawater (FSW)*	*Filtered Seawater with Vitamin B_{12} (FSW+ B_{12})*
$6x10^2$	50	2.6	4X10	4.5X10

References

1 - Heissenberger A., Leppard G.G., Herndl J.G., 1996. Relationship between the intracellular integrity and the morphology of the capsular envelope in attached and free-living marine bacteria. *Appl. Environ. Microbiol.*, 62: 4521-4528.

2 - Jacob J.M., 1989. Safe Food Handling World Health Organization Genava 142.

3 - Ducklow H.W., Carlson C.A., 1992. Oceanic bacterial production. *Adv. Microb. Ecol.*, 12: 113-181.

4 - APHA, American Public Health Association, American Water Work Association,Water Environment Federation, 1998. Standard Methods for the examination of water and waste water (20th ed) Clesceri, LS., Greenberg, A.E., Eaton, AD, EDS. Washington.

5 - Bordner R., Winter J., Scarpino P., 1978. Microbiological methods for monitoring the environment: water and wastes. Environmental Monitoring and Support Laborotory, Office of Research and Development. EPA-600/8-78/017

6 - Eguchi M., 1999. The nonculturable state of marine bacteria. 8th International Symposium on Microbial Ecology, Bell CR, Brylinski M, Johnson-Green P (Eds) Canada.

7 - Pinhassi J., Zweifel UL., Hangström A., 1997, Dominant marine bacterioplankton species found among colony-forming bacteria. *Appl. Environ. Microbiol.*, 63: 3359-3366.

8 - Schut F., Prins R.A., Gottschal J.C., 1997. Oligotrophy and pelagic marine bacteria: facts and fiction. *Aquat. Microb. Ecol.*, 12: 177-202.

9 - Bloomfield S.F., Steward G.S., Dodd C.E.R., Bototh I.R., Power E.G.M., 1998. The viable but non-culturable phenomenon explained? *Microbiology*, 144: 1-3.

ECTOENZYMATIC HYDROLYTIC ACTIVITIES IN THE SEA SURFACE MICROLAYER

J.M. Arrieta *, E. Sintes, T. Reinthaler and G.J. Herndl

Department of Biological Oceanography, Royal Netherlands Institute for Sea Research (NIOZ), P.O. Box 59, 1790 AB Den Burg, The Netherlands, txetxu@nioz.nl

Abstract

The skin of the sea, known as the sea surface microlayer (SML) has attracted considerable interest as a potential factor regulating the exchange between the ocean and the atmosphere. It is known that trace metals, inorganic nutrients and dissolved organic compounds are enriched in the SML as compared to the underlying waters, making the SML a "hot spot" for biological activity. However, most of this knowledge comes from coastal areas, which may be not representing the bulk of the global ocean's surface. Here we present the diel dynamics of bacterial heterotrophic activity in the SML of a Mediterranean eddy.

Keywords: surface microlayer, interface, Mediterranean Sea, bacteria, neuston

The SML is the part of the ocean most directly exposed to solar radiation and therefore it is potentially subjected to strong diel perturbations. In order to characterize the diel dynamics of the SML, samples were taken in the early morning, at noon and right before dusk using glass plate samplers. Samples of the underwater layer (UWL) were collected from a depth of about 30 cm at the same locations and times.

The SML has been reported to be significantly enriched in phosphate (1), carbohydrates and peptides (2) as compared to the underlying waters. Therefore the bacterial hydrolytic activities involved in the bacterial degradation of these compounds, (α- and β-glucosidase, aminopeptidase and phosphatase) were chosen as an estimate of bacterial heterotrophic activity.

The SML samples always showed higher levels of inorganic nutrients than those of the UWL as reported previously (1), however, ammonia and nitrate exhibited higher enrichment factors than phosphate (Table 1), resulting in much higher N:P ratios in the SML than in the UWL. Although there was a considerable variation between the different SML samples collected, bulk enzyme activities in the SML were generally several times higher than those in the underlying waters (Table 1). However, bacterioneuston abundances (SML) were not significantly higher than those of bacterioplankton (UWL), which resulted in much higher cell-specific activities of bacterioneuston as compared to bacterioplankton. The higher N:P ratios observed in the SML were matched by the ectoenzymatic activity pattern resulting in higher aminopeptidase:phosphatase in the UWL as compared to the SML. Thus there are remarkable differences between the two environments that are reflected in the response of their respective bacterial community.

Table 1. Enrichment factors (SML/UWL) of the different parameters measured (n=13).

	Average	Minimum	Maximum
Phosphate	3.7	1.6	10.6
Ammonia	11.5	3.0	28.6
Nitrite	3.2	2.4	5.0
Nitrate	80.8	2.7	355.5
Bacterial abundance	1.1	0.9	1.3
α-glucosidase	3.7	0.6	20.6
β-glucosidase	6.6	0.2	65
Aminopeptidase	2.5	0.7	8.9
Phosphatase	4.8	0.7	15.6

The highest levels of ectoenzyme activity were found in the early morning or in the evening samples and a marked inhibition of enzymatic hydrolysis was generally detected at noon for both bacterioneuston and bacterioplankton (Fig. 1). This pattern suggests a dramatic effect of UV radiation on enzyme activity on both communities as previously hypothesized. These data and the results of other analyses currently in progress will be presented and discussed.

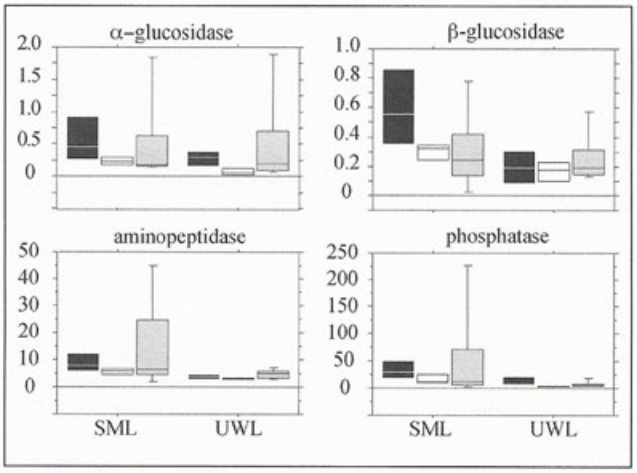


Fig. 1. Box plots and whisker plots of the diel variations in ectoenzyme activity for the SML and the UWL. Error bars represent the range, and the lines inside the boxes represent the median values. Samples collected in the morning are in black, those at noon in white, evening values are in gray.

References

1 - Falkowska L. 1999. Sea surface microlayer: a field evaluation of teflon plate, glass plate and screen sampling techniques. Part 2. Dissolved and suspended matter. *Oceanologia*, 41: 223-240.

2 - Henrichs S. M., and P. M. Williams. 1985. Dissolved and particulate amino acids and carbohydrates in the sea surface microlayer. *Marine Chemistry*, 17:141-163.

ETUDE ZOO SANITAIRE DES MOLLUSQUES BIVALVES DANS LE LAC DE BIZERTE EN TUNISIE

Attia El Hili H. *, El Bour M., Ayari W., Mraouna R. et El Abed A.
Unité de Pathologie des Animaux Aquatiques, INSTM, 2025 Salammbô - Tunisie - * hedia.attia@instm.rnrt.tn

Résumé

L'étude zoo-sanitaire des mollusques bivalves effectuée au lac de Bizerte a concerné trois espèces: la palourde (*Tapes decussatus*), la moule (*Mytillus galloprovincialis*) et l'huître creuse (*Crassostrea gigas*). Les échantillons prélevés pendant la période qui s'étale de 1999 à 2001, proviennent de trois sites: Faroua, Menzel Jemil et Jouaouda. Les résultats ont montré la présence d'un protozoaire parasite (*Perkinsus atlanticus*) responsable d'une maladie à déclaration obligatoire chez la palourde. Pour une même période, la prévalence de ce parasite a varié en fonction du site, ce qui suggère une éventuelle influence des paramètres *in situ*.

Mots clés: bivalves, parasites

Introduction

La palourde (*Tapes decussatus*) est présente dans le lac de Bizerte surtout dans les secteurs nord est (Menzel Jemil) et nord ouest (Faroua). Dans les secteurs sud et nord est (Jouaouda et Menzel jemil), il y a deux fermes conchylicoles qui grossissent principalement la moule (*Mytillus galloprovincialis)* et secondairement l'huître creuse *(Crassostrea gigas).*

Compte tenu de l'intérêt pour la production conchylicole du pays de connaître la situation zoo-sanitaire des bivalves et de maîtriser le contrôle et la gestion des transferts des ces animaux aussi bien à l'échelle nationale qu'internationale, nous avons démarré une étude pilote de suivi zoo-sanitaire au lac de Bizerte; ce présent travail en constitue une partie.

Matériels et méthodes

Le suivi a été réalisé pendant une période qui s'étale d'octobre 1999 à avril 2001. Il a intéressé six échantillons de palourdes, trois échantillons de moules et deux échantillons d'huîtres creuses. Les prélèvements ont été effectués en automne et au printemps. L'échantillonnage a été réalisé au niveau de trois sites: Faroua, Menzel Jemil et Jouaouda. La taille des échantillons a varié entre 24 et 34 individus et la technique de diagnostic que nous avons adoptée est l'histologie.

Résultats et discussion

L'examen des coupes histologiques au microscope binoculaire a montré la présence chez la palourde de protozoaires notamment de *Perkinsus atlanticus*, des trématodes et quelques foyers de rickettsies. Le Tableau 1 résume la liste des parasites observés sur les coupes ainsi que leur prévalences.

Tab. 1. Prévalences des parasites observés chez les palourdes de Menzel Jemil et Faroua

Sites de prélèvements	Site Menzel Jemil			Site Faroua		
Date de prélèvement	24/05/00	27/09/00	18/04/01	24/05/00	27/09/00	18/04/01
Perkinsus	13/34 ± 0,16	17/25 ± 0,18	14/25 ± 0,19	7/26 ± 0,17	16/32 ± 0,17	16/24 ± 0,19
Trématodes	5/34 ± 0,12	5/25 ± 0,16	2/25 ± 0,10	0	6/32 ± 0,13	3/24 ± 0,13

Les échantillons de moules ont été prélevés le 27/10/99 et le 24/05/00 à Menzel Jemil et le 18/04/01 à Jouaouda. Les échantillons d'huître creuses ont, quant à eux, été prélevés le 27/10/99 et le 14/11/00 à Jouaouda. L'analyse histologique a montré l'absence de parasite responsable de maladies à déclaration obligatoire chez ces deux espèces de bivalves. Cependant, nous avons noté la présence de grandes quantités de ciliés chez la moule.

Le parasite *Perkinsus atlanticus* n'a été que récemment considéré par le Code International pour les Animaux Aquatiques de l'Organisation Internationale des Epizootie comme étant responsable de maladie à déclaration obligatoire et ceci en conséquence des résultats de plusieurs travaux de recherche. Parmi ceux-ci, de Murrell *et al.* (1) en 2002 ont montré une grande similitude des séquences des génomes entre *Perkinsus atlanticus* et d'autres espèces de *Perkinsus* (notamment *P. olseni*) responsables de maladies à déclaration obligatoire. En Europe, ce parasite a été associé à des épisodes de mortalités massives et saisonnières chez la palourde *Ruditapes decussatus* (2). Il a aussi été détecté dans d'autres espèces de palourdes: *Ruditapes philippinarum, Venerupis pullustra* et *Venerupis aureus* mais avec une prévalence moindre que chez *Ruditapes decussatus* (3).

Ce parasite a été trouvé dans pratiquement tous les organes de l'animal avec une très nette dominance au niveau des branchies. Tous les trématodes que nous avons observés sont sous forme de kystes de métacercaires. Tous les ciliés et toutes les colonies de rickettsies ont été notés dans les branchies.

La comparaison statistique des prévalences de *Perkinsus* (Fig. 1) a montré que la différence des prévalences de *Perkinsus* entre les deux sites est faiblement significative en septembre 2000 (p ≈ 16%). De même, la différence des prévalences relatives au site Faroua est aussi faiblement significative entre septembre 2000 et Avril 2001 (p ≈ 21%). Ces différences bien que statistiquement peu significatives pourraient suggérer l'influence des paramètres environnementaux sur l'infestation des palourdes à *Perkinsus*.

Conclusion

Les résultats obtenus sur les palourdes sont très intéressants. Toutefois, il faut continuer la surveillance dans ce milieu lagunaire afin d'aboutir à des résultats plus nombreux et par conséquent plus significatifs qui nous permettent d'expliquer l'évolution des parasitoses et de déduire des hypothèses plus concrètes sur l'influence des paramètres *in situ* sur les infestations des palourdes à *Perkinsus*. L'absence de parasites responsables de maladies à déclaration obligatoire chez la moule et chez l'huître creuse est aussi un résultat préliminaire très intéressant qui nous encourage de continuer la surveillance conformément aux directives du Code Sanitaire International des Animaux Aquatiques afin de statuer le lac de Bizerte.

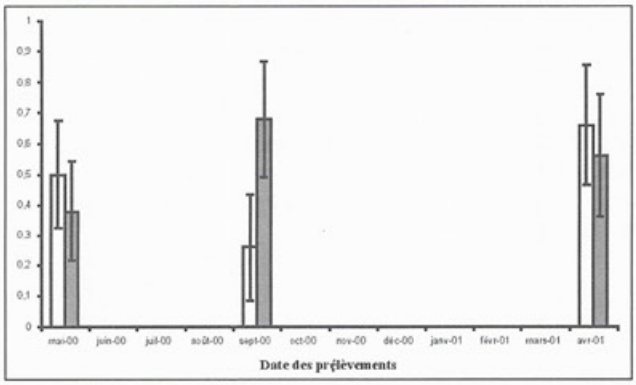


Fig. 1. Prévalence de *Perkinsus* chez la palourde *Tapes decussatus* des sites Faroua et Menzel Jemil du lac de Bizerte.

Références

1 - Murrell A., Kieeman S.N., Barker S.C. and Lester J.G., 2002. Synonymy of *Perkisus olseni* Lester & Davis, 1981 and *Perkinsus atlanticus* Azevedo, 1989 and an update on the phylogenetic position of the genus *Perkinsus. Bull. Eur. Ass. Fish Pathol.*, 22(4): 2002, 258.

2 - Azevedo C., 1989. Fine structure of *Perkinsus atlanticus* n. sp. (Apicomplexa, Perkinsea) parasite of the clam *Ruditapes decussates* from Portugal. *J. Parasitol.*, 75(4): 627-635.

3 - Navas J.I., Castillo M.C., Vera P. and Ruiz-Rico M., 1992. Principal parasites observed in clams, *Ruditapes decussatus* (L), *Ruditapes philippinarum* (Adam et Reeve), *Venerupis pullastra* (Montagu) and *Venerupis aureus* (Gmelin), from the Huelva coast (S. W. Spain). *Aquaculture*, 107: 193-199.

SPATIAL VARIABILITY OF MICROPLANKTON RESPIRATION IN THE ROSS SEA (ANTARCTICA) DURING AUSTRAL SPRING

Azzaro M. [1] *, La Ferla R. [1], Ribera d'Alcalà M. [2]

[1] IAMC-CNR, section of Istituto Sperimentale Talassografico, Messina, Italy, dedalus@ist.me.cnr.it
[2] Laboratorio di Oceanografia Biologica (SZN), Naples, Italy

Abstract

Respiratory electron transport system (ETS) measurements of the microplankton were performed along a south-north transect from the marginal ice zone (MIZ) to the pack ice-covered zone. ETS activity ranged from 0.14 to 1.47 ml O_2 $h^{-1}m^{-3}$ (mean value ± SD: 0.85 ± 0.35 ml O_2 $h^{-1}m^{-3}$) under the ice and from 0.17 to 2.81ml O_2 $h^{-1}m^{-3}$ (mean value ± SD: 1.47 ± 0.80 ml O_2 $h^{-1}m^{-3}$) in the marginal ice zone. The MIZ ecosystem was net autotrophic (P/R>1) while the pack ice zone was net hetertrophic (P/R<1).

Key-words: Ross Sea, ice-melting, microplankton, respiration

Introduction

Our knowledge on ecosystem metabolism of polar region is still rather poor compared to that of temperate latitudes. Recently this gap has been filled by several studies both in Antarctic and Arctic waters (1, 2, 3). However, little information is available regarding the impact of retreating pack-ice zone on remineralization processes and the balance between photosynthesis and respiration.

Research during ROSSMIZE cruise focused on the sea ice-covered zone and its northern edge during early spring. The aim of this study was to measure respiratory activity of microplankton in the water column under the pack-ice zone and in the marginal ice zone (MIZ), in order to improve the understanding of respiratory losses of newly formed organic carbon in these two subsystems.

Material and methods

The ROSSMIZE cruise was carried out from 16 November to 16 December1994, on board the R/V *Italica* in the Ross Sea (Fig. 1).

Microbial respiratory activity (<200 µm) was determined according to the ETS (Electron Transport System) assay, corrected to in situ temperature using an Arrhenius activation energy of 11 Kcal mol^{-1} (4) and converted to carbon dioxide production rates using a respiratory quotient of 1 (1). Sampling depths were selected according to optical levels (50, 20, 10, 5, 1 and 0.1% of incident irradiance) in the upper 100 m using a SBE 32/24 Carousel; a surface sample was also included.

Results and discussion

On the base of pack-ice cover, two main zones were distinguished on different spatial scales along a S-N transect: an area with pack-ice in its northern part (PIZ) and the marginal-ice zone (MIZ) in the southernmost part, characterized by drifting fragmented ice (Fig. 1).

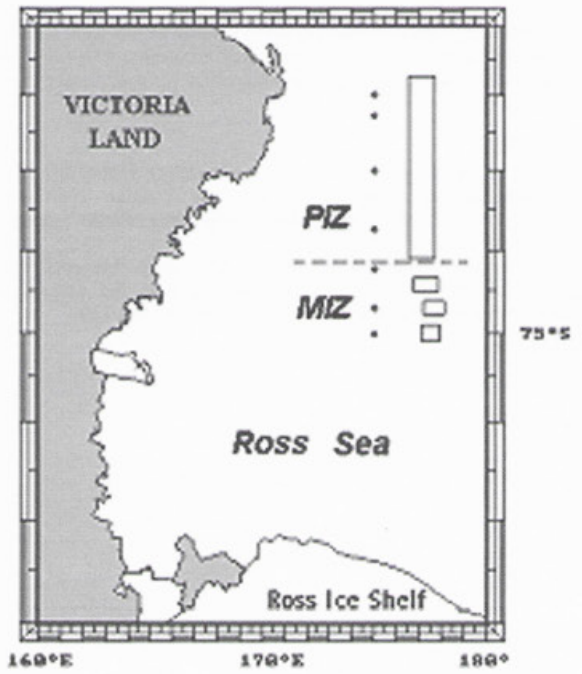


Fig.1. Map of sampling locations and pack ice typology.

In the PIZ, characterized by a prevalence of microphytoplankton (5), ETS activity ranged from 0.14 to 1.47 ml O_2 $h^{-1}m^{-3}$ (mean value ± SD: 0.85 ± 0.35 ml O_2 $h^{-1}m^{-3}$). A higher ETS activity was found in the MIZ (range: 0.17 to 2.81ml O_2 $h^{-1}m^{-3}$; mean value ± SD: 1.47 ± 0.80ml O_2 $h^{-1}m^{-3}$) where the picoplankton prevailed. The median ETS activity was 0.93 ml O_2 h^{-1} m^{-3} for the PIZ subsystem and 1.47ml O_2 h^{-1} m^{-3} in the MIZ (Fig.2). Mean depth integrated values of ETS activity in the PIZ and the MIZ were as mean 77.9 and 117.2 ml O_2 $h^{-1}m^{-2}$, respectively, confirming the different respiratory levels calculated on meter cubic basis. All these values fall in the same range of other published data for polar regions (2).

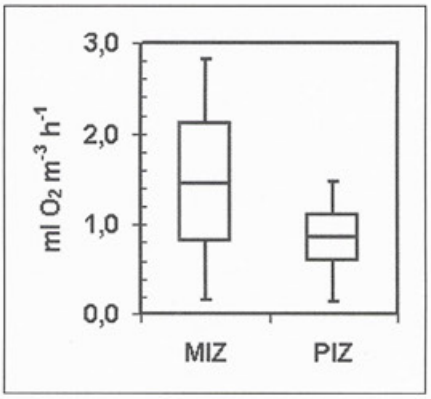


Fig.2. Box-and-whisker plots showing the range and the median ETS activity in MIZ and PIZ.

The different levels of respiratory activity observed in the two subsystems were statistically different (ANOVA test: MIZ versus PIZ $p<0.01$) and reflected the spatial variations of phytoplankton biomass and productivity determined on the same cruise (5). ETS activity correlated (r=0.42; n=44) with primary production (5), revealing a coupling between productive and consumptive processes according to previous field studies in the Antarctic Ocean (1, 3). With the aim to determine the overall system's metabolism of the two subsystems, the ratio between photosynthesis and respiration (P/R) was calculated. Our results show a different scenario for the MIZ and the PIZ, with ratios P/R=1.9 and P/R=0.3, respectively. These results are consistent with that of Martinez and Estrada (1) reported for the ice edge and below the ice cover of the Wedell Sea.

In conclusion this study indicates that: A) Levels of respiratory activity are lower under the ice and enhanced in the MIZ. B) The MIZ ecosystem was net autotrophic (P/R>1) while the PIZ was net heterotrophic (P/R<1) during the investigation period.

References

1 - Martinez R., and Estrada M., 1992. Respiratory electron transport activity of microplankton in the Weddel Sea during early spring: influence of the ice cover and the ice edge. *Polar Biology*, 12: 275-282.

2 - Arìstegui J., and Montero F., 1995. Plankton community in Bransfield Strait (Antarctic Ocean) during austral srping. *Journal of Plankton Research*, 17: 1647-1659.

3 - Estrada M., Martinez R., and Mathot S., 1992. Respiratory electron transport system activity in microplancton of the Weddel and Scotia Seas during late spring-early summer. Relationschips with other biological parameters. *Polar Biology*, 12: 35-42.

4 - Packard T.T., and Williams P.J. leB, 1981. Rates of respiratory oxygen consumption and electron transport in surface sea water from the northwest Atlantic. *Oceanologica Acta*, 4: 351-358.

5 - Saggiomo V., Carrada G.C., Mangoni O., Ribera d'Alcalà M., and Russo A., 1998. Spatial and temporal variability of size-fractioned biomass and primary production in the Ross Sea (Antarctica) during austral spring and summer. *Journal of Marine Systems*, 17: 115-127.

GROWTH AND PHYLOGENETIC COMPOSITION OF THE BACTERIAL ASSEMBLAGE DURING A LAGRANGIAN STUDY IN THE RHONE RIVER PLUME

Vanessa Balagué *, Beatriz Díez, Andrea Malits, Ramon Massana, Cèlia Marrasé, Carlos Pedrós-Alió
Institut de Ciències del Mar, CMIMA, CSIC, Ps. Marítim de la Barceloneta 37-49,
E-08003 Barcelona, Catalonia, Spain, * vbalague@icm.csic.es

Abstract
The Rhone River drains freshwater into the northwestern Mediterranean forming a plume that moves along the slope of the Catalan continental platform. This plume constitutes a water mass that can be followed in time in a Lagrangian way. We followed the water mass in cruise ARO2000 on board B/O *García del Cid* in early June 2000. Hydrography, concentrations of nutrients and the abundance and activities of microorganisms were determined simultaneously. Here we present the abundance, heterotrophic production and phylogenetic composition of the bacterioplankton in the plume.

Keywords: DGGE, Plume

The plume was tracked by three Argos buoys. Waters in the vicinity of the buoys were sampled at least once a day. Samples were taken with Niskin bottles in a rosette with a CTD profiler. Bacteria were counted by flow cytometry. Aliquots were incubated with ^{3}H-leucine to determine bacterial heterotrophic production.

Samples for DNA were filtered through 0.22 µm pore diameter Sterivex filters. DNA was extracted according to Schauer et al. (1). A PCR amplification was carried out with bacterial specific primers and the products were separated in a DGGE. The most abundant bands were excised and sequenced (2).

Figure 1 shows bacterial numbers (filled circles), bacterial heterotrophic production (empty circles), chlorophyll a (empty circles) and the percent of high DNA bacteria (filled circles). There was a storm on June 6 (arrow in Fig 1) that changed conditions. The first five days can be safely assumed to represent the same water mass and the same microbial assemblage. Bacteria grew during this period as chlorophyll decreased. Bacteria almost doubled in four days and there was a parallel increase in bacterial heterotrophic production. The percent of high DNA bacteria was relatively high during the first three days and decreased thereafter.

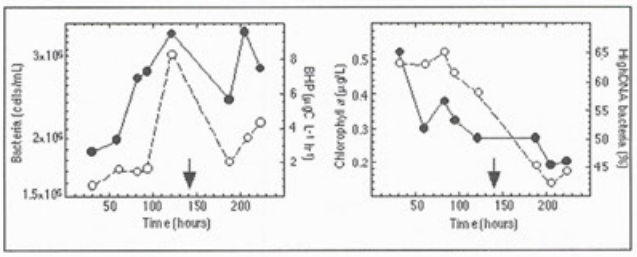
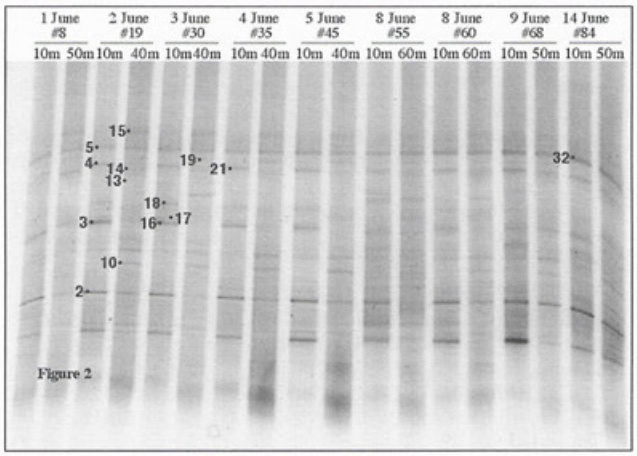


Figure 2 shows the DGGE gel for the whole period. For each sampling date, two samples are shown. The sample from 10 m depth corresponds to the plume and the second one to deeper water below the plume. The band patterns for the plume and the water outside were quite different. Thus, the plume had its own bacterial assemblage. On the contrary, the band patterns were very similar through the Lagrangian part of the study. Only after the storm some differences were observed. Most of the sequenced bands belonged either to the Cytophaga-Flavobacterium or to the alpha-Proteobacteria groups. All of the bands were closely related to uncultured clones. The only exception was band 5 that belonged to the recently isolated SAR11 group. A rather predominate band [2] was related to the *Roseobacter* clade.



The dynamics of bacterioplankton populations in the ocean are largely unknown. We have attempted to determine the scales in space and time at which bacterial assemblages change in the ocean. In previous studies we looked at spatial (1) and temporal (2) changes in the composition of the bacterioplankon in the coastal northwestern Mediterranean. The present study concentrated on short time changes in the bacterioplankton taking advantage of a hydrographical situation that allowed a Lagrangian study. Despite a doubling in bacterial numbers, the composition of the assemblage did not change significantly. Only after a storm occurred some changes were apparent in the DGGE band patterns. This constancy is consistent with the very smooth and slow changes in composition that we had observed in a seasonal study (2).

References

1 - Schauer, M., R. Massana and C. Pedrós-Alió. 2000. Spatial differences in bacterioplankton composition along the Catalan coast (NW Mediterranean) assessed by molecular fingerprinting. *FEMS Microbiol. Ecol.*, 33: 51-59.

2 - Schauer, M., V. Balagué, C. Pedrós-Ali and R. Massana. 2003. Temporal changes in bacterioplankton diversity in the oligotrophic Mediterranean Coast. *Aquatic Microbial Ecology*, 31:163-174.

ADHESION OF DIFFERENT MARINE BACTERIA, OUTERMEMBRANE PROTEINS AND LIPOPOLYSACCHARIDE PRODUCTION

Maria Blažina [1] *, Paolo Landini [2], Mirjana Najdek [1], Dragica Fuks [1] and Vesna Svetličić [3]
[1] Center for Marine Research, Ruder Bošković Institute, Rovinj, Croatia,
[2] Swiss Federal Institute of Environmental Technology (EAWAG), 8 600 Dübendorf, Switzerland
[3] Center for Marine and Environmental Research, Ruder Bošković Institute, Zagreb, Croatia
* maria.madzarac@cim.irb.hr

Abstract

Marine bacteria were identified by fatty acid analysis and their ability to attach to surfaces was tested. We found that bacteria belonging to *Cytophaga-Flavobacteria* (*CF*) displayed stronger adhesion properties than the *γ-Proteobacteria* isolates, thus suggesting that *CF* might be favoured in aggregate colonisation. These differences are also reflected in different outer membrane proteins and lipopolysaccharide composition.

Key words: marine bacteria, adhesion, mucilaginous aggregates, northern Adriatic

Introduction

Microbial exopolysaccharides (EPS) are carbohydrate-enriched polymers produced by microalge and bacteria that bind aggregates and form dense biofilms near the sediment-water interface. EPS synthesized by attached bacteria strengthen their binding to surfaces, but outer membrane proteins (OMP) are required for the early stages of adhesion (1).

Our aim was to determine the differences in EPS at the cell-surface of diverse strains commonly found in sediment and mucilaginous aggregates, and in attachment of these strains to solid surfaces.

Materials and Methods

Six Gram-negative bacterial strains isolated from northern Adriatic seawater were grown in Marine Broth, at 25°C with vigorous shaking. Each isolate was saponified, methylated and their fatty-acid (FA) patterns were analysed by GC/MSD. OMP and LPS of the strains were extracted and analysed by one-dimensional sodium dodecyl sulfate-polyacrylamide (SDS-PAGE) and polyacrylamide (PAGE) gel electrophoresis, respectively (2). For adhesion assays, cultures were washed and re-suspended in phosphate-buffered saline (PBS). The suspensions were loaded onto columns filled with pure sea sand (Fluka), fractions were collected and cell adhesion to sand was measured as the ratio of the optical density (OD_{280}) in each column fraction to the OD_{280} of the initial bacterial suspension (2).

Results and discussion

Bacterial isolates had FA patterns corresponding to *Cytophaga-Flavobacteria* (7, 25, 30, 31) and *Proteobacteria* (6, 38). PAGE analysis of EPS demonstrated a marked difference between marine bacteria 7/25, 38 and other three strains (Fig. 1). LPS analysis of strain 7 and 25 gave the same band, but slightly more expressed in strain 7. Strains 30 and 38 had a strong LPS and OMP analysis highlighted the differences in the extracellular composition of different bacteria: strains 7 and 25 produced acidic EPS that ran as a smear in PAGE (Figure 1A). In contrast, strains 30 and 38 produced high MW LPS, detectable as a dense band at the top of the gel. In addition, strain 38 produced lower MW EPS. Analysis of OMP highlighted the production of different dominant bands, expressed in strains 7, 25 (around 30 kDa) and 38 (around 40 kDa). In addition, higher MW bands were present in strains 7 and 25. Differences in the extracellular structures were reflected in adhesion properties: adhesion tests showed efficient attachment by strains 7, 25, 30 and 31 belonging to the *CF* group while 6 and 38 (*Proteobacteria*) displayed poor adherence (Fig. 2).

Favourable adhesive capabilities of *Cytophaga-Flavobacteria* indicate that these bacteria are well adapted for colonising solid surfaces. Since they mainly utilise decomposing refractory macromolecules, they can meet their nutritional requirements in the mucous matrix of aggregates or on epipelic biofilms (3), without having to compete with *Proteobacteria*, which mainly utilise lower MW substances. In mucilaginous aggregates found during periods of unusually massive aggregation in northern Adriatic, increasing proportions of branched fatty acids on aged mucilaginous aggregates (4) indicate more efficient aggregate colonization by *Cytophaga-Flavobacteria* over other bacterial populations. Differences between *CF* strains in OMP and LPS expression could allow us to define different mechanisms of adhesion control and should be further investigated.

Acknowledgement

The support of the project "Identification of bacterial structures important for bacterial adhesion using electrochemical adhesion sensors" (7KRPJO65706) is acknowledged.

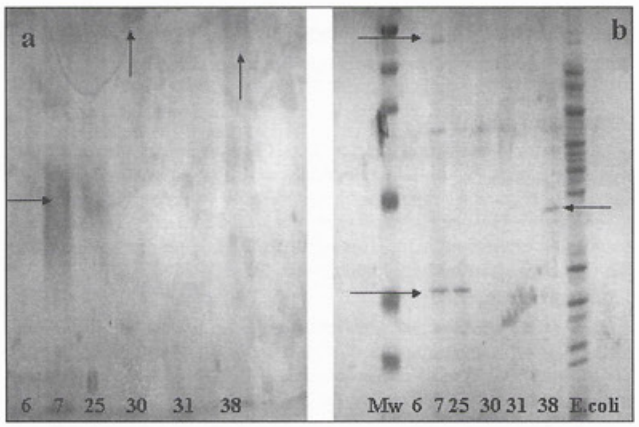


Fig. 1. a) PAGE analysis of bacterial LPS, and b) SDS-PAGE analysis of bacterial OMP.

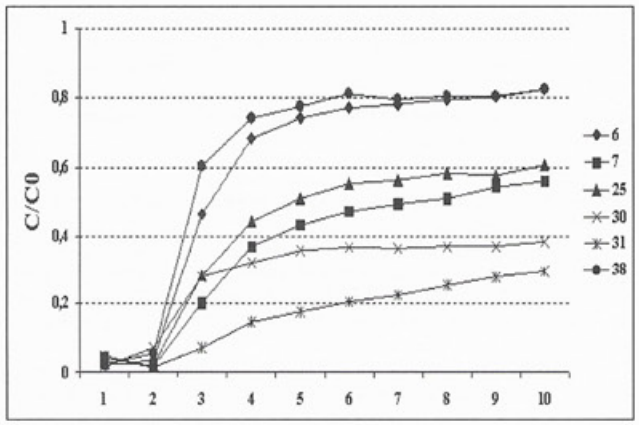


Fig. 2. Adhesion to a sand column. The C/C_0 value was calculated as the ratio of bacteria recovered from the flow-through column to bacteria loaded onto the column for each fraction.

References

1 - Jucker, B., Harms, H. and Zehnder, A. 1996. Adhesion of the Positively Charged Bacterium *Stenotrophomonas (Xantomonas) maltophilia* 70401 to Glass and Teflon. *J. Bacteriol.*, 178 (18): 5472-5479.

2 - Landini, P. and Zehnder, A. 2002. The Global regulatory *hns* Gene Negatively Affects Adhesion to Solid Surfaces by Anaerobically Grown *Escherichia coli* by Modulating expression of Flagellar Genes and Lipopolysaccharide Production. *J. Bacteriol.*, 184 (6): 1522-1529.

3 - Kirchman, D.L. 2001. The ecology of *Cytophaga-Flavobacteria* in aquatic environments. *FEMS Microbiol. Ecol.*, 39: 91-100.

4 - Najdek, M., Degobbis, D., Miokovic, D. and Ivancic, I. 2002. Fatty acid and phytoplankton compositions of different types of mucilaginous aggregates in the northern Adriatic. *J. Plankton Res.*, 24 (5): 429-441.

ETUDE DE LA SURVIE DE *SALMONELLA TYPHIMURIUM* EN EAU DE MER NATURELLE

Imen Boukef [1] *, Monia Elbour [1], Patrice Got [2], Marc Trousselier [2], Abdellatif Boudabbous [3]

[1] Laboratoire de Microbiologie, Institut National des Sciences et Technologie de la Mer, Salaambo, Tunisie
[2] Laboratoire d Hydrobiologie Marine, Université Montpellier II, France
[3] Laboratoire de Microbilogie, Faculté des Sciences, Tunis, Tunisie

Résumé

La présente étude est effectuée en vue de suivre l'état de survie de *Salmonella typhimurium* cultivée en eau de mer naturelle. Ainsi un modèle bactérien expérimental *S. typhimurium* a été utilisé pour suivre la survie de la bactérie dans des conditions différentes (i) survie en eau de mer à l'obscurité pendant 32 jours à température ambiante (22°C), (ii) survie en eau de mer en condition de rayonnement solaire pendant 4 heures.

Le suivi a concerné la cultivabilité (dénombrement des cellules cultivables), la détermination des cellules totales par marquage au Syber Green et l'intégrité membranaire par le test Live/Dead.

Les résultats obtenus montrent que pour les cellules maintenues en eau de mer à l'obscurité nous avons une décroissance de cellules cultivables (3 ULog) avec une altération de l'intégrité membranaire au bout du 18 jours de culture.

Cependant, pour les cellules ayant subi l'effet du rayonnement solaire, nous avons obtenu une décroissance de cultivabilité plus importante (4ULog) au bout de 4 heures avec une altération de l'intégrité membranaire décelée précocement.

Mots clés : Survie, Salmonalla typhimurium, VNC.

Introduction

Le devenir des entérobactéries dans l'écosystème marin a suscité plusieurs études (1, 2, 3). Cependant, seul un nombre restreint d'études a été mené en Tunisie (4, 5). La présente étude est établie en vue de comparer la survie de *S. typhimurium* C52 et *S. typhimurium* isolées de l'environnement, en condition d'eau de mer naturelle filtrée exposée ou non au rayonnement solaire.

Matériel et méthodes

les souches étudiées : *S. typhimurium* C52, fournie par le laboratoire d'hydrobiologie marine de l'université de Montpellier II et *S. typhimurium* (k) isolée à partir des eaux usées d'une stations d'épuration et identifiée à l'institut pasteur de Tunis.

Conditions expérimentales : les microcosmes de cultures sont des précultures de 24 heures, lavées et maintenues dans des flacons d'eau de mer filtrée sur 0.2 µm (pH : 4.18, O_2 : 7.56, salinité : 37.8 %).

Les microcosmes sont suivis en condition (i) eau de mer naturelle filtrée à l'obscurité, (ii) en eau de mer filtrée exposée au rayonnement solaire et l'intensité lumineuse et la température sont relevées.

Les paramètres suivis sont : la cultivabilité (dénombrement en CFU), le taux des cellules totales détecté en épifluorescence après marquage au Sybr Green et le pourcentage des cellules intègres déterminé par le test Live/Dead.

Résultats

Tests de survie en eau de mer naturelle filtrée à l'obscurité et à une température ambiante :

Le dénombrement des cellules cultivables pour les souches *S. typhimurium* C52 et K présente une diminution similaire pour les deux souches. Cependant, la souche *S. typhimurium* C52 ne présente une dimunution b du nombre de cellules cultivables qu'après 4 jours de latence (Fig.1a).

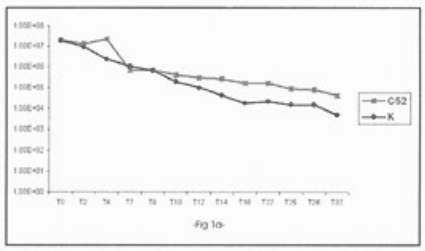
En comparaison de résultats obtenus antérieurement, nous constatons que *S. typhimurium* conserve sa cultivabilité plus longtemps (6, 7), probablement due à la présence de matière organique dissoute dans l'eau de mer naturelle filtrée (2).

Le taux des cellules intègres pour les deux souches C52 et K présente une diminution similaire, néanmoins, le nombre des cellules totales reste constant durant toute la durée de l'expérience (Fig.1b).

Tests de survie en eau de mer sous l'effet du rayonnement solaire :

Le dénombrement des cellules cultivables de *S. typhimurium* C52 et K présente une diminution de même ordre après 4 heures d'exposition.

Le taux des cellules intègres pour *S. typhimurium* C52 et K décroît sous l'effet du stress. Cependant, cette diminution est plus importante pour *S. typhimurium* K (souche sauvage); ceci serait dû probablement à une forme de résistance plus prononcée chez cette souche isolée de l'environnement (1),(8),(9). Le nombre de cellules totales est maintenu constant durant l'expérience.



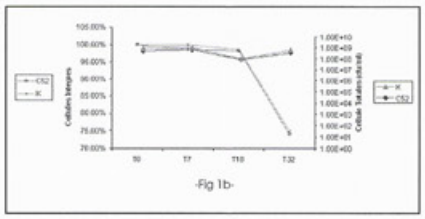


Fig. 1 : suivi de la survie en eau de mer à l'obscurité de *Salmonella typhimurium* C52 et K (32 jours)
(a) suivi de la variation des cellules cultivables (cfu/ml).
(b) suivi de la variation des cellules intègres (%) par rapport aux cellules totales.

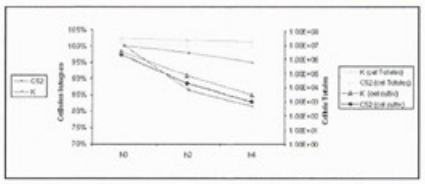


Fig. 2 : suivi de la survie de *Salmonella typhimirium* (C52 et K) en eau de mer avec exposition au rayonnement solaire. Variation en nombre des cellules cultivables (cfu/ml) et en nombre des cellules intègres (%) par rapport aux cellules totales (cfu/ml).

Références

1 - Gauthier M.J. *et al.*, 1993. Nouvelles perspectives sur l'adaptation des entérobactéries dans le milieu marin. *Mar. Life*, 3, n°1-2: 1-18.

2 - Dupray E. et Derrien A., 1995. Influence du passage de *Salmonella* spp et *E. coli* en eaux usées sur leur survie ultérieure en eaux de mer. *Wat. Res.*, 29, 4: p1005-1011.

3 - Trousselier M. *et al.*, 1998. Responses of enteric bacteria to environmental stresses in seawater. *Oceanologica Acta*, 21,6: 965-981.

4 - Bakrouf A., 1992. Bactériologie des eaux critères et études des variations somatiques des bactéries pathogènes en milieu marin (*Pseudomonas aeruginosa, Salmonella paratiphy B, Vibrion paraheamolitycus et Vibrio algynolitycus).* Thèse d'état Faculté de Pharmacie Monastir et l'unité INSERM (Santé Nice).

5 - Zaafran S., 2002. Effet de la lumière solaire sur la survie de *Salmonella typhimurium* en milieu marin. Thèse de doctorat en sciences biologiques Faculté des sciences de Tunis.

6 - Caro A. *et al.*, 1999. Physiological changes of *Salmonella typhimurium* cells under osmotic and starvation conditions by image analysis. *FEMS Microbiology Letters*, 179: 265-273.

7 - Joux F. *et al.*, 1997. Succession of cellular states in a *Salmonella typhimurium* population during starvation in artificial seawater microcosms. *FEMS Microbiology Letters*, 22: 65-76.

8 - Mezrioui. N. *et al.*, 1995. A microcosm study of the survival of *Escherichia coli* and *Salmonella typhimurium* in brackish water. *Wat. Res.*, 29, 2: 459-465.

9 - Baleux B. *et al.*, 1998. Survie et maintien de la virulence de *Salmonella typhimurium* VNC exposée simultanément à trois facteurs stressants expérimentaux. *Oceanologica Acta*, 21, 6: 939-950.

10 - Sinton L.W. *et al.*, 2002. Sunlight inactivation of fecal indicator bacteria and bacteriophages from waste stabilisation pond effluent in fresh and saline waters. *Applied and Environmental Microbiology*, 68, 3: 1122-1131.

MESOSCALE DYNAMICS OF PICOPHYTOPLANKTON IN THE MEDITERRANEAN SEA, WITH A FOCUS ON PHOTOACCLIMATION RESPONSES

C. Brunet [1] *, R. Casotti1 and V. Vantrepotte [2]

[1] Stazione Zoologica di Napoli, Villa Comunale, 80121 Napoli, Italy - * brunet@szn.it
[2] Université du Littoral, LISE, UPRES-A ELICO 8013, 62930 Wimereux, France

Abstract
Phytoplankton dynamics were investigated at the Italian side of the Strait of Sicily in July 1997 using HPLC pigment analysis of fractionated samples (< 3 µm and > 3 µm) and flow cytometry. Phytoplankton were dominated by the picoplankton fraction (more than 80% of total chlorophyll), which was numerically dominated by cyanobacteria of the genus *Prochlorococcus*, with average concentrations of 6.2 x 10^4 cell ml^{-1}. Picophytoplankton composition varied with water mass characteristics and along the water column, with the highest pigment diversity observed in the DCM. Photoacclimation responses were investigated using both, on board incubations and high-rate sampling at one site, and showed a strong response of the picoeukaryotic component to the diel light cycle.

Keywords: phytoplankton pigments, diel variability, flow cytometry, photoacclimation

The Strait of Sicily is a highly dynamical area, where different water masses mix, originating from the Atlantic Ocean and the western basin, the Levantine basin, and the Adriatic Sea (1). As a consequence, the area is hydrologically dynamic and several mesoscale physical structures are frequently present, such as filaments or meanders. It is therefore a site very suited to study the physical-biological coupling at mesoscales. In July 1997 a cruise took place in the framework of the SYMPLEX project (Synoptic Mesoscale Plankton Experiment), aimed at investigating phytoplankton dynamics as related to mesoscale physical structures. Several transects were sampled across a coastal filament, originating from horizontal advection of deep waters upwelling along the southern coast of Sicily. Apart from discrete samples taken at 45 stations (8 depths), also a fixed station was sampled every 3 h for a total of 50 h at 6 depths. At the same time as the fixed station, on-board incubations on filter-fractionated samples were done, to compare physiological responses to the diel light cycle and variations induced by changes in the light field, as for example induced by upwelling or mixing.

Mesoscale sampling

The filament separated a western area, dominated by the modified Atlantic Water (MAW), detected from its lower salinity in the first 50 m, from the so-called Ionian Water (IW), present in the eastern area, which was saltier. A strong horizontal temperature gradient (front) delimited the filament of cold water upwelling along the southern coast of Sicily, which was also very evident from satellite imagery (AVHRR). Phytoplankton biomass was low in the whole area (chl *a* average of 0.09 µg l^{-1} ± 0.08 µg l^{-1}), characterized by a recurrent Deep Chlorophyll Maximum (DCM), situated between 60 and 100 m depth) with picophytoplankton dominating (up to 94% of total chl *a*). The highest phytoplankton diversity was observed in the picoeukaryotic component (< 3 µm in size) of the DCM, with dinophytes, pelagophytes, prymnesiophytes and chlorophytes contributing to a significant fraction of the total chl *a* biomass of this fraction. Prokaryotic phytoplankton (*Synechococcus* and *Prochlorococcus*) dominated mainly in the MAW (more than 60%), while in the deeper DCM picoeukaryotes dominated (69%). In the IS, the relative percentage of phytoplankton < 3 µm was slightly lower than in the MAW, but picoeukaryotes dominated as well. Inside the filament, high concentrations of *Prochlorococcus*, with a higher cell red fluorescence with respect to the surrounding stations, clearly marked the deep origin of this cold water.

Diel sampling and on-board incubations

In order to estimate velocities of the vertical transport of phytoplankton during the upwelling, cellular red fluorescence estimated through flow cytometry on the picophytoplankton fraction was analyzed, and compared with both the data from the diel cycle sampling and the on board-incubations. The water column at the fixed station, located east of the filament, was strongly thermally stratified for the whole sampling period. Picophytoplankton dominated the DCM (70% of total chl *a*), located between 70 and 90 m depth (1.55 to 0.45% of incident light), and *Prochlorococcus* and picoeukaryotes dominated the picophytoplankton. Larger size phytoplankton dominated, instead, the surface layer of the water column. Photoprotective pigment markers, such as the ratios zeaxanthin/(violaxanthin + antheraxanthin + zeaxanthin) and Diatoxanthin/ (Diatoxanthin + Diadinoxanthin) showed high values in surface waters in the picophytoplankton fraction (both ratios) or in the larger phytoplankton (the second ratio), indicating the need of photoprotection in surface waters due to the excess light intensities present at the time of sampling. This process showed a significant diel variation in both size classes in the first 20 m, but indicated a faster reaction in the picophytoplankton fraction, suggesting a higher physiological plasticity of these small-sized algae, at least with respect to light utilization. Surprisingly, diel variations were observed even in the DCM, even though very little light irradiances were measured, suggesting that a response to the diel light cycle was present even at very low light intensities.

The on-board incubations consisted of incubating natural phytoplankton assemblages at higher (shift-up) or lower (shift-down) light intensities than present at their sampling depth, in order to estimate kinetic coefficients of the photoacclimation reaction. The shift-up experiments showed a very fast synthesis of Diatoxanthin with respect to total chl *a* in the picophytoplankton, suggesting faster photoacclimating responses of these algae as compared to larger phytoplankton (0.29 versus 0.10 h^{-1}). For the shift down experiment (from 1% to 0.1% incident light), no change in pigments was observed, but a significant increase in divinyl-chl *a*, a marker of *Prochlorococcus*, indicating a very strong photoacclimation response of this species, which successfully occupies the very deep layers of the water column. From flow cytometric detection of cellular red fluorescence of chlorophyll, it has been observed that the kinetics of low-light acclimation of *Prochlororcoccus* was much faster than that of *Synechococcus*, while the opposite was true for the kinetic of high-light acclimation. This confirms the hypothesis that *Synechococcus* is more adapted to high-light, nutrient poor surface waters, while *Prochlorococcus* is better suited to low-light, high nutrients waters reflecting their relative vertical distribution. The analysis of the picophytoplankton community proved to be a powerful tool to describe water mass changes and to estimate variations of physiological processes over time, which, in turn, may help to estimate vertical velocities of mixing in the surface layer of the water column (2).

References

1 - Bohm E., Nardelli B. B., Brunet C., Casotti. R., Conversano F., Corato F., D'Acunzo E. , D'Ortenzio F., Iudicone D., Lazzara L., Mangoni O., Marcelli M., Marullo S., Massi L., Mori G., Nardello I., Nuccio C., Ribera d'Alcala M., Saggiomo V., Santoleri R., Scardi M., Sparnocchia S., Tozzi S., Zoffoli S., 1998. SYMPLEX Experiment: first results on oceanic mesoscale dynamics and related primary production from AVHRR and SeaWifs satellite data and field experiments. SPIE, 3496 : 137-148.

2 - Brunet C., Casotti R., Aronne B. and Vantrepotte V., 2003. Measured photophysiological parameters used as tools to estimate vertical water movements in the coastal Mediterranean. *J. Plankton Research*, 25, in press.

BACTERIAL EXTRACELLULAR ENZYMATIC ACTIVITIES IN A TYRRHENIAN ECOSYSTEM (GULF OF MILAZZO)

Caruso G., * Decembrini F., Azzaro F., Raffa F., Galletta M.G.

Istituto per l'Ambiente Marino Costiero (IAMC) - Section of Messina, C.N.R., Messina, Italy - * caruso@ist.me.cnr.it

Abstract

Leucine aminopeptidase, β-glucosidase and alkaline phosphatase activities were estimated by fluorogenic substrates in a Tyrrhenian ecosystem; two different periods were studied, as indicative of different hydrographic structures (i.e., water column stratification and homogeneity). The measured values of metabolic activities sometimes followed a general decreasing coastal-offshore gradient; during water homogeneity, enhanced leucine aminopeptidase activity rates, heterotrophic and autotrophic biomasses occurred, while during water stratification high levels of metabolic activity were detected.

Key-words: Enzymes, bacteria, phytoplankton biomass, Mediterranean Sea

Introduction

Heterotrophic bacteria, which play a major role in the particulate to dissolved matter transformation, are known to promptly respond to environmental changes, modifying their metabolic patterns according to available organic compounds. Microbial activity rates are enhanced in highly enriched environments (1, 2). The Gulf of Milazzo ecosystem is located along the north-eastern coast of Sicily; in its more western part it receives organic matter inputs coming from stream and urban and industrial settlements. A tendency of this area towards eutrophication has been observed in the past (3). Unlike the hydrological and general biological parameters, bacterial dynamics and metabolism in this ecosystem remained poorly understood. As part of the Cluster 10 - MIUR Project, aimed at monitoring coastal Sicilian areas, the distribution and variation in extracellular enzymatic activity and bacterial abundance together with the phytoplankton biomass, were investigated. Focus was put on evaluating both the autotrophic and heterotrophic communities in relation to spatial (i.e., effect of continental input) and temporal scale (i.e., trophic status of waters due to seasonal organic enrichment).

Materials and Methods

Two oceanographic cruises (December 2002 and February 2003) have been performed by the R/V *L. Sanzo* of the IAMC-CNR, in the Gulf of Milazzo during late fall and winter, as representative of different hydrological conditions (water stratification and homogeneity, respectively). The ecological characteristics of the area are described in the same issue (4). Seawater samples (n=15 for each cruise) were collected by a rosette sampler above, within and below the Deep Chlorophyll Maximum (DCM) along a coastal-offshore transect located in the central-western section of the Gulf (latitude 38°12'N, longitude 15°14'E to latitude 38°17'N, longitude 15°22'E). The following parameters were measured: temperature, salinity, dissolved oxygen, fluorescence, nutrients (ammonia, nitrate, orthophosphate), autotrophic biomass expressed as chlorophyll-*a* (Chl-*a*), extracellular enzymatic activities (leucine aminopeptidase, AMP, β-glucosidase, β-Glu, alkaline phosphatase, AP) and heterotrophic bacterial abundance (MA) by Marine agar plate counts. Bacterial extracellular enzyme activities (EEA), expressed as the maximum velocity of hydrolysis (V_{max}), were determined using the specific fluorogenic substrates L-leucine-7-amido-4-methyl-coumarin hydrochloride (LEU-MCA), 4-methylumbelliferyl (MUF)-ß-glucoside and MUF-phosphate for the ectoenzymatic activities AMP, β–Glu and AP (2).

Results

Enzyme patterns displayed a general decreasing trend with increasing distance from the coast in both the periods examined. In December 2002, AMP values ranged from 0.284 to 15.36 µM/h, while β-GLU and AP values were between 0.0545 and 3.562 nM/h and between 0.14 and 867.62 nM/h, respectively. Heterotrophic bacteria ranged from 2 to 57 CFU/100ml. Auto- and heterotrophic biomasses, calculated from all the data, were significantly reciprocally correlated ($r= 0.758$, $P<0.01$, $n=13$) and correlated with temperature ($r= 0.734$ and 0.941, $P<0.01$, $n=13$, for MA and Chl-*a* respectively). In the stratified surface layer, the highest AMP and AP levels, as well as Chl-*a* and MA concentrations were found. Here, the metabolic activities correlated positively with temperature ($r= 0.997$, $P<0.01$; 0.954, $P<0.05$; 0.993, $P<0.01$, $n=4$ for AMP, β-Glu and AP respectively).

The stratified water structure was also reflected in the highest coefficient of variations (C.V.= standard deviation/mean *100) measured for heterotrophic (94.96) and autotrophic (50.53) biomasses. Within the DCM layer, phytoplankton contributed to the release of AP, as suggested by the close relationship ($r= 0.938$, $P<0.05$, $n=4$) between AP and Chl-*a*. Below this layer, the heterotrophic growth correlated with phytoplankton biomass, as shown by the MA-Chl-*a* relationship ($r= 0.976$, $P<0.05$, $n=4$). In February 2003, when water column became mixed, values of about 2 orders of magnitude higher than those previously observed were found for AMP (12.31-73089.26 nM/h) and bacterial heterotrophic density (70-1880 CFU/100ml). A similar increasing pattern was displayed by Chl-*a*, with values (from 0.065 to 0.45 µg/l) higher than in December (0.015 to 0.238 µg/l). The phytoplankton growth was supported by high ammonia (0.10-7.02 µM) and inorganic phosphate (0.09-1.01 µM) amounts available in this period. In contrast, AP and β-Glu activity values were lower than in December, ranging from 0.256 to 463.96 nM/h and from 0.00107 to 0.01505 nM/h, respectively. Peaks of AP and Chl-*a* shifted from surface towards intermediate depths, following the slight increase (0.37 °C) of temperature towards the bottom, while AMP activity and MA did not seem affected by the hydrological condition, being always higher in surface layers. Within the DCM layer, all the bacterial enzyme activities were significantly reciprocally correlated ($r= 0.989$, $P<0.01$; 0.952 and 0.909, $P<0.05$, $n=4$, for AMP-AP, AMP-β-Glu and β-Glu-AP, respectively).

Discussion

The bacterial activity values measured in our study ranged in the same order of magnitude as those reported for other pelagic Mediterranean waters (5). AMP was the prevalent enzyme, as observed in other temperate environments (6). Although the supply of terrigenous organic matter determined a spatial decreasing pattern of bacterial activity towards offshore stations, some enzyme peaks were also observed offshore in relation to the particular (anticyclonic) mesoscale water column structure (4). Temporal variations in organic matter decomposition rates were also found. In the well-mixed water column, the availability of nutrients supported both autotrophic and heterotrophic growth. When the water column becomes stratified, enhanced activity rates towards more refractory compounds were found. This preliminary study contributes to the knowledge of mean-term changes in microbial processes in Mediterranean ecosystems in relation to environmental conditions.

References

1 - Azam F., Smith D.C., Steward G.F., and Hagstrom A., 1993. Bacteria-organic matter coupling and significance for carbon cycling. *Microb. Ecol.*, 28: 167-179.

2 - Hoppe H.G., 1993. Use of fluorogenic model substrates for extracellular enzyme activity (EEA) measurement of bacteria. Pp. 423-431. *In:* Kemp P.F., Sherr B.F., Sherr E.B., Cole J.J. (eds), Handbook of methods in aquatic microbial ecology. Lewis Publ., Boca Raton.

3 - Giacobbe M.G., Maimone G., and Crisafi E., 1986. Analisi dei popolamenti fitoplanctonici e batterici di un'area del Golfo di Milazzo (Messina) nella prospettiva di un suo utilizzo in acquacoltura. *Nova Thalassia*, 8: 57-79.

4 - Decembrini F., Azzaro F., Galletta M.G., and Raffa F., this issue. Short-term changes of hydrobiological features in the Gulf of Milazzo (Tyrrhenian Sicily).

5 - Zaccone R., La Ferla R., Azzaro M., Caruso G., and Crisafi E., 2001. Spatial and temporal variations in microbial activity in the Mediterranean Sea. *Arch. Oceanogr. Limnol.*, 22: 199-206.

6 - Hoppe H.G., Arnosti C., and Herndl G.J., 2002. Ecological significance of bacterial enzymes in the marine environment. Pp.73-107. *In:* Burns R.G. and Dick R.P.(eds), Enzymes in the environment. Activity, ecology and applications. Marcel Dekker Inc., New York-Basel.

COASTAL POLLUTION MONITORING OF SOUTHERN ITALIAN SITES BY THE MUG ASSAY

Caruso G. *, Crisafi E., Mancuso M.

Istituto per l'Ambiente Marino Costiero (IAMC) – Section of Messina, C.N.R., Messina, Italy - * caruso@ist.me.cnr.it

Abstract

A five-year study was carried out on coastal samples collected from Sicilian and Calabrian areas in order to test the performance of an enzyme approach in comparison with the immunofluorescence (IF) and standard culture (FC) methods. The MUG assay was found to be more indicative of the *Escherichia coli* population, as estimated by IF method, than of the whole faecal coliform group determined by plate counts. The usefulness of MUG assay for monitoring mean and heavily polluted areas is suggested.

Keywords: Pollution, bacteria, b-glucuronidase, MUG

Introduction

The detection and enumeration of *Escherichia coli* are of fundamental importance for the control of waterborne diseases and the assessment of the microbiological quality of bathing waters (1). Different reasons support the need for rapid enzymatic methods: real-time assessment would be ideal for the management of water resources and the protection of public health; current standard procedures are labour- and time-consuming and unsuitable for microbiological monitoring; by the incorporation of synthetic enzyme substrates into culture media, rapid monitoring for specific bacteria may be performed, avoiding the need for isolation and confirmation tests (2). The measurement of the β-glucuronidase activity rate by using the 4-methylumbelliferyl-β-D-glucuronide (MUG assay) has been suggested as an indirect alternative approach to estimate the presence of *E. coli* (3). In this paper we report a five-years study carried out on coastal Mediterranean sites, where the reliability of this method for the monitoring of naturally contaminated samples has been tested, in comparison with the direct microscopic count by immunofluorescence (4) and culture methods.

Materials and methods

The MUG assay relies on the determination of β-glucuronidase activity, an enzyme specific of *E. coli* and *Shigella* spp., another Enterobacterium closely related to *E.coli* (2). The fluorogenic compound 4-methylumbelliferyl-β-D-glucuronide (MUG) is the most suitable substrate for the determination of the β–glucuronidase activity; it is enzymatically cleaved into its fluorescent product, 4-methylumbelliferone (MU).

For the enzyme assay, the procedure described by Caruso *et al.* (3) was followed: 10 ml aliquots of a concentrated sample were added at increasing MUG concentrations (from 5 to 50 µM, Sigma) and incubated at 44°C for 3h. Fluorescence intensity measurements were performed at an excitation of 365 nm and 445 nm emission wavelength (3). Data were expressed as the maximum rate of hydrolysis (V_{max}) of MUG (in nmol MU released per 100 ml per h), which provides a measure of the "potential" β-glucuronidase activity present in each sample.

Since 1996, a total of 197 samples were collected from coastal Sicilian and Calabrian sites and analysed by the MUG assay; faecal coliform (FC) and *E.coli* counts were also performed, respectively, by the membrane filtration method on m-FC agar plates and by the microscopic fluorescent antibody (IF) method (4).

Results

The bacterialcounts obtained on samples analysed showed that areas examined differed from each other in their pollution levels; the lowest faecal contamination was measured in Milazzo, followed by Gioia Tauro and Palermo Gulf, where the average values of faecal coliforms and *E.coli* were less than $2.38x10^2$ CFU $100ml^{-1}$ and $2.58x10^4$ cells 100 ml^{-1}, respectively. The Straits of Messina suffered a heavier microbial pollution than the other sites; here, FC and *E.coli* reached a maximum of $6.13x10^4$ CFU and $1.87x10^5$ cells $100ml^{-1}$. β-glucuronidase activity values ranged from 1.30 to 5.57 nmol MU/100ml/h.

The statistical analysis of the logarithmic-transformed enzymatic values, plotted versus the immunofluorescence and plate count showed that enzyme values correlated with IF values, and therefore with *E.coli* density, more significantly (R^2=0.1862, n=197, P<0.05) than with FC values (R^2=0.1244, n=197, P<0.05). In order to assay whether the response of the enzymatic assay was affected by the concentration of faecal coliform bacteria, samples were divided into different groups according to their FC concentrations. The regression analysis showed that at high pollution levels, where FC reached values over 10^5 CFU/100ml, the relationship obtained between FC and MUG was more significant (R^2=0.5774, n=79, P<0.05) than that found between FC and IF, while at low pollution levels (FC counts less than 10^3 CFU/100ml), a better relationship between FC and IF was obtained (R^2=0.1401, n=57, P<0.05), as compared to that between FC and MUG (R^2=0.1291, n=57, P<0.05). From 14 to 91% of the variance in the activity rates depended on the variations in the *E.coli* concentration, while a lower percentage (13 to 58%) of the variance in activity rates was explained by the variations in FC counts.

Discussion

Results show that the MUG assay represents a practical approach and can be seen as an alternative to standard culture methods to assess the microbiological quality of seawaters. It may be applied for early warning of faecal pollution episodes, making results available quickly (less than 4 h) and with reduced costs. The highly significant relationship found between log-transformed MUG and IF values suggested thathe enzymatic method is more specific for *E.coli* than for faecal coliforms.A possible explanation is also that the enzyme method is able to detect both viable and viable-but non-culturable (VBNC) cells, still metabolically active, which are estimated by IF only. This may lead to a more accurate estimate of the actual bacterial abundance (5). For heavily polluted samples, the enzymatic values were related more significantly than IF to standard counts, while for less contaminated samples the statistical relationship between IF and FC values was more significant than that found between MUG and FC. We may assume, in fact, that under highly polluted conditions, a high proportion of cells retained their metabolic activity due to the high organic matter availability, while in oligotrophic waters the greater presence of injured/damaged bacteria could account for the poor relationship between MUG and FC (5). Evaluations of metabolic activity may sometimes be different from abundance data, nevertheless the good correlation between the enzyme activity and *E. coli* values supports the determination of β-glucuronidase activity rate as an indirect measure of the presence of *E.coli* and the application of the MUG assay to the detection of this microorganism in marine waters.

Achnowledgements

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References

1 - Bonadonna L., Chiaretti G., Coccia A.M., and Semproni M., 1997. Valutazione comparativa di procedure analitiche per il rilevamento di *Enterobacteriaceae* in acque marine costiere. *Rapporti ISTISAN* , 97/3: 1-42.

2 - Hartman P.A., 1989. The MUG (Glucuronidase) test for *Escherichia coli* in food and water. Pp. 290-308. *In:* Balows A., Tilton R.C., Turano A. (eds.) Rapid methods and automation in microbiology and immunology. Brixia Academic Press, Brescia.

3 - Caruso G., Crisafi E., and Mancuso M., 2002. Development of an enzyme assay for rapid assessment of *Escherichia coli* in seawaters. *J. Appl. Microbiol.*, 93: 548-556.

4 - Caruso G., Zaccone R., and Crisafi E., 2000. Use of the indirect immunofluorescence technique for detection and enumeration of *Escherichia coli* in seawater samples. *Lett. Appl. Microb.*, 31: 274-278.

5 - George I., Petit M., Theate C., and Servais P., 2001. Use of rapid enzymatic assays to study the distribution of faecal coliforms in the Seine river (France). *Water Sci. Tech.*, 43: 77-80.

MICROPHYTOPLANKTON COMPOSITION ACROSS THE FRONTAL SYSTEM IN THE NORTHEN ADRIATIC (FEBRUARY, 2003)

Cetinić I. [1] *, Viličić D. [1], Burić Z. [1]

[1] Division of Biology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, PO Box 333, Zagreb, Croatia - * icetinic@botanic.hr

Abstract

Microphytoplankton composition was analysed along two transects: Po-Novigrad (PoN) and Pula – Rimini (PR) in the Northern Adriatic Sea, during February 2003. The PR transect was highly influenced by the freshwater discharge from the Po River. A complex frontal system was defined gradients in salinity, temperature and microphytoplankton composition. Thermohaline gradients along the PR transect were stronger than that along the PoN transect. According to salinity affinity, PCA analysis of species abundance reveals the presence of 4 characteristic groups of phytoplankton in the northern Adriatic.

Keywords: phytoplankton, Northern Adriatic, salinity, temperature

Introduction

Phytoplankton responses to freshwater inputs in the Northern Adriatic have been studied during the last 30 years. The Northern Adriatic is strongly influenced by freshwater inflow from the Po River, with an average yearly discharge of 3600 $m^3 s^{-1}$ (1). The results presented in this study describe winter aspect of the phytoplankton community structure in the Northern Adriatic.

Materials and methods

Twenty-six surface water samples were taken along two transects (PoN and PR) in the Northern Adriatic during a cruise aboard R/V *Knorr* (KN 172-03) between 2-3 February 2003 (Fig.1). Water samples for phytoplankton analysis were preserved in 2% neutralized formaldehyde (final concentration). The phytoplankton abundance was determined according to the inverted microscope method (2).

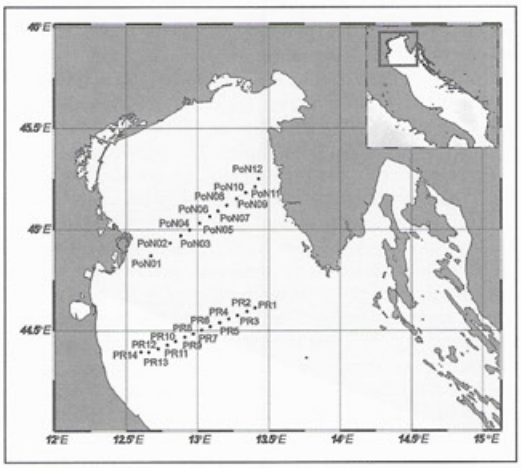


Fig.1. Northern Adriatic area and sampling locations.

Salinity and temperature were measured underway by the IMET meteorological sensor system.

Results and discusion

Strong influences by the river Po could be noticed in salinity and temperature dynamics, as well as microphytoplankton abundance across PR transect (Fig. 2). Along the PoN transect, the Po River influence was detected through the frontal system of less pronounced gradients. In both cases microphytoplankton were more abundant in water masses of lower salinity, due to nutrient enrichment by the Po River (1). Principal component analysis on species abundance data revealed the presence of 4 groups (Fig. 3). The first group, strongly influenced by river Po, was dominated by *Thalassionema nitzschioides* and *Dictyocha fibula*. The second group was dominated by the diatoms *Skeletonema costatum, Chaetoceros danicus* and some larger dinoflagellates such as *Ceratium furca, Noctiluca scintilans and Gymnodinium "simplex"*. The smaller dinoflagellate *Gyrodinium sp.* and the diatom *Pseudonitzschia sp.* were also present in the second group as well as in groups 3a and 3b. Group 3a was dominated by the diatoms *Cerataulina pelagica, Chaetoceros danicus, Diploneis bombus, Lioloma pacificum* and silicoflagellate *Dictyocha fibula*. Group 3b, consisting of samples from PoN and one sample from PR transect, could be connected to higher salinity gradients along the PoN transect. Group 3b was dominated by *Chaetoceros danicus* and *Nitzschia longissima/Cylindrotheca closterium*. It is concluded that *Pseudonitzschia* spp. and *Gyrodinium* sp., as well as all the species found in group 1 are typical representatives of the Northern Adriatic winter phytoplankton community in higher salinity waters. *Dictyocha fibula* could be considered as representative of the lower salinity community. Other species found in group 3a are considered as species tolerant to lower salinity, but require less turbulent conditions than those found in the proximity of the Po estuary.

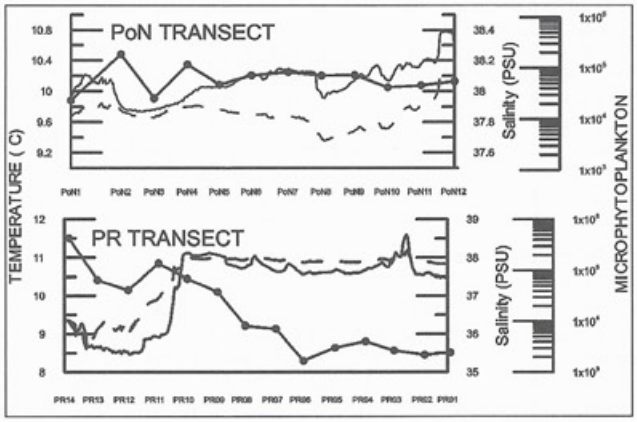


Fig. 2. Salinity (dashed line), temperature (solid line) and microphytoplankton abundance (line with dotes) on PoN and PR transects.

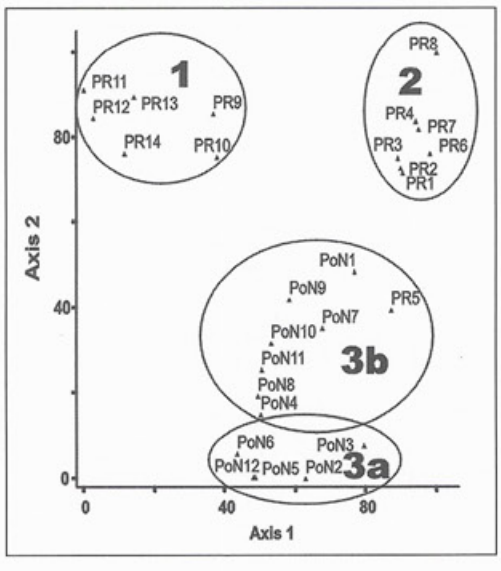


Fig. 3. PCA plot showing distribution of PoN and PR samples. 1, 2, 3a and 3b are groups defined by PCA analysis.

References

1 - Degobbis, D. and Gilmartin, M., 1990. Nitrogen, phosphorus and biogenic silicon budgets for the northern Adriatic Sea. *Oceanol. Acta*, 13: 31-45.

2 - Utermöhl, H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton Methodik. *Mitt. Int. Ver. Theor. Angew. Limnol.*, 9: 1-38.

SUR LA DIVERSITÉ DU PHYTOPLANCTON DES MILIEUX PORTUAIRES ET DES EAUX DE BALLAST DU GOLFE DE GABÈS (TUNISIE)

Dammak Zouari H. [1] *, Hamza A. [2], Mahfoudhi M. [2] et Bouain A. [1]

[1] Faculté des Sciences de Sfax, Route Soukra, Sfax, Tunisie
[2] INSTM Rue Madagaskar, Sfax, Tunisie - * Dammakr@yahoo.fr

Résumé

Le trafic maritime et les eaux de ballast sont identifiés comme des sources potentielles d'introduction d'espèces phytoplanctoniques nuisibles. Le golfe de Gabès qui produit plus que 70% de la richesse vénéricole de la Tunisie abrite trois ports et une des deux zones de ballast du pays. Afin de mieux contrôler la salubrité de nos exploitations conchylicoles, nous avons entrepris depuis 2001, un suivi de la qualité phytoplanctonique de ces milieux dégradés. Cette étude nous a permis d'évaluer la diversité des populations de ces milieux et d'inventorier les espèces introduites pouvant altérer les zones conchylicoles de la région.

Mots clés : Phytoplancton, ports, eaux de ballast, diversité.

Introduction

Le trafic maritime et les eaux de ballast sont de plus en plus incriminés dans les problèmes d'introduction d'organismes exotiques (1). Le phytoplancton est l'un des élus de ces mouvements et les risques sont majeurs si les espèces introduites sont toxiques.

Le golfe de Gabès constitue le principal pôle de production conchylicole du pays. Cette région est aussi connue pour ses infrastructures portuaires et son important trafic maritime.

La présente étude, effectuée depuis 2001, dans les ports de commerce de Sfax et de Zarzis et les étangs de ballastage du Terminal Pétrolier du TRAPSA est venue renforcer le réseau national de surveillance phytoplanctonique établi dans la région depuis 1995. De plus, cette étude a permis la détermination de la diversité phytoplanctonique de ces milieux et la capacité d'acclimatation dans notre région.

Matériels et méthodes

L'échantillonnage a été réalisé au niveau de 4 stations dans le port de commerce de Sfax, dans 3 stations dans le port de pêche et 9 stations pour le port de commerce de Zarzis. Pour le Terminal pétrolier du TRAPSA, nous avons prélevé au niveau des étangs de ballastage, dans une zone de communication avec le milieu marin ainsi que dans les citernes de jauge des navires.

La détermination et le dénombrement des échantillons sont realisés dans des cuves de sédimentation examinées au moyen d'un microscope inversé (méthode d'Uthermol) (2). Les paramètres physico-chimiques relevés sont la température, la salinité, le pH et les sels nutritifs. Les nitrates sont dosés par chromatographie ionique, l'NTK par volumétrie après minéralisation de l'azote organique, alors que les ions phosphates sont évalués selon la méthode de Murphy et Riley (3). La densité optique du complexe coloré est lue à 885 nm.

Résultats

Dans le port de commerce de Sfax, ce sont les dinoflagellés qui dominent sur les autres classes, ceci presque en toutes les saisons à l'exception de l'hiver où les diatomées sont majoritaires. Dans les ports de pêche de Sfax et de Zarzis, les dinoflagellés dominent au printemps à l'instar du statut phytoplanctonique de tout le golfe. Pour les eaux de ballast ainsi que dans le jauge des navires, nous avons constaté que les proportions des kystes de dinoflagellés sont considérables (Tab. 1).

Tab. 1. Liste des classes phytoplanctoniques dans le golfe de Gabès.

Proportions des classes phytoplanctoniques (%)		Port de commerce de Sfax	Port de pêche de Sfax	Port de Zarzis	Eau de ballast	Jauge des navire
Automne	dinoflagellés	44	33		31	
	diatomées	38	43		27	
	phytoflagellés	5	6	-	14	-
	kystes	10	12		21	
	cyanophycées	2	5		7	
Hiver	dinoflagellés	33	30	53	22	11
	diatomées	35	38	33	29	22
	phytoflagellés	11	10	7	9	0
	kystes	17	17	7	34	67
	cyanophycées	3	6	0	7	0
Printemps	dinoflagellés	41	40	45	20	
	diatomées	34	37	36	59	
	phytoflagellés	10	5	6	36	-
	kystes	12	12	9	36	
	cyanophycées	4	6	3	28	
Eté	dinoflagellés	49	35		18	15
	diatomées	31	37		33	8
	phytoflagellés	5	8	-	14	0
	kystes	11	15		28	69
	cyanophycées	3	5		7	8

Les milieux à trafic maritime international semblent plus riches en dinoflagellés certainement véhiculés par ces mouvements maritimes.

Parmi les espèces introduites, nous pouvons citer *Dinophysis sacculus* qui s'est installé dans les ports de Sfax au printemps et en été avec des concentrations assez importantes. De même *Gymnodinium breve* s'est manifesté avec des concentrations modérées dans tous les ports du golfe de Gabès sans saison préférentielle.

Pour *Alexandrium* nous avons noté l'apparition de ces dinoflagellés soit occasionnellement comme *Alexandrium acatenella* dans le port de Zarzis ou d'une façon assez permanente comme *Alexandrium margalefii* et *Alexandrium tamarense* dans les eaux de ballast (Tab. 2).

En comparant la qualité phytoplanctonique des eaux de ballast et des eaux côtières voisines du Terminal, nous avons remarqué la progression d'espèces nouvelles telles que *Gymnodinium breve* depuis les bassins de déballastage vers la zone marine avoisinante. En effet, en été, cette espèce est détectée dans les étangs de ballastage; puis nous l'avons identifiée dans la région marine voisine en automne et en hiver. Le même phénomène est décelé pour *Alexandrium margalefii* qui apparaît dans les étangs de ballastage en automne pour regagner la région avoisinante du Terminal en hiver.

Cette progression d'espèces nouvelles touche aussi *Alexandrium tamarense* qui occupe la zone côtière du Terminal et apparait dans les étangs de déballastage en automne (Tab. 2).

Tab. 2. Distribution des espèces nouvelles dans le golfe de Gabès identifiées dans les ports.

Espèces introduites	Port de commerce de Sfax				Port de pêche de Sfax				Port de Zarzis				Eau de ballast				Zone marine Terminal Pétrolier			
	A	H	P	E	A	H	P	E	A	H	P	E	A	H	P	E	A	H	P	E
Dinophysis sacculus			****	****			*	**												
Gymnodinium breve	**			**				**			*					*	*	*		**
																	*			
G. catenatum	*			***																**
Alexandruim tamarense		*											****				*			
																	*			
A. margalefii													****	**		*				
A. fraterculus				**							*									
A. acatenella											*									

*	20 à 100 cellules / l	***	501 à 1000 cellules / l
**	101 à 500 cellules / l	****	Supérieure à 1000 cellules / l

A : automne, H : hiver, P : printemps, E : été.

Conclusion

La dominance des Dinoflagellés est detectée dans toutes les stations étudiées. Les proportions des kystes sont assez élevées dans les eaux de ballast et dans le jauge des navires, ce qui est de nature à augmenter les risques de contamination par dispersion dans les zones avoisinantes.

Cette surveillance de ces milieux dégradés nous a permis de mettre en évidence l'introduction de nouvelles espèces *via* les navires ainsi que leurs eaux de ballast. Certaines espèces sont répertoriées comme toxiques et leur dérivation vers nos zones conchylicoles a été aussi notée.

Références

1 - Hallegraeff G. M., and Bloch C. J. 1992. Transport of dinoflagellate-cysts in ship's ballast water: implications for plankton biogeography and aquaculture. *J. Plankton Res.*, 14: 1067-1084.

2 - Utermöhl H., 1958. Zür Vervollkommung der quantitativen phytoplankton. *Methodik. Comm. Ass. Int. Limol.*, 9: 1-38.

3 - Murphy J., and Riley J. P., 1962. A modified single solution method for the determination of phosphate in natural waters. *Annal. Chem. Acta.*, 27: 31-36.

A SUMMARY DESCRIPTION OF THE MAIN BACTERIAL SPECIES PRESENT IN TUNISIAN COASTAL AREAS

EL Bour M. *, Attia El Hili H., Lakhal F., Ochi I., Mraouna R et El Abed A.
Lab. de Pathologie – INSTM – Salammbô, Tunisie - * monia.elbour@instm.rnrt.tn

Abstract
Monitoring different bacterial populations in coastal and lagoonal areas in Tunisia allowed us to distinguish more than 600 bacterial strains from seawater, sediments, shellfish and moribund fishes. Thirty-six different aerobic and anaerobic bacterial species were isolated. *Aeromonas hydrophila* was the most dominant species isolated during the last decade (75%). Biotyping methods were used to characterize 52 different biotypes within this species. Antimicrobial typing showed that multi-resistant strains were common among *A. hydrophila*. Experimental infection assays indicated negative effect of *A. hydrophila* on the mussel (*Mytilus galloprovencialis*). Studies are currently conducted to determine the effect of oligotrophic stress upon the biochemical, molecular and virulence characteristics of *A. hydrophila*.

Keywords : bacteria, aeromonads, biotyping, survival, pathogenesis.

Introduction

By using a biomonitoring approach for several coastal regions in Tunisia, we found that different bacterial populations were widespread in these areas [1]. Aerobic and anaerobic bacterial populations showed high levels of heterogeneity [2]. The present work describes features of the main bacterial species (*Aeromonas hydrophila)* present in Tunisian coastal areas.

Materials and Methods

Sampling and isolation: different bacterial strains were isolated from costal and lagoonal Tunisian ecosystems originating from the water column, sediment, shellfish and moribund fishes during the period 1994-2001. All the bacterial strains (mesophilic and psychrophilic aerobic and anaerobic populations) were isolated on basis of growth on selective media [3s] and morphological features.

Biotyping and antibacterial sensitiveness analysis: the characterization tools included: production of catalase and oxydase enzymes and biochemical Api system profiles (Api 20E, Api 20NE, Api 50CHE and Api 32Ana) besides the Biolog test of Micromer. The antibacterial sensitivity profiles for all the bacteria isolated were detected by the standard antibiogram method.

Oligotrophic stress analysis: The ability of *Aeromonas hydrophila* strains to survive in seawater was experimentally tested in microcosms inoculated and incubated at ambient temperature (about 20°C) in the dark without shaking. Growth and survival of bacteria were followed periodically by viable counts and measurements of optical densities at wavelength (at 620nm).

Experimental infection assays of M. galloprovencialis: These assays were done to test effect of *A. hydrophila* species on mussels maintained under farming conditions. Thus, we inoculated samples of mussels with suspension of *A. hydrophila* (suspension title = 5.10^7 cells/ml). Biological modifications of *M. galloprovincialis* were detected using the index condition measured periodically.

Results and Discussion

About 600 bacterial strains (87% aerobic species and 13% anaerobic species) were isolated from diverse habitats including water, sediments, shellfish and moribund fishes. The biochemical characterization profiles indicated 11 anaerobic species and 25 aerobic species.

A. hydrophila was the most dominant species isolated (75%). According to the enzymatic and metabolic tests, we distinguished 52 different biochemical profiles within the species *A. hydrophila*. The main profiles (15 biotypes) are listed in Table 1.

The results of antibiotic sensitivity tests showed that, multi-resistance patterns were common to more than one biochemical profile of *A. hydrophila* (Fig. 1). No specific correlation was found between biotypes and antibiotic resistance profiles obtained.

Under oligotrophic conditions, *A. hydrophila* strains grew slowly during the initial 8 d of incubation. Subsequently, the viable counts decreased and no growth was detected after 158 d (Fig. 2).

Mussels infected by *A. hydrophila* showed structural modifications of gonads. The index condition measured was influenced by the *A. hydrophila* strains injected.

Conclusion

Aerobic mesophilic bacteria were abundant in coastal ecosystems. Within these populations, *A. hydrophila* was the dominant species. Its growth seems to be influenced by the oligotrophic conditions of the seawater. Bivalves harboured different kinds of aerobic mesophilic bacteria. It seems that shellfish were affected by high concentration of mesophilic aeromonads.

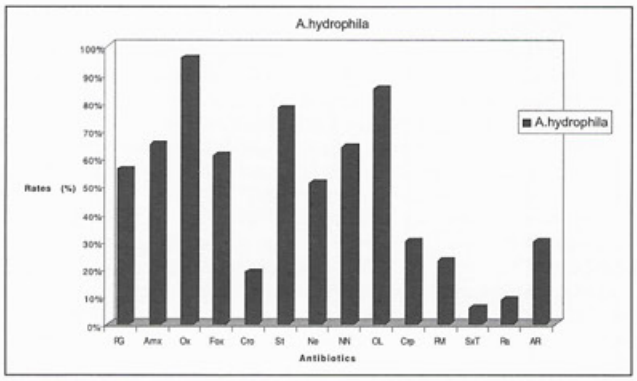


Fig. 1 : Antibacterial resistance profiles of Aeromonads *(A. hydrophila)*
Legend : PG : penicillin **G,** Amx : amoxicillin, **Ox** : oxacillin, **Fox** : cefoxitin, **Cro** : ceftriaxon, **St** : Streptomycin, **Ne** : neomycin, **AR** : flumequin, **NN** : tobramycin, **OL** : olendomycin, **C** : Chloramphenicol, **FM** : furans, **SXT** : Trimethoprim-sulfamids, **Ra** : Rifamycin

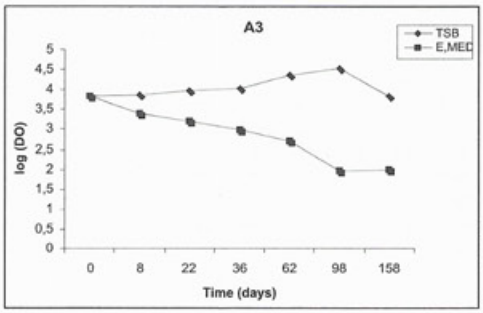


Fig. 2 : Survival curves of *A. hydrophila* in Trypcase Soja Broth (TSB) and in sea water

Table I : The main biotypes described within the species *Aeromonas hydrophila*

Référence	NO3	TRP	GLU	ADH	URE	ESC	GEL	PNG	GLU	ARA	MNE	MAN	NAG	MAL	GNT	CAP	ADI	MLT	CIT	PAC	OX	CAT
B1	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+
B6	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+
B3	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+
B10	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+
B47	+	-	+	-	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+
B5	+	+	+	-	-	+	+	-	+	+	+	+	+	+	+	+	-	+	+	-	+	+
B33	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+
B9	+	+	+	-	-	+	+	-	+	-	+	+	+	+	+	+	-	+	+	-	+	+
B14	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+
B7	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+
B11	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	+	-	+	+
B13	+	+	+	-	-	+	+	+	+	-	+	+	+	+	+	+	-	+	+	-	+	+
B15	+	+	+	+	-	+	+	+	+	-	+	+	+	+	+	-	-	+	+	-	+	+
B39	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+
B42	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+

Legend : (+) : positive reaction to the enzymatic or metabolic test, (-) : negative reaction to the test. (No3): nitrate reduction, (TRP) : Tryptophane, (ADH) : Arginine dihydrolase, (Ure) : Urease, (ESC) : Esculine, (GEL) : Gelatinase, (PNG) : Beta galactosidase, (Ara) : Arabinose, (Mne) : Mannose, (Man) : Mannitol, (Nag) : N-acetylglucosamine, (Mal) : Maltose, (Gnt) : Gluconate, (Cap) : Caprate, (Adi) : Adipate, (Mlt) : Malate, (Cit) : Citrate, (Pac) : Phenyl acetate, (Ox) : oxydase, (Cat) : Catalase.

References

1 - El Bour M., Attia El Hili H., Mraouna R. and Ayari W., 2001. Bacteriological Study of Mesophyllic Aeromonads Distribution in Shellfish. Proceedings of the fifth international Conference on the Mediterranean coastal environment, vol.1, pp 556-565.

2 - Morgane M, and Secombes C.J. The A layer influences the susceptibility of *A. salmonicida* to antibacterial peptides. *Fish and Shellfish Immunology*, Vol.10 : 637 642.

SURVIVAL STUDY OF LISTERIA MONOCYTOGENES IN SEAWATER

Elmnasser N. * and Bakhrouf A.

Laboratoire d'Analyse et de Contrôle des Polluants Chimiques et Microbiologiques de l'Environnement.
Faculté de Pharmacie. Rue Avicenne. 5000 Monastir, Tunisie - * mnassernoura@yahoo.fr

Abstract

We studied the behaviour of *Listeria monocytogenes* in sterile seawater. Recuperation of this bacterium on Tryptone Soya Agar shows that it can survive in sterile seawater for a long period of time in atypical colonies. Characters permitting the differentiation of *Listeria monocytogenes* and *Listeria innocua* are then modified.

Key words: Listeria monocytogenes, survival, seawater, adaptation.

Introduction

Until the late 1970s, it was generally assumed that *Listeria monocytogenes* does not survive in seawater (1). This view has been challenged by the finding that this bacterium can form a dormant life stage. *L. monocytogenes* is distributed widely in many natural environments (2). The success of *L. monocytogenes* as a pathogen seems to be related to its ability to adapt to its environment (3). The purpose of this work was to determined the morphological and metabolic modifications of *L.monocytogenes* growing in seawater.

Material and methods

Bacteria strain and cultural media

This study was carried out with *Listeria monocytogenes* strain isolated at the INSERM unity 452. Bacteria are recupered on Tryptone Soya Broth supplemented with yeast extract (0.6 %) (TSB) at 37°C for 24 h.

Growth agar was Tryptone Soya Agar supplemented with yeast extract (0.6 %) (TSA), or prepared with seawater (TSAM).

Starvation

Cells were grown for 24 h at 37°C and then washed three times in normal saline solution after centrifugation. The final pellet was suspended in 200 ml of filtered seawater.

Survival and recuperation tests

Culturability was assayed by spread plate counts. Serially diluted samples (0.1 ml) in sterilized seawater were spread in triplicate on plate media. After 24 to 48 h of incubation at 37°C, Colony-Forming Units (CFU) at appropriate dilutions were counted.

Biochemical profile of cells

The phenotypic profile was determined by Api *listeria* galleries.

Statistical analysis

Each point on the curves for enumeration of culturable cells presented in this study represents an average of 3 petri dishes. Statistical analysis was made by the Anova test carried out with the help of Program Stat View^{TM} 512^{+}.

Results

Quantitative variation analysis of *L. monocytogenes* incubated in microcosm seawater, showed a decrease by 99 % of CFU/ml after 24h of incubation in the seawater on TSA and TSAEM. The culturable forms continue to decrease until five weeks.

After one month in seawater microcosm, *L. monocytogenes* exhibited cultural modifications. Yellow pigmented, orange pigmented colonies appeared. Atypical colonies were cocci-rod forms with positive Gram, positive catalase and negative oxydase.

After one month of incubation in seawater, biochemical characters modifications are noted in the atypical colonies after their isolation from seawater microcosm (Table 1).

Table 1. L. monocytogenes biochemical characters before and after incubation in the seawater.

Characters / Colonies	DIM	ESC	MAN	DARL	XYL	RHA	MDG	RIB	G1P	TAG
L.monocytogenes	-	+	+	+	-	+	+	-	-	-
Yellow colonies	(+)	+	+	+	-	(-)	+	-	-	-
Orange colonies	(+)	+	(-)	+	-	+	+	-	-	-

DIM: Differentiation L. innocua / L. monocytogenes; **ESC**: Esculine; ?**MAN**: ?-Mannosidase; **DARL**: D-Arbitol; **XYL**: D-Xylose; **MDG**: ?-Methyl-D-Glucoside; **RIB**: Ribose; **G1P**: Glucose-1-Phosphate; **TAG**: D-Tagatose; (): modified characters of atypical colonies compared with the typical colonies.

The enzyme that allows the differentiation between *L. innocua* and *L. monocytogenes* (DIM on Api *Listeria*) changed. The yellow colonies lost their rhamnose enzyme and orange colonies lost their mannosidase activity.

Discussion and conclusion

In this work we showed that *L. monocytogenes* survives in the seawater for a long period under cultivable forms. Subsequently, the cells may be evolve towards viable but non cultivable forms as recently demonstrated by Besnard et *al.* (4).

After one month of *L. monocytogenes* survival in seawater, we have observed yellow and orange pigmented colonies. It was shown that 60 % of marine bacteria are pigmented (5). This pigmentation varied from yellow to red (6).

We showed that rods develop towards coccoid forms. This result agrees with morphological modifications described also to occur in *L. monocytogenes* subjected to high hydrostatic pressure (7). A morphological changes of cells and/or colonies can be explain by biochemical modifications of the envelopes of bacteria (8).

The results of Api *Listeria* tests show that the modifications in the phenotypic profile of the stressed colonies involved essentially the key characters of *L. monocytogenes* determination. The instability of enzymes cause problems in the characterisation of species isolated from the environment.

In an oligotrophic aquatic environment and at low organic matter concentrations, *L. monocytogenes* can adapt to environmental stress. This adaptation involves, biochemical and morphological modifications generally used in taxonomy.

References

1 - Aubert M., Gauthier M., and Daniel S., 1981. Les systèmes d'information des microorganismes marins. *Rev. Int. Océanogr. Méd.*, 60-61: 37-106.

2 - Farber J.M., and Peterkin P.I., 1991. *Listeria monocytogenes*, a food-borne pathogen. *Microbiol. Rev.*, 55: 476-511.

3 - Rouquette C., T.Ripio M., Pellegrini E., M.Bolla J., L.Tascon R., Vasquez-Boland J.A., and Berche P., 1996. Identification of a CLpC ATPase required for stress tolerance and in vivo survival of *L.monocytogenes*. *Mol. Microbiol.*, 21: 977-987.

4 - Besnard B., Federighi M., Declerq E., Jugiau F., and Cappelier J.M., 2002. Environmental and physico-chemical factors induce Vbnc state in *Listeria monocytogenes*. *Vet. Res.*, 33: 359-370.

5 - Rheinheimer B., 1974. Aquatic microbiology. John Wiley and Sons, London, pp. 80-82.

6 - Tsyban A.V., 1971. Marine bacterioneustron. *J. Oceanogr. Soc. Jap.*, 27: 56-66.

7 - Ritz M., Tholozan J.L., Federighi M., and Pilet M.F., 2001. Morphological and physiological characterization of *Listeria monocytogenes* subjected to high hydrostatic pressure. *Appl. Environ. Microbiol.* ,67: 2240-2247

8 - Csonka L.N., and Hanson A.D., 1991. Prpkaryotic osmoregulation: genetics and physiology. *Ann. Rev. Microbiol.*, 45: 569-606.

SPATIAL AND TEMPORAL SCALES FOR THE MONITORING OF BACTERIAL COMMUNITY STRUCTURE IN COASTAL ECOSYSTEMS.

J.F. Ghiglione *, M. Larcher, S. Emonet, P. Lebaron

Observatoire Océanographique de Banyuls - UMR CNRS 7621
Université Paris VI. Banyuls Sur Mer, France - * ghiglion@obs-banyuls.fr

Summary

One of the challenges in microbial ecology is to determine at what temporal and spatial scales the structure of natural communities should be monitored. Samples of different volumes and taken at different spatial (vertical and horizontal) and temporal (from hours to seasons) scales were analyzed to investigate at which scale one should monitor community structure at a coastal station. Investigations were performed in the Bay of Banyuls (Mediterranean, France). No changes in the community structure was detectable within a radius of 200 meters around the station whereas changes were found at both weekly and monthly scales.

Keywords : marine bacterial communities, diversity, sampling strategy

The last decade of microbial ecology has resulted in a veritable explosion of studies that use new molecular biological techniques to analyse the structure of microbial communities. These studies have improved our perception of microbial diversity and community composition in marine ecosystems (1). However, the temporal and spatial scales at which bacterial populations vary remained poorly documented. A comparison of recent studies of bacterial community dynamics in pelagic marine waters showed minimal differences in community compositions at stations a few miles apart near Anvers Island, Antartica (2) or 1500 km apart in the Arabian Sea (3), in opposition to clear differences observed along the Catalan Coast, Spain (4). Short-term studies showed major changes in bacterial communities consequent to qualitative changes in the pool of organic matter (5, 6). These evidences for space- and time-dependent bacterial community changes emphasized the importance of sampling strategies when studying the dynamic of natural communities.

Although a large set of methodologies have been developed to investigate the structure of bacterial communities, the selection of the most appropriate method depends on the questions to be answered and on the amount of samples to be processed within a reasonable period of time. Fingerprinting approaches offer the best compromise for the monitoring and comparison of microbial assemblages and for the assessment of temporal and spatial changes that would not have been feasible using time-intensive 16S rDNA sequence analysis. Denaturing gradient gel electrophoresis (DGGE) has become a very popular fingerprinting technique in marine microbial ecology, especially because bands with particular melting behaviour can be excised from the gel and subsequently sequenced to reveal the phylogenetic affiliation of the community members (7). However, its laborious technical optimisation including calibration of the linear gradient of DNA denaturants that makes gel-to-gel comparison difficult have made this technique impractical for the fine comparison of more than samples loaded on one gel (8). The recently developed capillary electrophoresis-single strand conformation polymorphism (CE-SSCP) fingerprinting technique permitted high reproducibility for reliable comparison of patterns from a theoretically infinite number of samples. Because a size standard with a different fluorescent label is added to each sample, CE-SSCP and further computing correction encompassed the problem of gel-to-gel comparison (9).

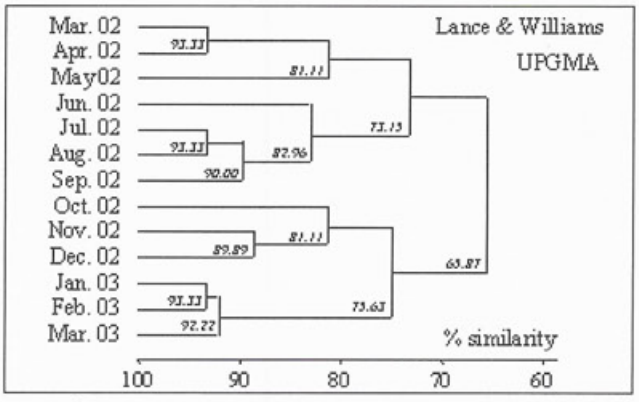


Fig. 1. Cluster analysis dendrogram based on comparison of 16S PCR-CE-SSCP patterns from one year sampling at the SOLA station (Mediterranean, France). The tree was constructed by applying unweighted pair group average linkage rules on a Lance and Williams index of similarity matrix calculated from the CE-SSCP profiles.

In this study, CE-SSCP technique was used to determine spatial and temporal scale changes in the structure of bacterial communities in a coastal ecosystem. Samples of different volumes and taken at different spatial (vertical and horizontal) and temporal (from hours to seasons) scales were analyzed to investigate at which scale one should monitor community structure at a coastal station. Investigations were performed in the Bay of Banyuls (Mediterranean, France).

No changes in the community structure was detectable within a radius of 200 meters around the SOLA station but changes occurred at larger scales. Changes were found at both weekly and monthly scales. Cluster analysis based on a one-year monitoring at the SOLA station showed changes in the seasonal distribution of bacterioplankton community structure, without any return to the initial community structure after one year (Fig. 1).

References

1 - Giovannoni S., Rappé M., 2000. Evolution, diversity, and molecular ecology of marine prokaryotes. Pp. 47-84. In: Kirchman DL (ed.) Microbial ecology of the oceans. Wiley-Liss, New York.

2 - Murray AE, Preston CM, Massana R, Taylor LT, Blakis A, Wu K, DeLong EF, 1998. Seasonal and spatial variability of bacterial and archaeal assemblages in the coastal waters near Anvers Island, Antarctica. *Appl. Environ. Microbiol.*, 64: 2585–2595.

3 - Riemann L, Steward GF, Fandino LB, Campbell L, Landry MR, Azam F, 1999. Bacterial community composition during two consecutive NE Monsoon periods in the Arabian Sea studied by denaturing gradient gel electrophoresis (DGGE) of rRNA genes. *Deep-Sea Res.* II, 46: 1791–1811.

4 - Schauer M, Massana R, Pedrós-Alió C, 2000. Spatial differences in bacterioplankton composition along the Catalan coast (NW Mediterranean) assessed by molecular fingerprinting. *FEMS Microbiol. Ecol.*, 33:51–59.

5 - Fandino L.B., Riemann L., Steward G.F., Long R.A., Azam F., 2001. Variations in bacterial community structure during a dinoflagellate bloom analyzed by DGGE and 16S rDNA sequencing. *Aquat. Microb. Ecol.*, 23: 119–130.

6 - Schäfer H., Bernard L., Courties C., Lebaron P., Servais P., Pukall R., Stackebrandt E., Troussellier M., Guindulain T., Vives-Rego J. and Muyzer G., 2001. Microbial community dynamics in Mediterranean nutrient-enriched seawater mesocosms: changes in the genetic diversity of bacterial populations. *FEMS Microbiol. Ecol.*, 34: 243-253.

7 - Muyzer, G., Brinkhoff, T., Nübel, U., Santegoeds, C., Schäfer, H. and Wawer, C., 1998. Denaturing gradient gel electrophoresis (DGGE) in microbial ecology. Pp. 1-27. *In* A.D.L. Akkermans, J.D. van Elsas, and F.J. de Bruijn (ed.), Molecular microbial ecology manual, vol. 3.4.4. Kluwer Academic Publishers, Dordrecht, The Netherlands.

8 - Moeseneder M.M., Arrieta J.M., Muyzer G., Winter C., Herndl G.J., 1999. Optimization of terminal-restriction fragment length polymorphism analysis for complex marine bacterioplankton communities and comparison with denaturing gradient gel electrophoresis. *Appl. Environ. Microbiol.*, Aug. 65(8): 3518-25.

9 - Zumstein E., Moletta R., Godon J.J., 2000. Examination of two years of community dynamics in an anaerobic bioreactor using fluorescence polymerase chain reaction (PCR) single-strand conformation polymorphism analysis. *Environ. Microbiol.*, 2:69-78.

SHORTCOMINGS OF CULTURING BACTERIA FROM THE DEEP SEA ANOXIC BASINS (MEDITERRANEAN SEA)

Laura Giuliano [1] *, Giuseppe D'Auria [1], Terence J. McGenity [2], Andrea M. Sass [2], Daniele Daffonchio [3], Sara Borin [3], Tullio Brusa [3], Fabienne Morel [4], Gilles Ravot [5]

[1] Istituto per l'Ambiente Marino Costiero (IAMC), CNR - Messina, Sp.ta S. Raineri 84 - 98122 Messina, Italy
[2] Department of Biological Sciences, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK
[3] Dipartimento di Scienze e Tecnologie Alimentari e Microbiologiche (DISTAM), via Celoria 2 - 20133 Milano, Italy
[4] LMM, CNRS UMR 6117, Centre d'Oceanologie de Marseille Case 907, Campus de Luminy -13 288 Marseille Cedex 9, France
[5] Protéus SA, Parc Georges Besse 70, allée Graham Bell 30 000 Nîmes, France

Abstract
Culturing of prokaryotes remains the ultimate goal for a detailed characterization of the metabolic pathways of microorganisms despite recent advances in genetic analysis of functional genes. We have isolated previously uncultured bacteria from four deep-sea hypersaline anoxic basins of the eastern Mediterranean Sea. Molecular analysis of isolated bacterial strains point towards a rich bacterial community present in this extreme environment.

Keywords: bacteria, culturing, deep sea, anoxic basins, Mediterranean Sea

Despite the introduction of culture-independent molecular screening techniques that allows microbiologists to examine a wide spectrum of microbial diversity, culturing techniques are still valuable and might reveal information which cannot be obtained by molecular techniques (1; 2; 3). The inability to culture bacteria has dampened efforts to study the links between bacterial taxonomic diversity and their functional role in the native environment (4; 5; 6; 7). Due to their non-cultivability, the metabolic potential of the highest number of described bacterial taxa and, therefore, their possible industrial application remains unknown. Studying the organisms in culture can not only provide new information about microbial evolution and ecology but may also yield a host of useful compounds, such as antibiotics or enzymes with unexpected properties.

Within the BIODEEP EU project (EVK3-2000-00042) we have managed to grow in the lab several strains of previously unculturable bacteria adapted to thrive at "extreme" conditions—an advance that may provide a new means of exploring the vast diversity of microbial species. For such an aim, four deep-sea hypersaline anoxic basins (DHABs) located in the Eastern Mediterranean Sea have been sampled at different layers. The DHABs are completely perennially hypersaline and oxygen-free environments that originate from ancient subterranean salt deposits (evaporites). Due to their physical and chemical features, the DHABs could easily represent prime regions for unraveling the extent of microbial diversity and for determining the lower limits of life-supporting environmental parameters.

About 250 bacteriological samples from the DHAB brines, interfaces and sediments have been processed with different parallel technologies and a special attention for reducing the possibility of contamination. The environmental conditions at the sampling site were used in media design (e.g. looking for ingredients needed for the bacteria to survive). About 500 bacterial strains have been isolated and identified by means of 16S rDNA-based molecular analysis. The results point towards a rich, mainly high-salt adapted prokaryotic diversity which may be used as baseline information for the assessment of microbial communities of other marine hypersaline anoxic environments. A statistic approach was used for comparing the used culture media on the basis of the selected taxonomical diversity and relative abundance. According to that, several media appeared to be equivalent to each other whereas few of them were unique. Repeated culturing of the same strain from more than one DHABs sample supported the hypothesis of the existence of DHABs adapted cultivable bacteria with similar metabolic patterns.

The tools described represent state-of–the-art technologies, which may be among those applied to monitoring life forms in DHABs-like terrestrial (and extraterrestrial?) environments.

References

1 - Leadbetter J.R., 2003. Cultivation of recalcitrant microbes: cells are alive, well and revealing their secrets in the 21st century laboratory. *Current Opinion in Microbiology,* 6(3): 274-281.
2 - Rappé M.S., Connon S.A., Vergin K.L., Giovannoni S.J., 2002. Cultivation of the ubiquitous SAR11 marine bacterioplankton clade. *Nature,* 418(6898): 630-633.
3 - Zengler K., Toledo G., Rappé M., Elkins J., Mathur E.J., Short J.M., Keller M., 2002. Cultivating the uncultured. *Proceedings of the National Academy of Sciences,* 99(24): 15681–15686.
4 - Chen F., Binder B., Robert E. Hodson R.E., 2000. Flow cytometric detection of specific gene expression in prokaryotic cells using in situ RT-PCR *FEMS Microbiology Letters,* 184(2): 291-296.
5 - Bachoon D.S., , Chen F., Hodson R.E., 2001. RNA recovery and detection of mRNA by RT-PCR from preserved prokaryotic samples. *FEMS Microbiology Letters,* 201(2):127-132.
6 - Radajewski S., McDonald I.R., Murrell J.C., 2003. Stable-isotope probing of nucleic acids: a window to the function of uncultured microorganisms. *Current Opinion in Biotechnology,* 14(3): 296-302.
7 - Wilkinson M.H.F., Schut F., 1998. Quantitative Measurements of Intestinal Ecology by Digital Image Analysed Microscopy. *Bioscience and Microflora,* 17 :7-14.

HOW MUCH DO BACTERIA DEPEND ON PHYTOPLANKTON METABOLISM?

González-Benítez N. [1] *, Gattuso J.P. [2]

[1] Área de Biodiversidad y Conservación. ESCET. Universidad Rey Juan Carlos. E-28933 Madrid, Spain
[2] LOV - UMR 7093. BP 28. F-06234 Villefranche-sur-Mer, France

Abstract

The degree of coupling between phytoplankton and bacteria was estimated in the Bay of Palma during summer 2002 by comparing the relative proportions of particulate and dissolved primary production with bacterial carbon demand. On the whole, these results suggest, that the bacterial growth efficiency responds to changes in phytoplankton production, increasing as the primary production increases. In summary, there is lack of dependence of bacterial metabolism on algal production in the oligotrophic area, whereas the most productive area showed a strong coupling between phytoplankton and bacterioplankton.

Keywords: Bacterial metabolism, PER, oligotrophy, BGE

Introduction

The production of dissolved organic carbon (DOC) is important in oceanic biogeochemistry and there are many different mechanisms of production although the ultimate source is phytoplankton. Dissolved primary production (DOC-pr) in marine systems has been often ignored because it is considered to be very low compared with the particulate fraction (POC-pr). Some authors (1) have suggested that the rate of POC-pr and the relative contribution of DOC-pr to total carbon fixation (PER) are inversely correlated, although other authors (2) have reported that PER is constant across marine and freshwater systems. Thus the issue, still unresolved, is important, since dissolved organic carbon represents an important source of labile carbon for heterotrophic bacteria(3). Depending on the bacteria growth efficiency (BGE), DOC consumed by bacteria will be either converted to POC or respired as CO_2 decreasing the organic carbon transfer to higher trophic levels. Both processes of bacterial metabolism, production and respiration, against the general idea are not well coupled, providing a metabolic flexibility necessary for survival under oligotrophic conditions (4). According to a recent study (5) the carbon cycle is mainly determined by the combined activities of bacteria and phytoplankton. Therefore, variations in BGE will affect the degree of coupling between bacteria and phytoplankton and, consequently, the biogeochemical cycles within marine ecosystems. Given the lack of simultaneous measurements of the BGE and the balance between DOC-pr and POC-pr, particularly in oligotrophic regions (although they cover ca 70% of the total marine surface), we have carried out the present experiment.

Material and methods

The study was conducted at Bay of Palm during June 2002. The water samples were collected at four depths between surface and 15 or 30 m depth. For phytoplanktonic POC-pr and DOC-pr rates, the seawater samples were dispensed into 30 ml glass bottles (three clear and one dark), spiked with 740 Kbq (20 µCi) $NaH^{14}CO_3$ and incubated *in situ* during the daylight period (12 h). Bacterial production (BP) was estimated as the rate of radioactive Leucine incorporation (6). For bacterial respiration (BR), the seawater samples were filtered, using a gentle filtration system (0.8 µm). The filtered water was incubated in 60 ml borosilicate glass bottles at *in situ* temperature (± 1 °C) in the dark over 12, 24 and 48 h.

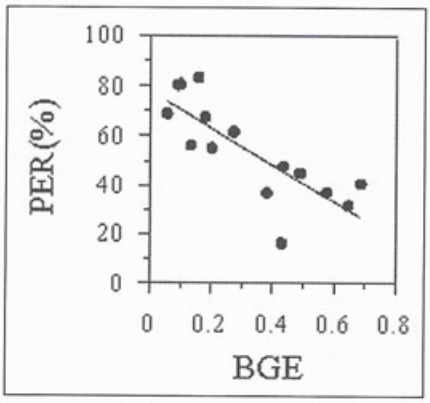
Results

We observed two contrasting regions within an oligotrophic aquatic system (Table 1). The percent of extracellular release (PER) was significantly lower within the most productive areas. However, bacterial production (BP) and BGE were higher in the most productive areas. BGE increased as the relative contribution of DOC-pr to total carbon fixation decreased (Fig. 1).

Table 1.-Mean (± SE) values of total carbon fixation (TOC-pr), percent of extracellular release (PER), bacterial production (BP), bacterial growth efficiency (BGE) and bacterial carbon demand (BCD) during summer 2002 in the Bay of Palma.

Bay of Palma (Summer 2002)	TOC (mg C m^{-3} h^{-1})	PER (%)	BP (pmol Leu L-1 h-1)	BGE (%)	BCD (% of TOC)
Bahía Posidonia	1.50 ± 0.30	69 ± 4	344 ± 56	44 ± 4	88 ± 21
Cap Enderrocat St 4	0.35 ± 0.09	37 ± 4	14 ± 4	6 ± 1	211 ± 43

Conclusions



The relative contribution of DOC-pr to total primary production decreases as the productivity of the system increases. In agreement with a recent study (7), this result provides evidence that PER is not constant, even within oligotrophic waters.

There was an important bacterial response to the variability in primary production by adapting their metabolism to this oligotrophic environment. BGE responded to changes in phytoplankton production, increasing as the primary production increased.

The organic carbon was consumed by bacteria less efficiently within the most oligotrophic area and most of the carbon was respired. Whereas the area with higher primary production, the energetic cost of bacterial growth appeared to decrease and therefore BGE increased.

There was a clear evidence of the small scale spatial variability within this oligotrophic aquatic system showing lack of dependence of bacterial metabolism on algal production within the less productive area, and strong coupling between phytoplankton and bacterioplankton within the most productive area.

References

1 - Fogg G.E., 1983. The ecological significance of extracellular products of phytoplankton photosynthesis. *Bot Mar.*, 26: 3-14.

2 - Baines S.B., Pace M.L., 1991. The production of dissolved organic matter by phytoplankton and its importance to bacteria: patterns across marine and freshwater systems. *Limnol Oceanogr.*, 36:1078-1090.

3 - Kirchman D.L., Suzuki Y., Garside C., Ducklow H.W., 1991. High turnover rates of dissolved organic carbon during a spring phytoplankton bloom. *Nature*, 352: 612-614.

4 - del Giorgio P.A., Cole J.J., 1998. Bacterial growth efficiency in natural aquatic systems. *Annu. Rev. Ecol. Syst.*, 29: 503-541.

5 - Azam F., 1998. *Science*, 280:694-696.

6 - Smith D.C., Azam F., 1992. A simple economical method for measuring bacterial protein synthesis rates in seawater using ^{3}H-Leucine. *Mar. Microb. Food Webs*, 6: 107-114.

7 - Moran X.A.G., Estrada M., Gasol J.M., Pedrós-Alió C., 2002. Dissolved primary production and strength of phytoplankton–bacterioplankton coupling in contrasting marine regions. *Microb Ecol.*, 44: 217-223.

HIGHLY ACTIVE BACTERIA IN THE SURFACE WATERS OF THE GULF OF TRIESTE (NORTHERN ADRIATIC SEA)

A. Karuza *, P. Del Negro, A. Paoli, S. Comisso, S. Fonda Umani
Laboratory of Marine Biology, Via Auguste Piccard 54, 34010 Trieste, Italy

Abstract
In this study we examined the metabolically active fraction of bacterial community in surface waters of the Gulf of Trieste using the CTC incubation method technique. The results suggested that the CTC+ cells are not responsible for the bulk of bacterial activity. The method seems to be adequate to detect only the cells with very active metabolism but not the cells in a transitory metabolic state. Therefore the CTC reduction assay should be viewed and interpreted as an efficient method for identifying the most highly active cells in bacterioplankton populations or assemblages.

Keywords: CTC, active bacteria, Gulf of Trieste

In the bulk of bacterial community there are at least three categories of cells that should be of biogeochemical relevance: i) actively growing cells which contribute to production and biomass ii) living but inactive cells and iii) dead and inactive cells. Although discrimination among these three cellular categories remains unclear (1), some methods have been suggested to determine the fraction of actively growing cells in complex assemblages.

For the purpose of our study we choose the CTC incubation method, a simple and fast technique to determine the number of bacteria that have measurable rates of electron transport system and therefore an active respiration.

Surface (0.5 m) water samples were bimonthly collected in a coastal station of the Gulf of Trieste from June 2002 to April 2003. Total bacteria abundances were determined using DAPI staining method (2), while metabolically active cells were detected using a CTC incubation technique (3). Bacterial Carbon Production (BCP) was determined by ^{3}H-leucine and ^{3}H-thymidine incorporation (4). Dissolved Organic Carbon (DOC) concentration was assessed by high temperature catalytic oxidation (5). Rates of oxygen utilization were calculated from changes in dissolved oxygen concentration, using the Winkler method, over a 24 h period in samples incubated in the dark and *in situ* temperature. Temperature data were obtained by a Idronaut Ocean Seven (Model 316) multiparametric probe.

Bacterial abundances ranged between 2.51 x 10^8 and 4.78 x 10^9 cells L^{-1} whereas the number of active cells (CTC+) fluctuated from 1.72 x 10^6 to 9.92 x 10^7 cells L^{-1}. The percentage of CTC+ bacteria ranged between 0.03 and 7.41%. The abundance of CTC+ cells was strongly correlated to total bacterial numbers and, better than with total bacteria, it showed strict relationships with temperature and substrate availability, evaluated as DOC concentration. On the contrary, bacterial production, measured as ^{3}H-leucine and ^{3}H-thymidine incorporation, were correlated to total number of bacteria only (Tab. 1). Respiration rate within the plankton community resulted strongly correlated to total number of bacteria where the active fraction only partially support the respiration process.

Setting aside methodological differences, our results, like those of many other authors (e.g. 6), show that not all bacteria are metabolically active and that the water temperature appears to have had a profound effect on the pattern of induction of respiration activity. The statistical dependence between CTC+ bacteria and DOC, could have been caused solely by the increase in temperature which is also usually the controlling factor in the phenomena involved in the production of autochthonous organic matter readily assimilable by bacteria.

Although it could seem surprisingly because of the principle of the CTC method based on detecting cell respiratory activity characteristic for growing cells, oxygen consume rate and BCP had better statistical relationships with total bacteria abundances rather than active cells, contrarily to the results of Smith (7). This could concern a limit of the method that detects only the cells with very active metabolism but not the cells in a transitory state, between CTC+ and CTC-, that contribute to the total respiration measured and therefore the CTC reduction assay should be viewed and interpreted as identifying the most highly active cells in bacterioplankton populations or assemblages. Indeed, the level of cell activity is what determines the detectability of respiring cells, since even bacteria in a starvation survival state must sustain certain functions.

Table 1. Parameters of linear regression analysis.

x	y_1	r_1	p_1	y_2	r_2	p_2	n
temperature	CTC+	0.91	<0.001	total bacteria	0.79	<0.001	n=17
^{3}H-TdR	CTC+	0.21	n.s.	total bacteria	0.7	<0.01	n=15
^{3}H-Leu	CTC+	0.24	n.s.	total bacteria	0.77	<0.001	n=17
respiration	CTC+	0.67	<0.01	total bacteria	0.87	<0.001	n=17
DOC	CTC+	0.63	<0.01	total bacteria	0.5	<0.05	n=18

References

1 - Gasol J.M., Zweifel U.L., Peters F., Fuhrman J.A. and Hagstrom A., 1999. Significance of size and nucleic acid content heterogeneity as measured by flow citometry in natural plankton bacteria. *Appl. Environ. Microbiol.*, 65: 4475-4483.
2 - Porter K.G. and Feig Y.S., 1980. The use of DAPI for identifying and counting aquatic microflora. *Limnol. Oceanogr.*, 25: 943-948.
3 - Rodriguez G.G., Phipps D., Ishiguro K. and Ridgeway H.F., 1992. Use of a fluorescent redox probe for direct visualization of actively respiring bacteria. *Appl. Environ. Microbiol.*, 58: 1801-1808.
4 - Smith D.C. and Azam F., 1992. A simple, economical method for measuring bacterial protein synthesis rates in sea water using 3H-leucine. *Mar. Microb. Food Webs*, 6: 107-114.
5 - Sugimura Y. and Suzuki Y., 1988. A high-temperature catalytic oxidation method for the determination of non-volatile dissolved organic carbon in seawater by direct injection of a liquid sample. *Mar. Chem.*, 24: 105-131.
6 - Jugnia L.B., Debroas R.D., Sime-Ngando T. and Devaux J., 2000. Variations in the number of active bacteria in the euphotic zone of a recently flooded reservoir. *Aquat. Microb. Ecol.*, 22: 251-259.
7 - Smith E.M., 1998. Coherence of microbial respiration rate and cell-specific bacterial activity in a coastal planktonic community. *Aquat. Microb. Ecol.*, 16: 27-35.

RECOVERY OF VIABLE BUT NONCULTURABLE *AEROMONAS HYDROPHILA* CELLS AND MAINTENANCE OF ABILITY TO ADHERE TO MCCOY CELLS AFTER RESUSCITATION

S. Maalej [1] *, R. Gdoura [2] and A. Bouain [1]

[1] Faculté des Sciences de Sfax, Unité de recherche UR/0907. 3018, Sfax, Tunisia - * sami.maalej@fss.rnu.tn
[2] Faculté de Médecine de Sfax, Laboratoire de Microbiologie. Sfax, Tunisia

Abstract

Maintenance of pathogenicity of viable but nonculturable *Aeromonas hydrophila* cells experimentaly stressed at 5°C in natural seawater microcosms was investigated. Pathogenicity, in terms of cytotoxicity and ability to adhere to McCoy cells, was lost concomitantly with culturability, whereas cell viability remained undamaged, as determined by the direct viable count. Recovered cells, by a temperature shift from 5 to 23°C restore their adhesion properties.

Keywords: Aeromonas hydrophila, VBNC, resuscitation, pathogenicity

Aeromonas hydrophila is an opportunist human pathogen which is widely distributed in aquatic environments (1,2). A relationship between changes in water temperature and the incidence of *Aeromonas* spp. has been reported. In seawater within arid regions, aeromonads were found in high numbers in late summer/early autumn when the temperature was around 20-25°C and were rarely detected during cold seasons (3). The inability to isolate *A. hydrophila* during the winter months or from cold waters may result from the entry of cells into the viable but nonculturable (VBNC) state (4). However, contreversial results were produced from attempts to restore culturability. Moreover, in our knowledge, none of the reported studies adressing the pathogenicity of *A. hydrophila* nonculturable and recovered cells.

In this study, *A. hydrophila* ATCC 7966 with cytotoxic activity was used for entering the VBNC state when it was incubated in filtered sterilized natural seawater. Cells were grown on BHI broth, collected and immediately suspended in 0.5-liter bottles containing 100 ml of filter-sterilized natural seawater to obtain a final concentration of 10^8 cfu.ml^{-1} and incubated without shaking at 5°C. At fixed times, samples were collected for culturable, total and Direct Viable Counting (5). After about 45 days of starvation, when the culturable cells declined below the detection level of 0.1 cfu.ml^{-1}, microcosms were shifted to room temperature (23°C) without exogenous nutrient addition. Culturable cells first appeared after one day then increasing to a maximum of 10^4 cfu. ml^{-1} within 3 days of room temperature incubation. Comparison of the growth rates of the stressed population and of the untreated bacteria growing in the same autoclaved initial cell suspension, significantly showed faster growth for the stressed cells, suggesting that in addition to growth of the few culturable stressed cells, a given amount of injured cells entered a culturable state.

In order to test the pathogenicity of culturabe, VBNC, and recovered cells, attachment ability and cytoxic activity with McCoy cells were used. Each bacterial suspension was adjusted to 10^6 viable (i.e. DVC-positive) bacteria and a portion of 300 ?l of a bacterial suspension was added to the cell monolayer. After 1 h of incubation at 37°C in a 5% CO_2 atmosphere to permit bacterial adhesion, the cells were stained with Giemsa for 1 mn and visualized by light microscopy under oil immersion at a magnification of x 100. Our results showed clearly that entry into the VBNC state was accompanied by a loss of the adhesion property (Fig. 1A and B). This loss is transient because, after temperature upshift, the ability to adhere to McCoy cells was recovered. (Fig. 1C).

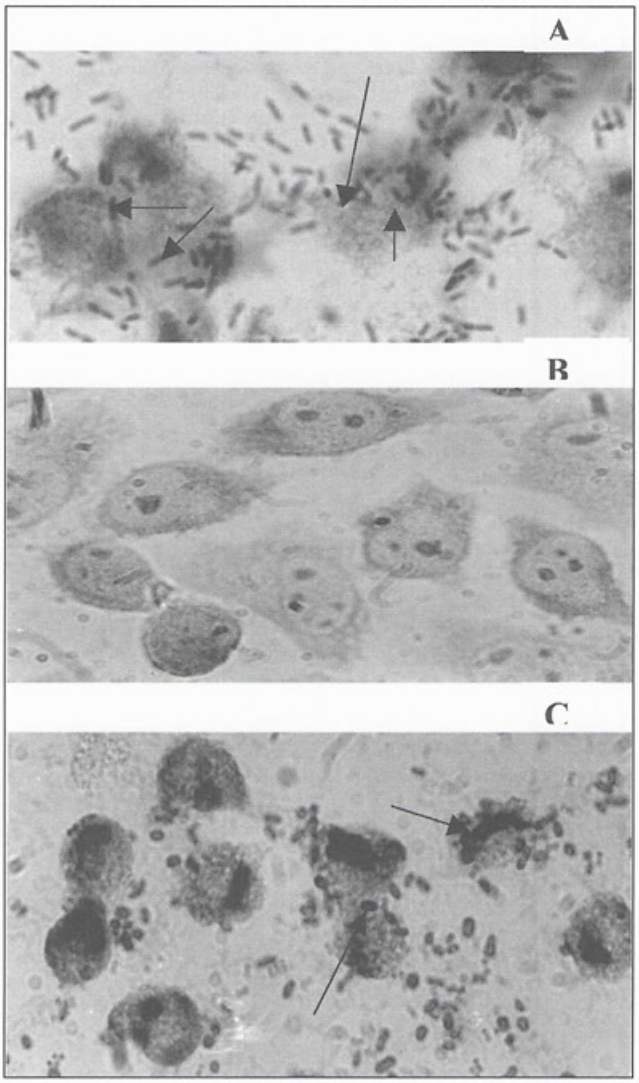


Fig. 1. Photograph of *Aeromonas hydrophila* cells in the adhesion assay with McCoy cells. (A) Adhesion by culturable cells, representing the day 0 sample. (B) Adhesion by VBNC cells collected after 45 days. (C) Adhesion by recovered cells after 3 days.

References

1 - Janda, J. M. & Abott, S. L. 1998. Evolving concepts regarding the genus *Aeromonas*: an expanding panorama of species, disease presentation, and unanswered questions. *Clin. Infect. Dis.*, 27: 332-344.

2 - Schiavano, G., Bruscolini, F., Albano, A. & Brandi, G. 1998. Virulence factors in *Aeromonas* spp. and their association with gastrointestinal disease. *New Microbio.*, 21: 23-28.

3 - Maalej, S., Mahjoubi, A., Elazri, C. & Dukan, S. 2003. Simulaneous effects of environmental factors on motile *Aeromonas* dynamics in an urban effluent and in the natural seawater. *Water Res.*, 37: 2865-2874.

4 - Wai, S. N., Mizunoe, Y., Takade, A. & Yoshida, S. 2000. A comparison of solid and liquid media for resuscitation of starvation-and low-temperature-induced nonculturable cells of *Aeromonas hydrophila*. *Arch. Microbiol.*, 173: 307-310.

5 - Kogure, K., U. Simidu, and N. Taga. 1979. A tentative direct microscopic method for counting living marine bacteria. *Can. J. Microbiol.*, 25: 420.

EXTRACELLULAR CARBOHYDRATES RELEASED BY P-LIMITED DIATOMS

Erika Magaletti [1] *, Ranieri Urbani [2], Paola Sist [2] and Anna Maria Cicero [1]

[1] ICRAM, via di Casalotti, 300, 00166 Roma, Italy

[2] University of Trieste, Department of Biochemistry, Biophysics and Macromolecular Chemistry, via L. Giorgieri, 1, I 34127 Trieste, Italy - * e.magaletti@icram.org

Abstract

A laboratory study was performed on the extracellular production of carbohydrates by the marine diatoms *Cylindrotheca closterium*, *Thalassiosira pseudonana* and *Skeletonema costatum* to investigate the role of P-limitation and growth status on abundance and chemical characteristics of the released polysaccharides. Inorganic phosphorus depletion caused an increase of total polysaccharides in all species and a reduction in the molar percentage of glucose. Maximum exopolysaccharide production was found at the transition stage between exponential and stationary growth phase.

Key-words: Diatoms, exopolysaccharides, mucilage, phosphorus

Cultures of the marine diatoms *Thalassiosira pseudonana* Hasle & Heimdal, *Skeletonema costatum* (Greville) Cleve and *Cylindrotheca closterium* (Ehrenberg) Lewin & Reimann, were isolated from the Northern Adriatic and maintained in f/2 medium at 18° C, 16:8 h light:dark cycle, 112 ME m^{-2} s^{-1} irradiance. Cells were treated with an antibiotic mix [1] for 24 h. P-replete (P+; 36 µM of P-PO_4) and P-deplete treatments (P-; 6 µM of P-PO_4) were established for each species in duplicate flasks.

Cells were enumerated using a Bürker counting chamber and light microscopy. Nutrient concentrations were determined spectrophotometrically [2], extracellular carbohydrates and aldoses composition were determined colorimetrically [3] and by gas-chromatography [4], respectively.

The production of total exopolysaccharides was significantly higher under the P-depleted condition (P-) compared to the P-replete condition (P+) (Fig. 1.). Maximum carbohydrate concentrations were found in *T. pseudonana* (26.8 µmol C/10^6 cells). The aldose signature varied according to growth status (Fig. 2A). Glucose was generally the most abundant monomer during the exponential growth phase. In the stationary growth, the percentage of glucose decreased and galactose, mannose, xylose, rhamnose and fucose increased. Changes in aldoses were most pronounced in *C. closterium* (Fig. 2B).

The diatom species investigated are commonly found in the Northern Adriatic Sea [5]. Species-specific differences in abundance and chemical characteristics of the exudates may have an important impact on the degradability of the exudates, thus influencing the dynamics of organic matter in coastal waters [6].

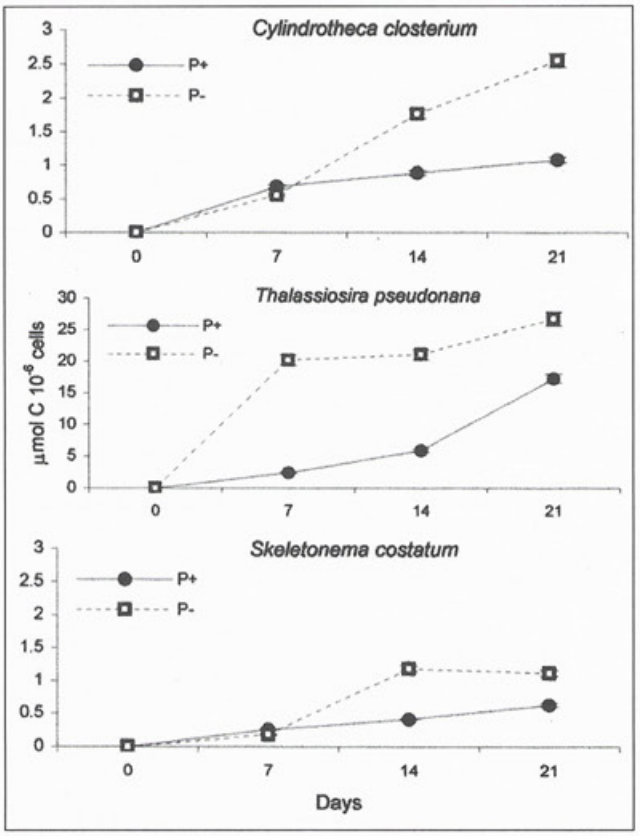


Fig. 1. Temporal variation of total extracellular carbohydrates (µmol C/106 cells) in batch cultures of three diatom species. P+: P-replete; P : P-depleted.

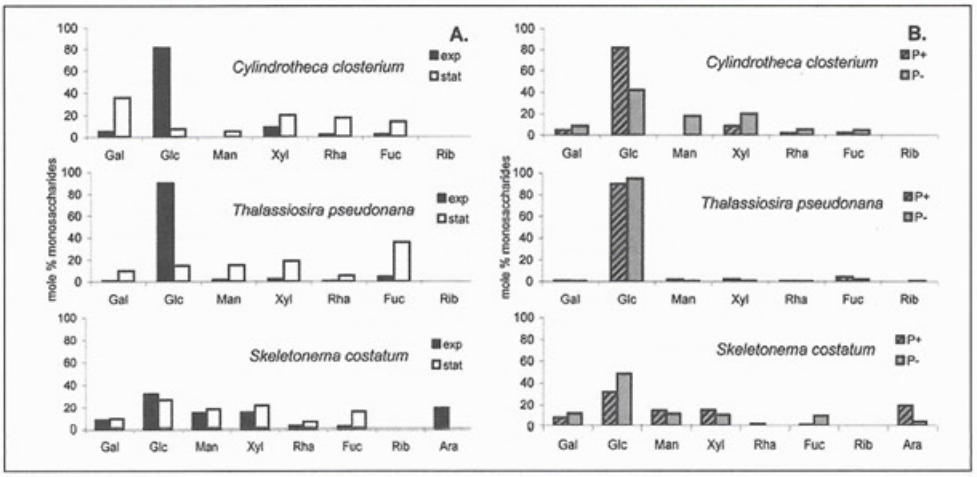


Fig. 2. Aldoses composition of dissolved extracellular carbohydrates released by three diatom species under different growth stages (A.) and nutrient conditions (B.).

References

1 - Guerrini F., Mazzotti A., Boni L., Pistocchi R., 1998. Bacterial-algal interactions in polysaccharide production. *Aquat. Microb. Ecol.*, 15: 247-253.

2 - Strickland J.D.H., and Parsons T.R., 1972. A practical handbook of seawater analysis, 2nd edition. *Bull. Fish. Res. Bd. Can.*

3 - Myklestad S., Skanoy E., and Hestmann S., 1997. A sensitive and rapid method for analysis of dissolved mono- and polysaccharides in seawater. *Mar. Chem.*, 56: 279-286.

4 - Blakeney A.B., Harris P.J., Henry R.J. and Stone B.A., 1983. A simple and rapid preparation of alditol acetates for monosaccharide analysis. *Carbohyd. Res.*, 113: 291-299.

5 - Regione Emilia Romagna-ARPA, Struttura Oceanografica Daphne, 2002. Eutrofizzazione delle acque costiere dell'Emilia Romagna, Rapporto 2002. P. 200.

6 - Puddu A., Zoppini A., Fazi S., Rosati M., Amalfitano S., and Magaletti E., 2003. Bacterial uptake of DOM released from P-limited phytoplankton. *FEMS Microbiol. Ecol.* (In press).

OCCURRENCE OF CAMPYLOBACTER AND *ARCOBACTER* SPP. IN SEAWATER AND ZOOPLANKTON SPECIMENS

Maugeri T.L. [1] *, Carbone M. [2], Fera M.T. [2], Irrera G.P. [1] and Gugliandolo C. [1]

[1] Dip. di Biologia Animale ed Ecologia Marina, Salita Sperone 31, Università di Messina, 98166 Messina
[2] Dip. di Patologia e Microbiologia Sperimentale, Via C.Valeria 1, Università di Messina, 98125 Messina - * tmaugeri@unime.it

Abstract

The presence of *Campylobacter* and *Arcobacter* spp., bacteria related to human and animal health, as free-living or associated with small (>64µm) and large plankton (>200µm) was monitored in a coastal zone. The occurrence was evaluated by cultural and molecular methods during an annual sampling cycle. The bacterial isolation was more frequent from water and large plankton than from small plankton. *Campylobacter concisus* was cultured from plankton and seawater samples in April, *C. coli* and *C. lari* only from plankton in May 2001. A multiplex PCR method was useful for the simultaneous detection and identification of *Arcobacter butzleri, A. cryaerophilus* and *A. skirrowii* on bacterial colonies and on samples without cultivation.

Keywords: free living bacteria, associated zooplankton bacteria.

Current taxonomic status of *Campylobacteraceae* includes three genera *Campylobacter*, *Arcobacter* and *Helicobacter* that constitute a phylogenetically distinct group referred as either ribosomal RNA superfamily or the epsilon division of the class *Proteobacteria.* All genera include human and no human pathogenic species and widespread forms. Arcobacters differ from other microaerophilic curved bacteria for their aerotolerance and ability to grow at temperature lower than 25°C. Four species, *A. butzleri*, *A. skirrowi*, *A. cryaerophilus* and *A. nitrofigilis*, have been described, differing for the ability to grow at 42°C and for the antibiotic sensitivity [1].

At present *Arcobacter*, as *Campylobacter*, are considered as emerging human foodborne pathogens. The survival of these bacteria in the environment is not well understood. Search on the campylobacters demonstrated the occurrence of thermophilic *Campylobacter* in fresh and marine water, and in the sewage [2]. The presence of *Campylobacter* outside warm-blooded animals, domestic and wild, is considered as sign of recent contamination because *Campylobacter* survive for a shorter time than the usual faecal indicators.

In the framework of a national survey we searched potentially pathogenic bacteria in water and plankton samples collected from a coastal station fixed in the Straits of Messina (Italy).

Seawater was monthly collected from April 2001 to March 2002 using sterilised bottles. To collect free-living bacteria, seawater samples were first filtered through 200 µm net and then through 64 µm net, and concentrated using 0.22 µm membrane filters (Millipore Corp., Bedford, MA). The filters were washed with filter-sterilised, phosphate-buffered saline (PBS) and used for cultural and molecular analyses. To collect small plankton (>64 µm), seawater samples passing through a 200 µm net were successively passed through a 64 µm net. The 64 µm net was washed and suspended in PBS. Sample containing small plankton and associated bacteria was divided in three aliquots for plankton, cultural and molecular analyses. Large plankton (>200µm) was collected with a 200 µm mesh plankton net. Retained large plankton and associated bacteria were suspended in 500 ml sterile seawater and divided in three aliquots for plankton, cultural and molecular analyses.

Seawater, small and large plankton were inoculated into tubes of *Campylobacter* Broth (BBL). After incubation for 2 days at 42°C a loop from positive cultures was streaked on Columbia Blood Agar Base (Karmali) (Oxoid) and incubated at 42°C in microaerobic atmosphere.

Samples were inoculated into *Arcobacter* Broth CM965 (AM) (Oxoid) supplemented with CAT (Cefoperazone, Amphotericin B, Teicoplanin) Selective Supplement SR 174E (AM174), selective for *Arcobacter* species, or with CCDA (Cefoperazone and Amphotericin B) Selective Supplement SR 155 for *Arcobacter butzleri* (AM155). After aerobic incubation at 30°C for 24 hours liquid cultures were streaked onto plates of the same enrichments media agarised with 1.5 % (AMA) [3]. In order to confirm the identification of the isolates as *A. butzleri*, *A. cryaerophilus* and *A. skirrowii* a multiplex PCR (m-PCR) assay was performed [4] including *Arcobacter butzleri* ATCC 49616, *A. cryaerophilus* ATCC 43157 and *A. skirrowii* ATCC 51132 as reference strains. Five PCR primers, named ARCO, BUTZ, SKIR, CRY1, and CRY2, based on the 16S rRNA and 23rRNA sequences [4] were used. The selected primers amplify a 257-bp fragment from *A. cryaerophilus*, a 401-bp fragment from *A. butzleri* and a 641-bp fragment from *A. skirrowii*. Amplified products were detected by electrophoresis in agarose gel. The m-PCR assay was also used for the detection and differentiation of *Arcobacter* spp. present in the samples without cultivation, to detect the "viable but not cultivable (VBNC)" state. Zooplankton was numerically largest in spring and in late autumn and mainly consisted of copepods.

Presumptive campylobacters were observed from all samples in April, but did not in summer when the level of UV radiation and changes in temperature influenced negatively their presence [5].

Campylobacter does not always correlate with faecal indicators given that they become non-culturable much faster than the indicators. This suggested that wild birds could represent the source of *Campylobacter* in our coastal waters rather than the sewage effluent. In April, species phenotypically identified as *C. concisus* were isolated from both seawater and large plankton samples. In May *C. coli* and *C. lari* were isolated only from large plankton but not from the other samples.

Presumptive Arcobacter strains obtained from both the enrichments used (AM174 and AM155 for the isolation of *Arcobacter* spp. and *A. butzleri*, respectively) were almost all identified as *A. butzleri*. This species was predominant in seawater samples but was also recovered from small and large plankton. The enrichment broth AM174 (permissive for *A. butzleri*) inoculated with seawater and plankton produced also isolates of *A. cryaerophilus*, confirmed by PCR.

Molecular assay was used to identify *A. butzleri*, *A. cryaerophilus* and *A. skirrowi* directly from samples without cultivation (Fig. 1). These results confirm that *Campylobacter* and *Arcobac ter* strains are widespread in the environment. They indicate recent contamination with animal (often avian) faeces or sewage. In the marine environment, plankton appear as potential reservoir of these bacteria.

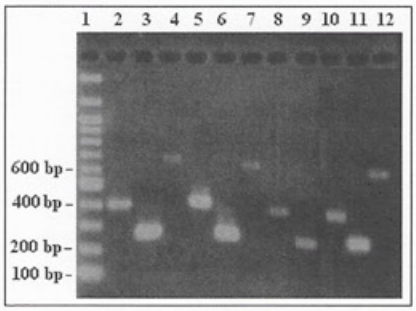


Fig. 1: m-PCR products amplified from marine samples and reference strains.
Lane 1: 100 bp ladder; lanes 2, 3 and 4: seawater samples; lanes 5, 6 and 7: large plankton; lanes 8 and 9: small plankton; 10: *A. butzleri* ATCC 49616; lane 11: *A. cryaerophilus* ATCC 43157; lane 12: *A. skirrowii* ATCC 51132.

References

1 - Vandamme, P., Goossens. H. 1992. Taxonomy of *Campylobacter*, *Arcobacter* and *Helicobacter*: a review. *Zentralbl. Bakteriol.*, 276, 447-472.
2 - Jones K. 2001. Campylobacters in water, seawage and the environment. *J. Appl.Microbiol.*, 90, 68S-79S.
3 - Maugeri T.L., Gugliandolo C., Carbone M., Caccamo D., Fera M.T. 2000. Isolation of *Arcobacter* spp. from a brackish environment. *Microbiologica,* 23, 143-149.
4 - Houf K., Tutenel A., De Zutter L., Van Hoof J., Vandamme P. 2000. Development of a multiplex PCR assay for the simultaneous detection and identification of *Arcobacter butzleri*, *Arcobacter cryaerophilus* and *Arcobacter skirrowii*. *FEMS Microbiol. Lett.*, 193, 89-94.
5 - Obiri-Danso K., Jones K. 1999. The effect of a new sewage treatment plant on faecal indicator numbers, *Campylobacters* and bathing water compliance in Morecambe bay. *J. Appl .Microbiol.*, 86, 603- 614.

WINTER PELAGIC PHOTOSYNTHESIS IN THE NW MEDITERRANEAN. EVIDENCE OF HIGH PRIMARY PRODUCTION RATES

X.A.G. Morán [1] * and M. Estrada [2]

[1] Instituto Español de Oceanografía, Centro Oceanográfico de Xixón, Xixón, Spain - * xelu.moran@gi.ieo.es
[2] Institut de Ciències del Mar, CMIMA, CSIC, Barcelona, Spain - marta@icm.csic.es

Abstract
Primary production in the NW Mediterranean was estimated in two cruises (Mar'99 and Jan-Feb'00) by means of *in situ* incubations and photosynthesis-irradiance relationships. Both approaches showed a good agreement. Photosynthetic parameters displayed differences within the mixed layer, suggesting rapid photoacclimation. Phytoplankton assemblages were acclimated to lower irradiances during 2000. Although a high variability was found between years, stations and visits, chlorophyll *a*-normalized rates were ~1 mg C mg Chl a^{-1} h^{-1} in both cruises. Primary production rates were generally higher in 1999 than in 2000, ranging 326-1963 mg C m^{-2} d^{-1} and 124-868 mg C m^{-2} d^{-1}, respectively. These results support the hypothesis of a late winter, rather than spring, maximum of primary production in the NW Mediterranean.

Keywords: phytoplankton, primary production, photosynthetic parameters, NW Mediterranean, winter

The NW Mediterranean was sampled during the winters of 1999 (3-13 March) and 2000 (29 January-10 February) in the HIVERN cruises. We estimated primary production at 6 stations with the ^{14}C technique using two methods, short-term *in situ* incubations and photosynthesis-irradiance (*P-E*) relationships. *In situ* incubations were performed with water collected from 8 depths down to 60 m. For the *P-E* experiments, water was taken from 2 depths within the photic layer (mostly 5 and 30 m) and incubated under an irradiance gradient of ~2-2000 µmol photons m^{-2} s^{-1}. Photosynthetic parameters were obtained with the model of Platt et al. (1). The depth profiles of photosynthetically active radiation (PAR) and chlorophyll *a* together with the daily variation in surface PAR were used to estimate integrated rates of primary production from photosynthetic parameters.

Photosynthetic parameters (Table 1) indicated that phytoplankton assemblages were acclimated to lower irradiances in 2000, as expected from the earlier sampling. Photoinhibition was commonly observed in deep samples. Alhough the parameters were differentially affected in the two years most of them presented significant differences between surface and deep values within the well-mixed upper layer, suggesting that photoacclimation was faster than water column mixing rates, as previously observed in the Alboran Sea (2).

Table 1. Mean (± SD) photosynthetic parameters in surface (5 m) and deep (15-60 m) samples in the two cruises. P^B_m: maximum chlorophyll *a*-normalized photosynthetic rate (mg C mg Chl a^{-1} h^{-1}); α: initial slope of the *P-E* relationship [mg C mg Chl a^{-1} h^{-1} (µmol photons m^{-2} s^{-1})$^{-1}$]; ß: photoinhibition paramenter (same units as α). E_k: light saturation parameter (µmol photons m^{-2} s^{-1}).

	P^B_m	α	β	E_k
Mar 1999				
surface	2.32 ± 0.76	0.013 ± 0.005	0 ± 0.0001	204 ± 114
deep	1.77 ± 0.57	0.015 ± 0.007	0.0008 ± 0.0012	127 ± 48
Jan-Feb 2000				
surface	1.64 ± 0.55	0.012 ± 0.001	0.0002 ± 0.0003	154 ± 90
deep	1.56 ± 0.48	0.017 ± 0.006	0.0018 ± 0.0016	97 ± 35

A good agreement was found between both methods of estimating primary production. Fig. 1 shows the relationship between chlorophyll *a*-normalized hourly rates at the depths of the *P-E* experiments of all stations (n=35). The slope of the linear regression (*In situ* PP = -0.06 + 0.96 *P-E* PP, r^2=0.68, p<0.001) was not significantly different from 1.0 (*t*-test, p=0.28). Estimates of *in situ* and *P-E*-derived integrated primary production rates were also significantly correlated (r=0.85, p<0.001, n=16).

Surface phytoplankton biomass was a good estimate of integrated primary production rate (r^2=0.71). A high variability was found between years, stations and consecutive visits, with relative increases up to 9-fold, but integrated assimilation numbers were virtually the same in both periods (1.07 ± 0.37 and 0.99 ± 0.45 mg C mg Chl a^{-1} h^{-1}, respectively), suggesting similar phytoplankton assemblages and/or photoacclimation responses during the later winter months. Due to later sampling, values were generally higher in 1999 than in 2000, with respective ranges of 0.3-2 g C m^{-2} d^{-1} and 0.1-0.9 mg C m^{-2} d^{-1}. These values, particularly the 1999 ones, are considerably higher than those available from other more intensively sampled periods (3) and comparable to more productive systems, supporting the hypothesis of a late winter, rather than spring, maximum of primary production in the NW Mediterranean.

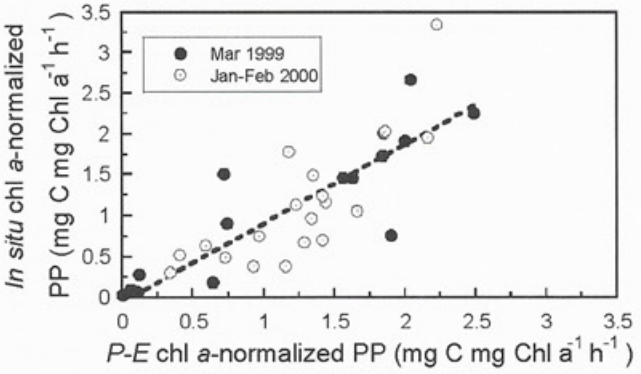


Fig. 1. Relationship between chlorophyll *a*-normalized primary production rates obtained in *in situ* and *P-E* experiments. Linear regression explained in the text.

References

1 - Platt T., Gallegos C.L., and Harrison W.G., 1980. Photoinhibition of photosynthesis in natural assemblages of marine phytoplankton. *J. Mar. Res.*, 38: 687-701.
2 - Morán X.A.G., and Estrada M., 2001. Short-term variability of photosynthetic parameters and particulate and dissolved primary production in the Alboran Sea (SW Mediterranean). *Mar. Ecol. Prog. Ser.*, 212: 53-67.
3 - Estrada M., 1996. Primary production in the northwestern Mediterranean. *Sci. Mar.*, 60: 55-64.

CARACTÉRISTIQUES ET SENSIBILITÉ À DIFFÉRENTS ANTIBIOTIQUES DES *VIBRIO* PATHOGÈNES POUR LES POISSONS D'ÉLEVAGE LOUP ET DAURADE

Nakbi Amel * et Bakhrouf Amina

Laboratoire d'Analyse et de Contrôle des Polluants Chimiques et Microbiologiques de l'Environnement.
Faculté de Pharmacie. Rue avicenne. 5000 Monastir, Tunisie - * Nakbi_amel@yahoo.fr

Résumé

La recherche et l'identification des bactéries pathogènes du loup (*Dicentrarchus labrax*) et de daurade (*Sparus aurata*) ont été poursuivies au cours des deux années (2001/2002) dans deux stations de pisciculture de littoral méditerranéen, en Tunisie. Les vibrions les plus fréquemment isolés au cours des épizooties étaient *Vibrio alginolyticus*. Ils ont été isolés en culture pure des différents organes internes (foie, cœur, rate, rein et muscle ulcéreux) des poissons malades. Nous avons étudié les caractères biochimiques et antibiotypiques de ces souches et nous avons trouvé qu'ils présentaient des caractères communs en faveur de leur virulence.

Mots clés : pisciculture, Vibrio, épizootie.

Introduction

Les problèmes d'épizooties observés chez les stades juvénile et adulte du loup et de daurade d'élevage, nous ont incité à rechercher et caractériser les germes susceptibles d'être pathogènes. *Vibrio alginolyticus*, *Vibrio vulnificus*, *Vibrio anguillarum* sont fréquemment isolés dans des cas d'épizooties chez le loup (*Dicentrarchus labrax*) et la daurade (*Sparus aurata*) en aquaculture méditerranéenne (1,2,3). Nous avons pu décrire chez des daurades en phase de pré-grossissement (40 à 50 g) des lésions bien délimitées sous forme de nécroses congestives au niveau des flancs et des nageoires, surtout à la base des nageoires caudales. Les conditions décrites dans les deux stations d'aquaculture étudiées présentent une salinité de 40‰, une température de l'ordre de 15-18°C, un taux d'oxygénation de 4 à 5 ppm et une densité de 50 à 70 kg/m^3. Ces conditions sont adéquates pour l'élevage, mais aussi favorables pour le développement des vibrions plutôt que d'autres germes.

Matériel et méthodes

Les prélèvements des organes et tissus infectés (muscle, foie, cœur, rate, et rein) est effectué stérilement. L'enrichissement a été réalisé dans du bouillon nutritif préparé à l'eau de mer. Les souches ont été ensemencées sur 2 milieux gélosés : une gélose nutritive préparée à l'eau de mer (**GNEM**) susceptible de permettre la croissance d'un grand nombre de bactéries hétérotrophes marines et **TCBS** agar, en principe sélectif pour les vibrions halophiles. L'incubation a été faite à température ambiante (22°C). La caractérisation des souches obtenues a été faite selon une micro-méthode standardisée, galeries Api 20NE (Biomérieux). En addition aux caractères étudiés sur ces galeries, quelques tests complémentaires nécessaires à l'identification des bactéries de l'environnement ont été réalisés (type respiratoire, type d'hémolyse sur gélose au sang du mouton et l'utilisation de mucus épithélial de la peau de daurade comme source de carbone (3).La sensibilité des souches aux antibiotiques a été effectuée selon la méthode de Chabbert (4).

Résultats

Nous avons constaté que la vibriose est présente durant toutes les saisons, il s'agit d'une pathologie à caractère insidieux. Les examens bactériologiques ont permis d'isoler des souches de *Vibrio*. Nous avons sélectionné les biotypes qui ont été responsables des mortalités importantes. Deux biotypes de *Vibrio alginolyticus* ont été isolés dans deux épizooties différentes de daurade en phase de prégrossissement quatre autres biotypes de *Vibrio alginolyticus* ont été isolés de l'hémoculture des géniteurs du loup et une souche de *Vibrio vulnificus* a été isolées chez des daurades malades de pré-grossissement. Toutes ces souches ont été isolés en culture pure à partir de différents organes internes: rein, rate, cœur, et foie, muscles infectés et du sang. Les caractères biochimiques et antibiotypiques ont été résumés dans le tableau 1.

Discussion et conclusion

Les épizooties semblent être fréquentes dans les deux centres d'aquaculture. Les *Vibrio* isolés disposent d'un arsenal enzymatique riche tels que les hémolysines et les protéases capables d'hydrolyser les substrats provenant de l'hôte notamment le mucus épithélial des poissons. Plusieurs facteurs favorisent l'expression de la virulence des *Vibrio*. Les manipulations de pêche et de tri dans les bassins de prégrossissement sont stressantes pour le poisson ce qui affaiblit son système immunitaire. La densité élevée dans les bassins ainsi que les conditions de température, salinité et oxygène dissous favorisent la multiplication et la transmission de ces germes (1, 3).

L'étude de la résistance aux antibiotiques montre que les germes sont très résistants. Cela pourrait être dû à la présence des mêmes déterminants plasmidiques échangés entre les vibrions dans les eaux de la station d'aquaculture. La multirésistance des vibrions, due à l'utilisation abusive et non contrôlée des antibiotiques au cours des maladies, les rend plus menaçants car l'échange des plasmides entre les bacilles à Gram négatif est facilité en milieu marin (5).

Tableau 1. Caractères biochimiques et antibiotypiques des Vibrio isolés au cours des épizooties

Souches I: souches isolées des épizooties des daurades. 1,2: *Vibrio alginolyticus*. 3: *Vibrio vulnificus*. Souches II: souches isolées des épizooties du loup. 1: *Vibrio parahaemolyticus*. 2,3,4: *Vibrio alginolyticus*. R: résistant, S: sensible, I: intermédiaire.

Souche / Caractères	Souches I			Souches II			
	1	2	3	1	2	3	4
NO_3	+	+	+	+	+	+	+
TRP	+	+	+	+	+	+	+
GLU (f)	+	+	+	+	+	+	+
ADH	-	-	-	-	-	-	-
URE	-	-	-	-	-	-	-
ESC	+	+	+	-	-	-	-
GEL	+	+	+	+	+	+	+
PNP	-	-	+	-	-	-	-
GLU (o)	+	+	+-	+	-	+	-
ARA	-	-	-	-	-	-	-
MNE	-	-	-	+	-	-	-
MAN	+	+	-	+	+	+	+
NAG	-	-	-	+	-	-	-
MAL	-	-	-	+	-	+	-
GNT	-	-	-	+	-	+	+
CAP	-	-	-	-	-	-	-
ADI	-	-	-	-	-	-	-
MLT	+	+	-	+	+	+	+
CIT	+	-	-	+	-	-	-
PAC	-	-	-	-	-	-	-
OX	+	+	+	+	+	+	+
Hémolyse	+	+	+	+	+	+	+
Utilisation de mucus epithelial	+	+	+	+	+	+	+
Antibiotiques							
Ampicilline	R	R	R	R	R	R	R
Ticarcilline	R	R	R	R	R	R	R
Gentamicine	R	R	I	R	R	R	R
Tobramycine	R	R	R	R	R	R	R
Kanamycine	R	R	R	R	R	R	R
Tétracycline	R	R	I	R	R	R	R
Acide oxolinique	S	I	I	I	I	I	I
Fluméquine	S	S	I	I	I	I	I

Références

1 - Bakhrouf A., Ben Ouda H. et Oueslati R., 1995. Essai de traitement des vibrioses du loup *Dicentrarchus labrax* dans une zone de pisciculture, à Monastir, Tunisie. *Marine life,* 5(2) : 47-54.

2 - Balebona M.C, Andreu M.J., Bordas A.M., Zorilla I., Morinigo A.M. et Borrego J.J., 1998. Pathogenicity of *Vibrio alginolyticus* for cultured gilt –head sea bream (*Sparus aurata*). *Appl. Env. Microbiol.*, 64(11): 4269-4275.

3 - Bordas M.A., Balebona M.C., Zorilla I., Borrego J.J. et Morinigo A.M., 1996. Kinetics of adhesion of selected fish-pathogenic *Vibrio* strains to skin mucus of gilt –head sea bream (*Sparus aurata* L.). *Appl. Env. Microbiol.,* 62(10) : 3650-3654.

4 - Chabbert Y.A., 1963. L'antibiogramme, sensibilité bactérienne aux antibiotiques. Collection «techniques de base» Editions de la Tourelle, Saint-Mandré, 230 p.

5 - Gauthier M.J., Flatau G.N. et Bernard P., 1981. Tolérance au plomb, au cadmium et au vanadium et résistance aux antibiotiques chez les bactéries hétérotrophes de sédiments marins portuaires ou littoraux. *Revue. Int. Océanogr. Méd.,* pp. 65-83.

DIEL DYNAMICS IN VIRIOPLANKTON ACTIVITY

Verónica Parada *, Eva Sintes and Gerhard Herndl

Department of Biological Oceanography, Netherlands Institute for Sea Research (NIOZ),
P.O.Box 59, 1790 AB Den Burg, Texel, The Netherlands - * vparada@nioz.nl

Abstract

Changes in resources availability can influence the production of bacteria at a diel scale and might consequently also generate short-term modifications in viral lysis rates. We examined the diel changes of viral production every 4-8 h in relation to bacteria activity in three water masses of the North Sea during July 2003. Viral activity was highest at all stations during dawn, ranging from $7.7x10^5$ ml^{-1} h^{-1} to $55.1x10^5$ ml^{-1} h^{-1} but did not follow the dynamics in bacterial production. The results indicate that viral lysis does not exhibit pronounced diel dynamics in the North Sea.

Key words: viral production, bacterial growth rate, diel cycle

Introduction

Recognition of viruses as the most abundant component of aquatic microbial communities has generated scientific interest focusing on their impact on the dynamics of host communities. Diel patterns in planktonic activity might be reflected in associated dynamics of the respective viral component, however, this has not be investigated yet [1, 2]. While bacterioplankton abundance and biomass remain usually fairly stable, their activity changes at a scale of hours [3, 4]. As viral production depends on bacterial activity, we hypothesized that diel dynamics in bacterial production should be reflected in short-term changes of viral lysis.

Materials and Methods

We sampled surface waters of the North Sea at three drifting stations during summer (July 2003) every 4-8 h for a total period of 28-48 h. Viral production was estimated using the virus-dilution approach [5, 6]. Bacterial activity was measured via [^{14}C]-leucine incorporation. Bacterial and viral abundance was determined in duplicate by flow cytometry.

Results and conclusion

Viral abundance averaged $21x10^7$ ml^{-1} at the southern station, $10x10^7$ ml^{-1} at the central station and $8x10^7$ ml^{-1} at the northern station of the North Sea. Viral abundance displayed short-term oscillations but not a diel trend. Viral production ranged from $1.8x10^4$ to $5.5x10^6$ ml^{-1} h^{-1} at the southern station (Fig. 1), from $7.7x10^3$ to $1.0x10^6$ ml^{-1} h^{-1} at the central station (Fig. 2) and from $6.4x10^4$ to $3.3x10^5$ml^{-1} h^{-1} at the northern station. The highest values of viral lysis were recorded around dawn in all the stations.

The range of bacterial abundance and activity, respectively, was $5.9x10^5$ ml^{-1} and 0.94 -3.1 nmol Leu l^{-1}d^{-1} at the southern station, $4.6x10^5$ ml^{-1} and 0.13-1.63 nmol Leu l^{-1}d^{-1} at the central station and $3.0x10^5$ ml^{-1} and 0.85-1.33 nmol Leu l^{-1}d^{-1} at the northern station. Bacterial activity was slightly lower during the night in all the stations. Bacterial growth rate was 0.11-0.46 d^{-1} at the southern station (Fig.1), 0.06-0.24 d^{-1} at the central station and 0.20-0.34 d^{-1} at the northern station.

Pronounced diel dynamics in the viral activity were not detectable, probably due to the low diel dynamics in bacterial activity in the mesotrophic North Sea. More pronounced diel patterns in bacterioplankton growth has been reported for oligotrophic systems such as the Mediterranean Sea.

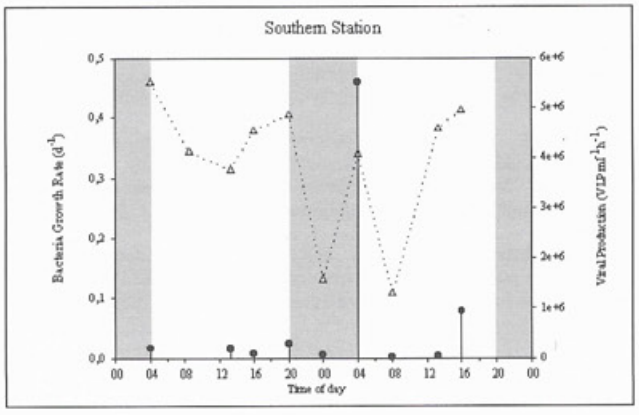


Fig. 1. Dynamics of bacterial growth rates (triangles) and viral production (circles) at the Southern Station of the North Sea.

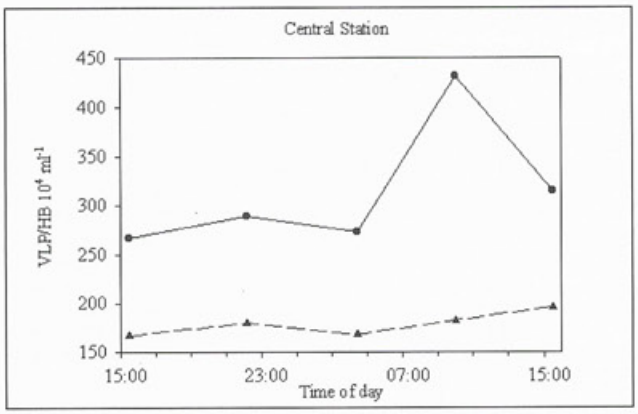


Fig. 2. Dynamics of virus like particles (VLP, circles) and heterotrophic bacterial (HB) abundance during incubation of water from 13:15 h at the Central station.

References

1 - Suttle, C.A., 1994. The significance of viruses to mortality in aquatic microbial communities. *Microb. Ecol.*, 28: 237-243.

2 - Wommack, K.E. and Colwell, R.R., 2000. Virioplankton: viruses in aquatic ecosystems. Microbiol. Mol. BioI. Rev., 64: 52 69-114.

3 - Lenski, R.E., 1988. Dynamics of interactions between bacteria and virulent bacteriophage. *Adv. Microb. Ecol.*, 10: 1-44.

4 - Steward GF, Wikner J, Cochlan WP, Smith DC, Azam F., 1992. Estimation of virus production in the sea: 2. Field results. Marine Microbial Food Webs, 6:79-90.

5 - Wilhelm, S.W. and Suttle, C.A., 1999. Viruses and nutrient cycles in the Sea. *Bioscience*, 49: 781-788.

6 - Weinbauer, M., Winter, C. and Hofle, M., 2002. Reconsidering transmission electron microscopy based estimates of viral infection of bacterioplankton using conversion factors derived from natural communities. *Aquat. Microb. Ecol.*, 27: 103-110.

ACTIVATION OF CARBONIC ANHYDRASE IN BRANCHIAL CAVITY TISSUES OF LOBSTER HOMARUS GAMMARUS CONDITIONED BY DILUTE SEAWATER

Dijana Pavičić-Hamer * and Čedomil Lucu
Institute Rudjer Bošković, Center for Marine Research, G. Paliage 5, 52210 Rovinj, Croatia
* pavicic@cim.irb.hr

Abstract
The activity of carbonic anhydrase (CA) and its distribution in the branchial cavity tissues has been studied in the lobster *Homarus gammarus* from ambient seawater (SW, salinity 38) and dilute seawater (DSW, salinity 20). In DSW-acclimated lobsters, almost 70% of total CA in tissues of the branchial cavity was found in epipodites and the rest was equally distributed between branchiostegites and gills. In cytosol fractions of tissues from DSW acclimated lobsters, the main proportion of 76% in epipodites, 61% in branchiostegite of total CA activity. Partially purified membranes contained 7% in epipodites and 16% in branchiostegite. These results indicate the importance of epipodites and branchiostegite in CA induction when lobsters are acclimated to DSW.

Keywords: carbonic anhydrase; dilute seawater; branchial cavity tissues; lobster Homarus gammarus

Introduction

Lobsters *Homarus gammarus* are mainly described as a non-regulating stenohaline species, able to tolerate only a narrow range of seawater salinity (1). However, recently it was found that lobsters can also temporary migrate to estuarine habitats where salinity fluctuates (2). In the lobsters acclimated to DSW, the specific activity of Na^+,K^+-ATPase was increased, particularly in the epipodites and the gills (3, 4). In addition to Na^+,K^+-ATPase, CA represents a key enzyme involved in the ion osmoregulation in hyperosmoregulating crabs, where it supplies ions for maintaining osmoconcentration gradients between the haemolymph and ambient seawater (5). CA is a multifunctional enzyme, with an additional role in respiration and acid-base regulation in the cells. CA supplies cells with H^+ and HCO_3^-, which then serve as counterions for the active uptake of important osmolytes Na^+ and Cl^- (6). In this work we studied CA of branchial cavity tissues during acclimation to DSW of the osmoregulating commercially important lobster *Homarus gammarus.*

Materials and methods

European lobsters *Homarus gammarus* (Linnaeus, 1758), weighing 312±110 g, were collected on the west Istrian coast of Adriatic Sea near Rovinj, Croatia. The activity of CA was measured using a modified method by comparison of uncatalyzed and catalyzed reaction times in tissue homogenates (with addition of Triton-100) (7). Differential centrifugation of tissues homogenates was used for measurements of the CA distribution in subcellular fractions, and to define the relation and distribution of cytosolic and membrane-bound CA (8).

Results and discussion

In lobsters acclimated to DSW, the adjustment of the blood hyperosmolarity is correlated with increased activity of Na^+,K^+-ATPase in epipodites and branchiostegite (3, 4). In the lobsters acclimated to DSW for two weeks, CA activity in the branchiostegite and epipodite was 8 and 6 times higher than the CA activity in lobsters held in SW (Fig. 1). These results show that epipodite and branchiostegite have an important osmoregulatory role when lobsters are acclimated to DSW.

Differential centrifugation of tissues showed that the cytosolic fraction of CA was inducible by exposure of lobsters to lower SW osmoconcentration (Fig. 2). In epipodites and branchiostegite the cytosolic fraction of CA in DSW acclimated lobsters amounted to 76% and 61%, respectively, of the total CA activity. The respective proportion of CA bound to membrane fraction from epipodites and branchiostegite of DSW-acclimated lobsters amounted to 7% and 16% of the total CA (Fig. 2). A slight activation of CA in homogenates and in partially purified membranes of gills was not confirmed as a statistically significant difference between the SW and DSW groups. Our results on the dominant proportion of the cytosolic CA are in accordance with results of Henry (5). We suggest that CA is mainly involved in the transport of osmolyte ions and respiration. The adaptive ion regulating mechanism in lobsters maintain homeostasis when lobsters migrate to brackish water habitats with a fluctuating salinity. Moreover, results provide knowledge to protect lobster populations in marine habitats.

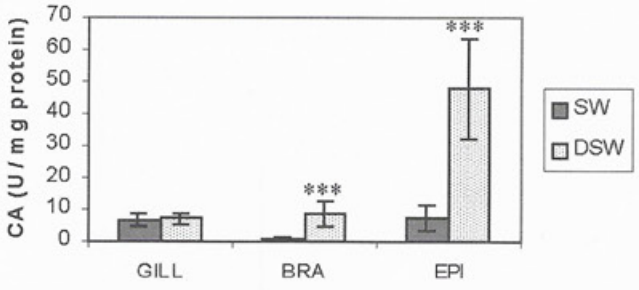


Fig. 1. Specific activities of carbonic anhydrase (CA) in epipodite, branchiostegite and gills of lobsters *Homarus gammarus* acclimated to seawater (SW) and to dilute seawater (DSW).
Mean values for 6 individual samples are given, error bars indicated SE. Asterisks denote significant differences from the SW value (Student's t-test p>0.001).

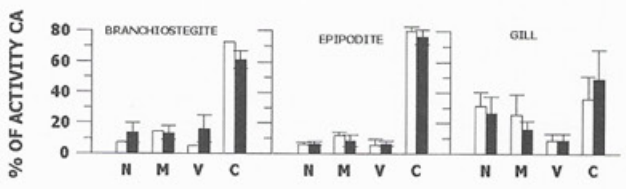


Fig. 2. Distribution of CA activity in subcellular fraction (N = nuclear; M = mitochondrial; V = membrane and C = cytosol) of epipodite, branchiostegite and gills from lobsters acclimated to SW (open bars) and DSW (dark bars).

References

1 - Péqueux A., 1995. Osmotic regulation in crustaceans. *J. Crustacean Biol.*, 15(1): 1-60.
2 - Linnane A., Ball B., Munday B., and Mercer J.P., 2000. On the occurrence of juvenile lobster *Homarus gammarus* in intertidal habitat. *J. Mar. Biol. Ass. U K*, 80: 375-376.
3 - Lucu Č., and Devescovi M., 1999. Osmoregulation and branchial Na^+,K^+-ATPase in the lobster *Homarus gammarus* acclimated to dilute seawater. *J. Exp. Mar. Biol. Ecol.*, 234: 291-304.
4 - Flik G., and Haond C., 2000. Na^+ and Ca^+ pumps in the gills, epipodites and branchiostegites of the European lobster *Homarus gammarus*: effects of dilute sea water. *J. Exp. Biol.*, 203: 213-220.
5 - Henry R.P., 2001. Environmentally mediated carbonic anhydrase induction in the gills of euryhaline crustaceans. *J. Exp. Biol.*, 204: 991-1002.
6 - Henry R.P., 1996. Multiple roles of carbonic anhydrase in cellular transport and metabolism. *Annu. Rev. Physiol.*, 58: 523-538.
7 - Bruns W., Dermietzel R., and Gross G., 1986. Carbonic anhydrase in the sarcoplasmatic reticulum of rabbit sceletal muscule. *J. Physiol.*, 371: 351-364.
8 - Flik G., Verbost P.M., Atsma V., and Lucu Č., 1994. Calcium transport in gill plasma membrane of the shore crab *Carcinus maenas*: evidence for carriers driven by ATP and a Na^+-gradient. *J. Exp. Biol.*, 185: 109-123.

RESOURCE AVAILABILITY AND THE GROWTH OF DIFFERENT BACTERIOPLANKTON

Jarone Pinhassi *, Laura Alonso and Josep M. Gasol
Institut de Ciències del Mar-CMIMA (CSIC), Barcelona, Catalunya, Spain - * jarone@cmima.csic.es

Abstract
The simultaneous use of nutrient limitation and dissolved organic carbon utilization bioassays during different seasons provided insights into the role of variable supply of resources for the growth of marine bacterioplankton. Furthermore, phylogenetic analyses of bacteria responding to different treatments in bioassays yield important novel clues to the adaptation of different bacterial groups and species to particular levels of nutrient availability in the sea. These findings suggest that variable patterns of resource availability and utilization may aid in explaining the abundance and activity of specific marine bacteria.

Key words: Marine bacterioplankton, Dissolved organic carbon, Nutrient limitation

Introduction

Present inventories of the composition of bacterioplankton offer a fairly good picture of the overall diversity among bacteria in the sea. Nevertheless, almost no information exists to explain precisely why particular groups or species of bacteria are successful. It is reasonable to assume that several physical, chemical and biological factors act selectively on the bacterioplankton. Considering the plethora of possible combinations between these factors it is intriguing that patterns of preference for particular conditions of some bacteria are emerging. For example, distinct marine bacterial isolates differ substantially in their enzymatic capacities, suggesting they are adapted to utilize different portions of organic matter [1]. In mesocosm experiments, a few *Cytophaga* species had a high growth capacity in the presence of elevated protein concentrations [2]. Using microautoradiography, it was confirmed that marine *Cytophaga* have a preference for complex macromolecules, such as protein [3]. To contribute understanding of how bacterioplankton are affected by resource availability we report results from a study of the growth of bacterioplankton in nutrient limitation and dissolved organic carbon utilization bioassays.

Material and methods

Surface seawater from the NW Mediterranean Sea was collected monthly from 28 January to 16 September 2003 at a coastal site 40 km N of Barcelona, Spain (41°40'N, 2°48'E).

The effect of nutrient addition on the growth of heterotrophic bacteria was examined in samples of 250 ml of unfiltered seawater. Nutrients were added to final concentrations of 20 µM C (as glucose or dimethylsulfoniopropionate, DMSP), 2 µM N (NH_4Cl), and 0.6 µM P (NaH_2PO_4), singly and in all different combinations in duplicates. Control bottles received no nutrients. After incubation for 24 h at in situ temperature in the dark, samples for bacterial production, bacterial abundance and microbial community DNA were collected.

We determined the growth of bacteria combined with measurements of dissolved organic carbon (DOC) consumption in duplicate seawater dilution cultures enriched with ammonium and phosphate as well as in duplicate control cultures without additions. The bacterial assemblage (0.8 µm-pore-size filtered) was inoculated into 0.2 µm-pore-size filtered water used as growth medium. Bacterial growth was monitored until stationary phase (4 d), and subsamples for bacterial abundance and thymidine and leucine incorporation were collected twice daily. Microbial community DNA for phylogenetic analyses was taken at the endpoint. These analyses included PCR-denaturing gradient gel electrophoresis (DGGE) of 16S rDNA and sequencing of bands.

Results and discussion

The nutrient addition experiments with unfiltered seawater showed that bacterioplankton growth was limited by the availability of P during most of the year (Fig. 1). Notable exceptions occurred during winter, when rain storms provoked temporary upwelling of deep water and/or land runoff that provided bacteria with nutrients. Combined addition of C, either as glucose or DMSP, and P consistently yielded higher growth compared to only P (Fig. 1). This suggests that although labile DOC accumulates in this sea area during summer (see [4] and below) it is less easily utilized compared to glucose or DMSP. Our data also indicate that DMSP is a highly preferred source of organic carbon to marine bacteria.

Bacteria in the control dilution cultures ranged between 0.7 to 1.2 x 10^6 cells ml^{-1}, with highest values in winter. During winter, growth of bacteria in the enriched dilution cultures was only slightly higher than in the controls, while in spring and summer enrichment caused up to fourfold higher bacterial growth rates and abundance. These data corroborate that DOC accumulates in surface seawater in regions where bacterioplankton growth is limited by mineral nutrients [4].

Analyses of bacterioplankton composition in our bioassays showed that some bacteria abundant in the initial water also grew in the control dilution cultures - particularly *Roseobacter* and *Cytophaga* relatives. Although these groups are frequently detected as abundant in seawater using DGGE and FISH, it was found that specific members of these groups became dominant in the cultures depending on nutrient status and season. In the enriched cultures, fast-growing gamma-proteobacteria, such as *Alteromonas*, quickly became dominant. Overall, there was a intimate relationship between the amount of DOC consumed and the composition of the bacterial assemblage.

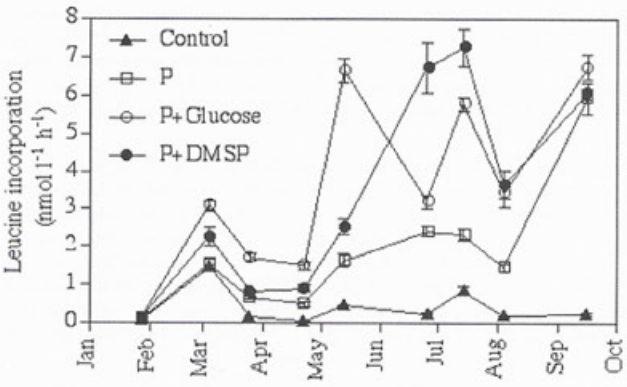


Fig. 1. Temporal changes of the response in bacterial production to the addition of nutrients. Treatments without P behaved as the control.

Acknowledgements

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References

1 - Martinez, J., Smith, D.C., Steward, G.F. and Azam, F., 1996. Variability in ectohydrolytic enzyme activities of pelagic marine bacteria and its significance for substrate processing in the sea. *Aquat. Microb. Ecol.*, 10: 223-230.

2 - Pinhassi, J., Azam, F., Hemphälä, J., Long, R.A., Martinez, J., Zweifel, U.L. and Hagström, Å., 1999. Coupling between bacterioplankton species composition, population dynamics, and organic matter degradation. *Aquat. Microb. Ecol.*, 17: 13-26.

3 - Cottrell, M.T. and Kirchman, D.L., 2000. Natural assemblages of marine Proteobacteria and members of the *Cytophaga-Flavobacter* cluster consuming low- and high-molecular-weight dissolved organic matter. *Appl. Environ. Microbiol.*, 66: 1692-1697.

4 - Thingstad, T.F., Hagström, Å. and Rassoulzadegan, F., 1997. Accumulation of degradable DOC in surface waters: Is it caused by a malfunctioning microbial loop? *Limnol. Oceanogr.*, 42: 398-404.

COMPARISON OF MICROBIAL COMMUNITY COMPOSITION FROM DIFFERENT SEDIMENTS OF THE EASTERN MEDITERRANEAN SEA USING T-RFLP, DGGE AND PLFA ANALYSIS

Paraskevi N. Polymenakou [1, 3] *, Stefan Bertilsson [2], Anastasios Tselepides [1], Euripides G. Stephanou [3]

[1] Institute of Marine Biology of Crete, Old American Base of Gournes, Heraklion Crete, Greece - * polymen@imbc.gr; ttse@imbc.gr
[2] Department of Limnology, Evolutionary Biology Center, Uppsala University, Uppsala, Sweden - stebe@ebc.uu.se
[3] ECPL, Chemistry Department, University of Crete, Heraklion Crete, Greece - stephanou@chemistry.uoc.gr

Abstract

The distribution of complex marine bacterial communities in different sediments of the Eastern Mediterranean Sea was investigated by denaturing gradient gel electrophoresis (DGGE), terminal restriction fragment length polymorphism (T-RFLP) and phospholipid-linked fatty acid (PLFA) fingerprinting methods. Dendrograms derived from DGGE, T-RFLP and PLFA profiles were significantly different. The DGGE derived dendrogram groups the North (Thermaikos Gulf) and South (Cretan Sea, Ionian Sea, Levantine Sea) sampling sites, whereas T-RFLP analysis indicates differences between shallow and deep sea sediments. However, PLFA analysis placed the shallow Therm30 station from the North within the deep Southern cluster of stations.

Keywords: DGGE, T-RFLP, PLFA, Eastern Mediterranean Sea, sediments

The eastern Mediterranean Basin is considered to be one of the most oligotrophic regions in the world with an overall nutrient deficit (1). The areas under investigation (Thermaikos Gulf, Cretan, South Ionian and Levantine Sea) are characterized by persistent geomorphological, hydrographic and meteorological features (1-3), which affect the distribution of nutrients and organic matter production in the euphotic zone and eventually its propagation to the ocean floor to fuel benthic communities (4).

Within the benthic community, bacteria are significant due to their key role in regulating the biogeochemical cycles of the major organic elements (carbon, nitrogen, oxygen and sulfur). The role of sediments in regulating microbial community composition is poorly known. Hence, sediment samples from a variety of environments (Thermaikos Gulf, Cretan Sea, Levantine Sea and the deep South Ionian Sea) were chosen for the analysis of microbial communities by performing three different culture independent fingerprinting techniques (i.e. the DGGE, T-RFLP based on 16S rRNA amplification and PLFA analyses).

The dendrogram derived from the DGGE analysis displayed two distinct clusters (Fig. 1a). The first cluster contained all the samples from Thermaikos Gulf and was grouped far from the other cluster, indicating that the largest shift in community composition occurred with sampling location. High similarity was obtained between the Thermaikos Gulf stations (77.78 – 95.24 % similarity) indicating that this region contained very similar bacterial populations which differ significantly from the sampling sites in the South. These stations were found internally similar (40 – 85.41 % similarity).

However, the T-RFLP fingerprinting technique produced a different set of clusters compared to the DGGE method (Fig. 1b). The first cluster contained all the shallow stations from Thermaikos Gulf and Cretan Sea. The samples from Thermaikos Gulf show high similarity (52.63 – 68.42 %); however, station Therm30 is clustered together with station Creta-2 indicating the similarity of bacterial composition between these geographically distinct sampling sites.

The total PLFA content in the sediments averaged 95.70 – 2293.93 ng/g dry weight of sediment and it is almost three times lower compared to other environments probably due to the low organic carbon content (5, 6). The highest similarity value was recorded from Thermaikos Gulf (94.84% similarity between stations Therm27 and Therm38) and the lowest between the South Ionian Sea and Thermaikos Gulf (30.98% similarity between stations S.Ionian-B and Therm17).

DGGE and T-RFLP analyses demonstrated that the community structure changed with sampling location and depth, respectively. DGGE profiles were simpler than those of T-RFLP, indicating the slightly higher resolution of the T-RFLP fingerprinting technique. However, PLFA analysis shows a completely different profile. The complexity of the bottom geomorphology and the local hydrological features of the different sampling sites, can explain the structural shifts of the microbial community. Therefore, depending on the questions posed and the complexity of the environment under investigation, a number of different fingerprinting techniques must be applied to assess the whole or viable bacterial community composition.

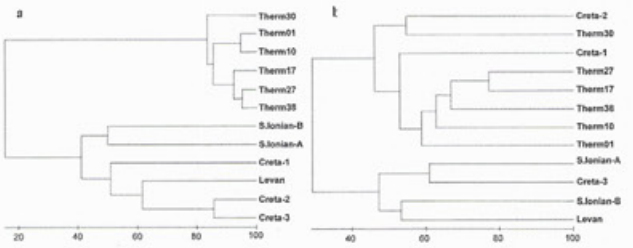

Fig. 1. Cluster analysis dendrograms from the different surface sediment samples taken in the Eastern Mediterranean Sea based on comparison of a) DGGE patterns b) T-RFLP patterns.

References

1 - Tselepides A., Zervakis V., Polychronaki T., Danovaro R., and Chronis G., 2000a. Distribution of nutrients and particulate organic matter in relation to the prevailing hydrographic features of the Cretan Sea (NE Mediterranean). *Prog. Oceanogr.*, 46: 113-142.

2 - Lascaratos A., Roether W., Nittis K., and Klein B., 1999. Recent changes in deep water formation and spreading in the eastern Mediterranean Sea: a review. *Prog. Oceanogr.*, 44: 5-36.

3 - Balopoulos E.Th., Theocharis A., Kontoyiannis H., Varnavas S., Voutsinou-Taliadouri F., Iona A., Souvermezoglou A., Ignatiades L., Gotsis-Skretas O., Pavlidou A., 1999. Major advances in the oceanography of the southern Aegean Sea-Cretan Straits system (Eastern Mediterranean). *Prog. Oceanogr.*, 44: 109-130.

4 - Tselepides A., Polychronaki T., Marrale D., Akoumianaki I., Dell'Anno A., Pusceddu A., and Danovaro R., 2000b. Organic matter composition of the continental shelf and bathyal sediments of the Cretan Sea. *Prog. Oceanogr.*, 46: 311-344.

5 - Guezennec J., and Fiala-Medioni A., 1996. Bacterial abundance and diversity in the Barbados Trench determined by phospholipid analysis. *FEMS Microbiol. Ecol.*, 19: 83-93.

6 - Bowman J.P., McCammon S.A., Gibson J.A.E., Robertson L., and Nichols P.D., 2003. Prokaryotic metabolic activity and community structure in Antarctic continental shelf sediments. *Appl. Environ. Microbiol.*, 69: 2448-2462.

FUNCTIONAL DIVERSITY OF BACTERIOPLANKTON COMMUNITIES IN CONTRASTING ENVIRONMENTS OF THE NW MEDITERRANEAN COAST

Sala M.M. *, Felipe J., Gasol J.M., Pinhassi J. and Estrada M.
Institut de Ciències del Mar-CMIMA (CSIC), Barcelona, Spain - * msala@icm.csic.es

Abstract
We studied the metabolic diversity of bacterioplankton in four contrasting environments of the Catalan coast (NW Mediterranean) by comparing the profiles of sole carbon sources using Biolog-Eco microplates. Bacterioplankton communities were metabolically different in enclosed and open environments. Patterns of carbon utilization during harmful algal blooms were not different from those obtained from other enclosed environments.

Keywords: bacterioplankton metabolism, Biolog, HABs, coastal zone

Introduction

A lot of information is now available on the phylogenetic bacterial diversity in marine environments. However, to understand the biogeochemical role of different microbial communities it is essential to have knowledge also on their functional diversity. Previous studies in the coastal zone of the Catalan coast have shown that the bacterial community was phylogenetically different in enclosed from open areas (1). To our knowledge, no information on functional diversity in the Mediterranean Sea has been reported. In other environments, functional diversity has been assessed using Biolog plates (2). Since each species of bacteria differ in the specific organic substrates that they can use as carbon and energy sources, each community would have a characteristic profile of carbon source utilization in the Biolog plate. The aim of our study was to evaluate if bacterial functional diversity was different in zones with different trophic conditions. Among the enclosed zones, we have included two blooms of the toxic dinoflagellate *Alexandrium.*

Material and methods

Metabolic diversity of bacterioplankton was studied in the surface of four different regions of the Catalan Coast (NW Mediterranean). Station AH (Arenys de Mar Harbour) was sampled in January 2002 during a bloom of the dinoflagellate *Alexandrium minutum*. Station TH (Tarragona Harbour) was sampled in June 2001 during a bloom of the dinoflagellate *Alexandrium catenella*). Station BH (Barcelona Harbour) was sampled regularly from June 2001 until October 2002 a period with no HABs (harmful algal bloom) detectable. Apart from the three harbours, we collected samples from two coastal open environments in Blanes (St. BL) and Masnou (St. MA) in different periods between 2001 and 2003.

Metabolic diversity was assessed by means of Biolog-Eco microplates that provide profiles of sole carbon source utilization (see ref. 3 for a review). Biolog-Eco plates contain 31 different carbon sources in triplicates. After inoculation of the wells (150 µl sample), the plates are incubated for 6 days and absorbance is afterwards measured at 590 nm. The pattern of color development of each plate gives a fingerprint for every community. The patterns of color development were compared after normalizing the data according to ref. 4. Hierarchical cluster analysis (HCA) was used to determine differences between patterns of substrate utilization. The Wards Method and City-block distance clustering was used in this analysis. Data from HCA were used to construct a dendogram (Fig. 1) and the shorter the leaf the greater the similarity.

Results and discussion

The dendogram, and the principal component analysis, showed two groups of samples. The first group contained all the samples from the oligotrophic areas (BL and MA) and some BH samples with low chlorophyll concentrations. The second group contained only samples from the enclosed environments, i.e. the harbours. Included in this group we found the samples from HABs (AH and TH) and most of the BH samples. Seasonal grouping could not be easily observed among the enclosed samples from BH. Patterns of metabolic activity of bacterioplankton during HABs did not differ from those obtained in BH along the year, when no dinoflagellates bloom was detected.

Our results suggest that, similarly to phylogenetic diversity (1), functional diversity of bacterioplankton populations is different in harbors than in open coastal stations, with metabolic capabilities of bacterioplankton during HABs not different from those of other enclosed areas.

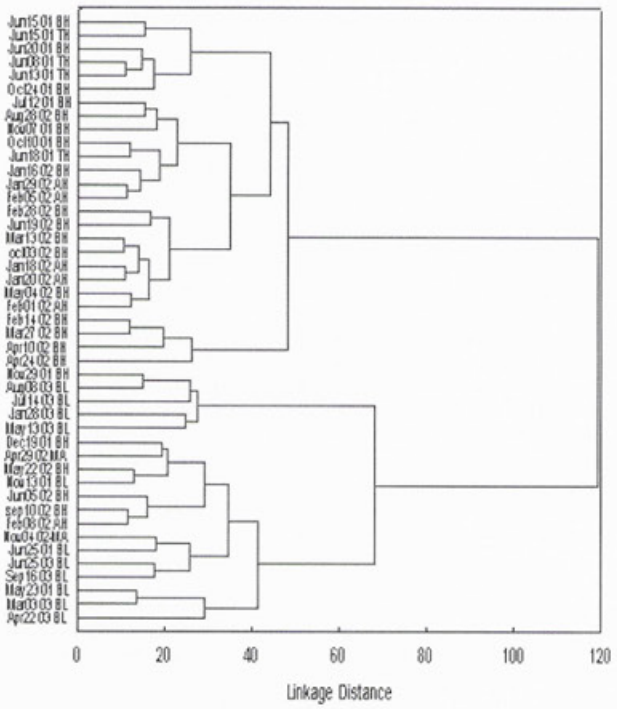

Fig.1. HCA results for Biolog data obtained from the Catalan coast. Branches are labeled by date and station: BH: Barcelona harbour, TH: Tarragona harbour, AH: Arenys harbour, BL: Blanes and MA: Masnou.

Acknowledgements

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References

1 - Schauer, M., Massana, R., and Pedrós-Alio, C., 2000. Spatial differences in bacterioplankton composition along the Catalan coast (NW Mediterranean) assessed by molecular fingerprinting. *FEMS Microb. Ecol.*, 33: 51-59.
2 - Schultz, G.E,. and Ducklow, H., 2000. Changes in bacterioplankton metabolic capabilities along a salinity gradient in the York River estuary, Virginia, USA. *Aquat. Microb. Ecol.,* 22: 163-174.
3 - Preston-Mafham, J., Boddy, L., and Randerson, P.F., 2002. Analysis of microbial community functional diversity using sole-carbon-source utilisation profiles - a critique. *FEMS Microb. Ecol.*, 42: 1-14.
4 - Garland, J.L., and Mills, A.L. 1991. Classification and characterization of heterotrophic microbial communities on the basis of patterns of community-level sole-carbon-source utilization. *Appl. Environ. Microbiol.* 57: 2351-2359.

GROWTH AND MORTALITY RATES OF HIGH-DNA AND LOW-DNA-BACTERIA IN SURFACE AND DEEP CHLOROPHYLL MAXIMUM LAYERS

Renate Scharek [1, 2 *] and Mikel Latasa [1]

[1] Institut de Ciencies del Mar (ICM, CSIC), Passeig Marítim de la Barceloneta, 37-49, E-08003 Barcelona, Spain
[2] Instituto Español de Oceanografía (IEO) Centro Oceanográfico de Gijón, Avda. Principe de Asturias, 70 bis E-33212 Gijón, Spain
* rscharek@icm.csic.es

Abstract
Protozoan grazing on marine heterotrophic bacteria was measured in summer 1999 in northwestern Mediterranean coastal waters. Serial dilution experiments were performed with water of the surface and deep chlorophyll maximum layer (DCM). Measured growth and grazing rates indicate that high-DNA-bacteria being the most active component of the bacterial community in the surface layer, not only with respect to production but also as a prey for grazers. However, this tendency was not observed in the DCM, insinuating profound differences between both habitats in structure and functioning of the respective bacterial populations and microbial networks.

Key words: microbial foodwebs, dilution experiments, flow cytometry

Introduction

Heterotrophic bacteria constitute a fundamental component in marine planktonic microbial foodwebs and in dynamics of marine carbon fluxes (1). Bacterial productivity and mortality are key parameters to understand their population dynamics and therefore, the role of bacteria in biogeochemical processes and ecosystem functioning. One approach to measure bacterial net growth and mortality by bacterivory is to modify the encounter rates between predator and prey applying the dilution method (2), which manipulates the microbial community as a whole. Flow cytometrical measurements combined with nuclear staining allow to obtain indications about the DNA content of bacterial populations (3). This parameter can give information about distinct assemblages and/or their physiological status. We combined both methods in order to measure growth and grazing rates for heterotrophic bacterial populations during a cruise along the northwestern Mediterranean coast (Catalunya, Spain). Our results provide new insights into the growth dynamics of bacterial populations and how they are affected by grazing in distinct habitats of the water column.

Material and methods

During the cruise ARO-2000 (May 30 - June 9, 2000) growth and grazing rates were determined with the seawater dilution method at stations situated in the frontal slope-edge-current. Eight experiments were done with water from the surface (5m) and four experiments with water from the DCM. Water was obtained by means of a modified 30 L Niskin® bottle. Temperature and light conditions were simulated on deck with a cooling system and a blue Plexiglas incubator.

High and low-DNA-bacteria were quantified flow-cytometrically after staining with DNA stain Syto 13 (Molecular Probes). Significance of differences of calculated growth and grazing rates between high and low-DNA-bacteria from the surface and DCM was tested with the t-test (4).

Results and discussion

A freshened surface current in the frontal zone extended to about 10 m, and sometimes 20 m, depth carrying water influenced by the Rhone river. Between 5 m and DCM depth, a temperature decrease of 5 to 6° C was measured. The DCM was located between 40 and 70 m and coincided with the lowest part of the thermocline. Chlorophyll fluorescence intensities were between 3 and 22 times higher in the DCM than in the surface layer.

Concentrations of total bacteria at the beginning of the experiments ranged between 0.8 and 2.5 10^6 ml^{-1} in the surface and between 1.2 and 1.7 10^6 ml^{-1} in the DCM. In the surface layer, proportions of high-DNA-bacteria to total bacterial concentrations varied between 34 and 55%. In the DCM, the high-DNA-bacteria proportions were slightly lower (39 to 47%).

Bacterial concentrations at the end of the experiments did not differ considerably from the ones at the beginning indicating a match between growth and grazing.

Intrinsic total bacterial growth rates ranged from 0.44 to 1.64 d^{-1} in the surface and from 0.49 to 1.19 d^{-1} in the DCM. Average grazing rates on the bacterial community ranged from 0.74 to 1.29 d^{-1} in the surface and from 0.32 to 1.02 d^{-1} in the DCM. Different rates were measured for high-DNA and low-DNA-bacteria populations. In the surface, average grazing and growth rates of high-DNA-bacteria were twice as high as those of low-DNA-bacteria. In the DCM, the opposing trend was apparent: average grazing rates on high-DNA-bacteria were about a third of the rates on low-DNA-bacteria and average intrinsic growth rates were about half.

Average grazing rates on high-DNA-bacteria were nearly four times higher in the surface than in the DCM and average intrinsic growth rates were nearly three times higher. Average grazing rates on low-DNA-bacteria and their growth rates were higher in the DCM compared to the surface, however, not significantly (Fig.1).

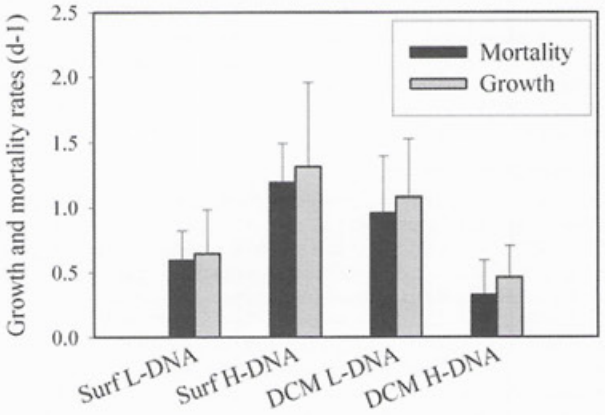

Fig. 1. Growth and mortality rates of high-DNA and low-DNA-bacteria in the surface and the DCM. Indicated are arithmetic means and one standard deviation.

A strong coupling between intrinsic growth and grazing rates was observed in both layers and in both bacterial fractions. As a result, bacterial concentrations and proportions between high-DNA and low-DNA-bacteria remained more or less the same.

Our observations provide evidence for the hypothesis that high-DNA-bacteria are the most active component of the bacterial community (5). Nevertheless this trend presented itself only in the surface layer, as in the DCM the opposing tendency was apparent. Besides the measured differences in bacterial growth and mortality rates, the properties of the different layers, coastal river-plume at the surface versus typical oceanic DCM, insinuate distinct phylogenetic affiliations of the bacterial populations and dissimilarities of the microbial foodwebs.

References

1 - Pomeroy L.R., 1974. The ocean´s food web, a changing paradigm. *BioScience*, 24: 499-504.
2 - Landry, M.R., and Hasset, R.P. 1982. Estimating the grazing impact of marine microzooplankton. *Marine Biology*, 67: 283-288.
3 - Li W.K.W., Jellett J.F., and Dickie P.M., 1995. DNA distributions in planktonic bacteria stained with TOTO or TO-PRO. *Limnol. Oceanogr.*, 40: 1485-1495.
4 - Sokal R.R., and Rohlf F.J. 1981. Biometry. W.H. Freeman and Company, New York: 859 p.
5 - Gasol J.-M., Zweifel U.L., Peters F., Fuhrman J. A., and Hagström A., 1999. Significance of size and nucleic acid content heterogenity as measured by flow cytometry in natural planktonic bacteria. *Appl. Environ. Microbiol.*, 65: 4475-4483.

BACTERIAL BIOMASS IN SEDIMENTS OF COASTAL ADRIATIC SEA

S. Šestanović *, M. Šolić and N. Krstulović
Institute of Oceanography and Fisheries, Split, Croatia - * sesta@izor.hr

Abstract
The changes in bacterial biomass and morphological diversity of bacterial cells were studied in sediments of the eastern middle Adriatic Sea. Bacterial biomass showed seasonal changes, varying from 78 to 378 mg C g^{-1}. Rods dominated bacterial biomass during the whole year. The majority of cocci biomass consisted of cells with the volume between 0.01 -0.5 mm^3. During January and December, filamentous bacteria covered up to 17% bacterial biomass.

Key words: bacterial biomass, sediment, Adriatic Sea

Introduction

Sediment bacteria comprise a large fraction of total benthic biomass. To elucidate their trophic role, accurate measurements of their biomass are needed. The changes in bacterial biomass depend upon environmental conditions. Nutrient limitations can lead to the formations of ultramicrocells (1). Under heavy protozoan grazing, the distribution of bacterial cell types may shift toward filamentous forms resistant to grazing (2).

Materials and methods

Undisturbed sediment cores were collected monthly, from January to December 2002, with a piston corer, at one coastal station in Kaštela Bay, middle Adriatic Sea. Bacteria were counted and sized under epifluorescent microscope (3). The volume of each cell was calculated following equation of (4). Cell volumes were converted to bacterial biomass using the equation given by (5). The results were expressed in grams of sediment dry weight.

Results

Bacterial biomass ranged from 78 to 378 µg C g^{-1} (Fig. 1). Rods dominated bacterial biomass during the whole year, especially during winter, covering 61 -72% of bacterial biomass (Fig. 2). During non-winter period rods smaller than 0.5 μm^3 prevailed. Rods larger than 1 μm^3 dominated during winter. The importance of cocci increased during warmer months when they accounted for up to 45% of bacterial biomass. The majority of cocci biomass consisted of cells with the volume between 0.01 -0.5 μm^3. Filamentous bacteria covered 10 -24% of bacterial biomass. During the non-winter period, their biomass mainly consisted of cells smaller than 1 μm^3. During January and December, a shift toward cells larger than 1 μm^3 occurred. In that period, those cells covered up to 17% of bacterial biomass.

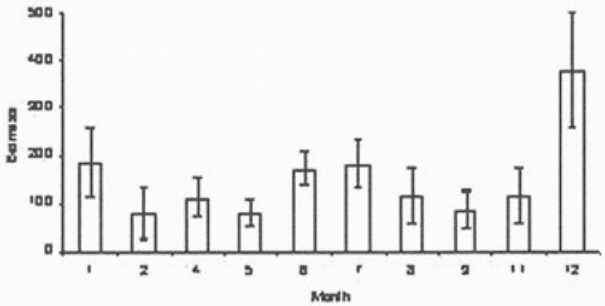

Fig. 1. Monthly distribution of bacterial biomass (mean ± 1 SD) (µg C g^{-1}).

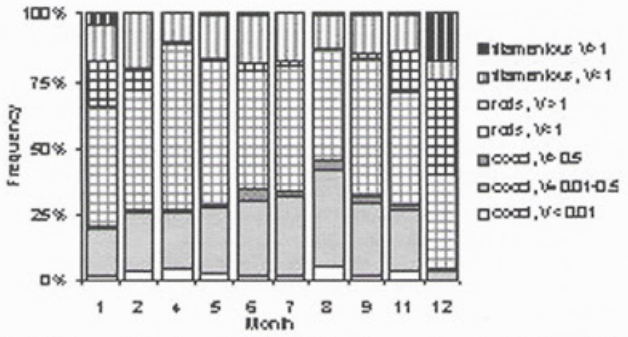

Fig. 2. The contribution of different size classes of bacteria in bacterial biomass (V= volume in μm^3).

Discussion

Bacterial biomass was one order of magnitude higher than values reported in other coastal areas of the Mediterranean Sea (6). Our study indicates annual patterns of bacterial biomass changes.

The size and shape of bacterial cells are affected by the conditions in the environment. The quality and quantity of available organic matter, temperature and grazing pressure, can provoke changes in cell morphology. As opposite to water column, where protozoan predation exerts a major influence on bacterial biomass, in benthic environments grazing has no considerable impact on bacterial dynamics. According to (7), the major parameter that determines the distribution of bacteria and flagellates in sediments is the size of sediment particles. The decrease of sediment grain size is accompanied with decrease in bacterial production and increase in flagellate biomass. Therefore, flagellates could have a stronger control over bacterial dynamics only when bacterial production is minimal. In order to reveal the importance of predation for bacteria in sediments of coastal Adriatic Sea, it would be essential to elucidate the changes in bacteriovorous protozoa abundance, as well as in benthic bacterial production. The future investigations will focus on these problems.

References

1 - Šimek, K., Vrba, J., Pernthaler, J., Posch, T., Hartman, P., Nedoma, J. and Psenner, R., 1997. Morphological and compositional shifts in an experimental bacterial community influenced by protists with contrasting feeding modes. *Appl. Environ. Microb.*, 63: 587-595.
2 - Holmquist, L. and Kjellember, S., 1993. Changes in viability, respiratory activity and morphology of marine Vibrio sp. Strain S14 during starvation of individual nutrients and subsequent recovey. *FEMS Microbiology Ecology*, 12: 215-224.
3 - Hobbie, J.E., Daley, R.J. and Jasper, S., 1977. Use of nucleopore filters for counting bacteria by fluorescence microscopy. *Appl. Environ. Microb.*, 33: 1225-1228.
4 - Bratbak, G., 1985. Bacterial biovolume and biomass estimations. *Appl. Environ. Microb.*, 49: 1488-1493.
5 - Norland, S., 1993. The relationship between biomass and volume of bacteria. Pp. 303-309. In: P.F. Kemp, B.F. Sherr, E.B. Sherr, and J.J. Cole (eds.), Handbook of methods in aquatic microbial ecology. Boca Raton, Lewis Publishers.
6 - Mirto, S., La Rosa, T., Danovaro, R. and Mazzola, A., 2000. Microbial and meiofaunal response to intensive mussel-farm biodeposition in coastal sediments of the western Mediterranean. *Mar. Pollut. Bull.*, 40: 244-252.
7 - Hamels, I., Muylaert, K., Casteleyn, G. and Vyverman. W., 2001. Uncoupling of bacterial production and flagellate grazing in aquatic sediments: a case study from and intertidal flat. *Aquatic Microbial Ecology*, 25: 31-42.

SIMULTANEOUS EFFECT OF DIFFERENT VARIABLES ON BACTERIAL AND HNF ABUNDANCES IN KASTELA BAY (ADRIATIC SEA)

S. Šestanović*, M. Šolić, N. Krstulović, N. Bojanić and Ž. Ninčević
Institute of Oceanography and Fisheries, Split, Croatia - * sesta@izor.hr

Abstract
Simultaneous effects of temperature, concentration of chl a and bacterial production on bacterial abundance, as well as of temperature, bacterial abundance and bacterial production on heterotrophic nanoflagellate (HNF) abundance were studied monthly from January 1997 to December 1998 in the coastal middle Adriatic Sea. The results showed that bacterial abundance was not limited by substrate supply. The effect of temperature on bacterial abundance was very high, and temperature obscured the effect of bacterial production, suggesting that bacterial growth itself is highly temperature dependent. About 60% of the variability in HNF abundance can be explained with bacterial abundance, bacterial production and temperature.

Key words: Bacteria, heterotrophic nanoflagellates, Adriatic Sea

Introduction

Distribution and dynamics of microbial organisms are result of the complex interactions among environmental variables and interspecies relationships. Heterotrophic nanoflagellates (HNF) have been identified as a major source of bacterial mortality in aquatic ecosystems, but their predation pressure is found to be dependent on temperature and trophic state of the studied area (1, 2). The effects of these factors are not always clear as they can act simultaneously, changing their relative importance spatially and temporally. The aim of this study was to gain a better understanding of seasonal patterns of bacterial and HNF abundances according to simultaneous effect of different factors.

Material and Methods

Sampling was conducted monthly, from January 1997 to December 1998 at a coastal station located in an enclosed shallow basin Kaštela Bay. Phytoplankton biomass was estimated from chl *a* concentrations using fluorimetric methods (3). Enumeration of bacteria and HNF were made by epifluorescence microscopy using the standard AODC technique (4) for bacteria, and proflavine staining (5) for HNF. Bacterial cell production was measured from DNA synthesis based on incorporation rates of 3H-thymidine (6).

Results and discussion

Bacterial abundance was positively correlated with temperature ($r = 0.55$; $P < 0.001$), while correlation with bacterial production was statistically significant but relative low ($r = 0.289$; $P < 0.05$) (Table 1). On the other hand, bacterial abundance was not related to chl *a* concentration, suggesting that input from land is more important source for substrate supply than phytoplankton. However, since the Kaštela Bay receives large quantities of nutrients throughout the year, this location shows conditions in which substrate concentrations are almost always above saturating level. Therefore, it seems that temperature was the main factor that determined whether bacteria attain maximal growth. Analysis of simultaneous effect of temperature and bacterial production on bacterial abundance showed that effect of temperature masked effect of bacterial production. That is, the effect of bacterial production on bacterial abundance failed to occur when temperature stayed constant, suggesting that in Kaštela Bay, bacterial growth itself is highly temperature dependent seasonal phenomenon (7).

Table 1. Simultaneous effect of different variables on bacterial and HNF abundances.

Dependent variable	Independent variables	r	r_p	β	R	R^2 (%)
Bacteria	Temperature	0.549**	0.589**	0.615	0.591**	35
	Chl *a*	0.055	0.254*	0.230		
Bacteria	Temperature	0.549**	0.523**	0.519	0.565**	32
	Bacterial production	0.249	0.160	0.137		
Bacteria	Chl *a*	0.055	0.041	0.040	0.304*	6
	Bacterial production	0.289*	0.286*	0.247		
Bacteria	Temperature	0.549**	0.564**	0.587		
	Chl *a*	0.055	0.249	0.216	0.601**	36
	Bacterial production	0.249	0.132	0.110		
HNF	Bacterial abundance	0.754**	0.665**	0.693	0.760**	58
	Temperature	0.493**	0.141	0.111		
HNF	Bacterial abundance	0.754**	0.745**	0.722	0.773**	60
	Bacterial production	0.306*	0.255*	0.170		
HNF	Temperature	0.493**	0.454**	0.445	0.530**	28
	Bacterial production	0.306*	0.224	0.201		
HNF	Bacterial abundance	0.754**	0.668**	0.680		
	Temperature	0.493**	0.105	0.080	0.775**	60
	Bacterial production	0.306*	0.237	0.159		

r - coefficient of correlation - rp - coefficient of partial correlation - b (beta coefficient) - regression coefficients (b) stated in terms of their standard deviations - R - coefficient of multiple regression - R2 (%) - coefficient of multiple determination; measure of the proportion (percentage) of variance explained
** $P < 0.01$; * $P < 0.05$.

HNF abundance was positively correlated with temperature, bacterial abundance and bacterial production (Table 1). The strongest correlation ($r = 0.754$; $P < 0.001$) was found with bacterial abundance. The coefficient of multiple determination (R^2), which measures the overall degree of association between HNF abundance and independent variables, varied from 0.58 to 0.60. That means that about 60% of the variability in HNF abundance can be explained with bacterial abundance, bacterial production and temperature. The highest relative importance of bacterial abundance in controlling HNF abundance is shown by the coefficients of partial correlation (r_p) and beta coefficients (β) (Table 1). Bacterial abundance obscured the effects of both other factors, particularly the effects of temperature. This result suggests that bacterial abundance itself was highly temperature dependent, since temperature influences variation in HNF abundance indirectly through the changes in bacterial abundance.

As we stated before, inconsistent relationship between bacterial abundance and productivity could be result of conditions in which substrate supply is above saturation level, but it could also suggests conditions in which mortality factors such as bacterivory and viral lysis are very strong. It seems that in Kaštela Bay temperature controlled not only bacterial abundance but also the abundance of bacteriovorous protozoa, which in turn determined bacterial abundance by high grazing pressure. In these conditions, grazing was a main control of bacterial abundance, particulary during summer. The weak relationship between bacteria and HNF during colder months could be a result of the weak grazing pressure on bacteria by HNF, as well as of high grazing pressure on HNF by ciliates (1, 2, 7). This is supported by the study that found high ciliate abundances during winter, and low abundance and grazing pressure on HNF during summer in Kaštela Bay (8).

In conclusion, this study suggests that relative importance of various factors in regulating bacterial and HNF abundances might change over the seasonal scale. In the coastal area, bacteria were not limited by substrate supply, but were rather controlled by HNF grazing and temperature. Moreover, the fluctuation of bacterial abundance explained significant part of variance in HNF abundance.

References

1 - Šolić M., Krstulović N., Bojanić N., Marasović I., Ninčević Z., 1998. Seasonal switching between relative importance of bottom-up and top-down control of bacterial and heterotrophic nanoflagellate abundances. *J. Mar. Biol. Assoc. UK*, 78: 755-766.
2 - Šolić M., Krstulović N., Šestanović S., 2001. The roles of predation, substrate supply and temperature in controlling bacterial abundance: interaction between spatial and seasonal scale. *Acta Adriat.*, 42: 35-48.
3 - Strickland J.D.H., Parsons T.R., 1972. A practical handbook of seawater analysis. *B. Fish Res. Board Can.*, 167: 310.
4 - Hobbie J.E., Daley R.J., Jasper J., 1977. Use of Nucleopore filters for counting bacteria by fluorescence microscopy. *Appl. Environ. Microbiol*, 33: 1225-1228.
5 - Haas L.W., 1982. Improved epifluorescence microscopy for observing planktonic microorganisms. *Ann. Inst. Oceanogr. Paris*, 58: 261-266.
6 - Fuhrman J.A., Azam F., 1982. Thymidine incorporation as a measure of heterotrophic bacterioplankton production in marine surface waters: evaluation and field results. *Mar. Biol.*, 66: 109-120.
7 - Šolić M., Krstulović N., 1994. The role of predation in controlling bacterial and heterotrophic nanoflagellate standing stocks in the coastal Adriatic Sea: seasonal patterns. *Mar. Ecol. Prog. Ser.*, 114: 219-235.
8 - Bojanić N., 2001) Seasonal distribution of the ciliated protozoa in Kaštela Bay. *J. Mar. Biol. Assoc. UK*, 81: 383-390.

BACTERIAL ACTIVITY IN THE SURFACE MICROLAYER OF THE OPEN MEDITERRANEAN SEA

Eva Sintes * and Gerhard J. Herndl

Department of Biological Oceanography, Royal Netherlands Institute of Sea Research, PO Box 59, NL-1790 AB Den Burg, The Netherlands - * esintes@nioz.nl, herndl@nioz.nl

Abstract

Diel dynamics in the activity and viability of bacterial cells were studied in the surface microlayer (SML) and the underlying water layer (UWL) of the open Mediterranean Sea, following a drifting buoy. Bacterial abundance was rather stable and only slightly higher in the SML as compared to the UWL. The cell-specific activity of bacteria was variable, however, and diel cycles of bacterial activity showed a decrease in the percentage of active cells and a slight increase in the percentage of cells with compromised cell membranes during the day, which might be related to UV-induced damage.

Keywords: Bacteria, sea surface microlayer, activity, viability

Introduction

The SML is a unique microenvironment characterized by the accumulation of dissolved and particulate inorganic and organic matter (1). Accumulation of organisms (2, 3) and enhanced enzymatic activities have been reported for these waters (4). Essentially all the information available thus far on the SML originates from studies conducted in coastal areas, lakes or ponds, but diel dynamics of the activity of organisms of the open sea SML are still lacking.

Material and Methods

To determine the diel dynamics of the microorganisms in the SML of open sea areas, we sampled the SML and the UWL waters over diel cycles, following a drifting buoy in the open Mediterranean Sea. The first sampling (29-30 Sept. 03) was characterized by a calm sea state and bright sunshine while the second diel cycle (4-5 Oct 03) was preceded by a day with wind force 7 and white caps, calming down overnight prior to sampling. We measured the abundance of bacteria by flow cytometry distinguishing high and low-DNA bacteria, CTC+ cells (highly active cells), and cells with compromised cell membranes. Bacterial production via ^{3}H-leucine uptake was measured as well, along with some basic chemical parameters (inorganic nutrients, dissolved organic carbon, DOC).

Results and Discussion

Bacterial abundance was rather stable, ranging between 2.97 and 4.29 x 10^5 cells ml^{-1} during the first sampling, and between 4.67 and 6.56 x 10^5 cells ml^{-1} during the second diel cycle, decreasing slightly around noon and being higher in the SML with one exception. The specific production of bacterial cells, calculated as the bacterial production per cell, was variable (Fig. 1), ranging from 0.20 to 5.99 fgC cell^{-1} d^{-1} with no clear diel pattern. Other factors related to the activity and viability of the microbial cells showed distinct diel dynamics. The percentage of high-DNA cells generally decreased during the day and increased over night (Fig. 2). The respiratory activity per CTC+ cell decreased around noon, while the percentage of cells with a compromised cell membrane increased concurrently.

The higher biomass of microorganisms in the SML, as found elsewhere (2, 3), was related to the higher nutrient and DOC concentrations. The decrease in bacterial activity around noon is most likely mediated by the damaging effect of UV radiation on bacteria (5) and/or photolysis of DOM (6) forming radicals.

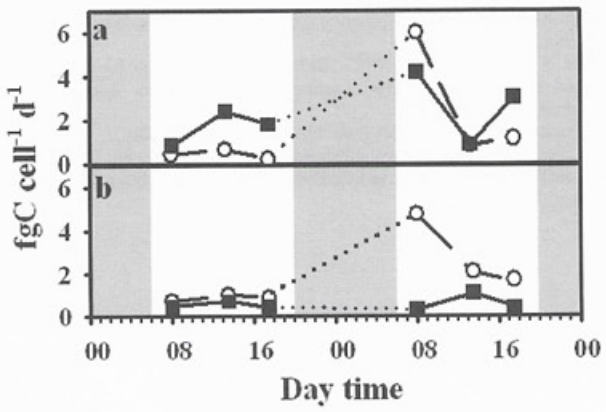

Fig. 1. Diel dynamics of the specific production of bacteria in the surface microlayer (circles) and the underlying water layer (squares) during (a) the first (29-30 Sept.) and (b) the second diel cycle (4-5 Oct.) of sampling.

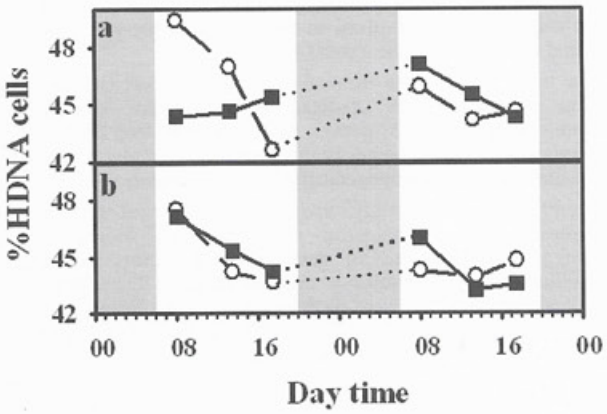

Fig. 2. Diel dynamics in the percentage of high-DNA cells. Legend as in Fig. 1.

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References

1 - Liss, P.S., and Duce, R.A. (eds.), 1997. The sea surface and global change. Cambridge Univ. Press (UK), 534 p.

2 - Williams, P.M., Carlucci, A.F., Henrichs, S.M., van Vleet, E.S., Horrigan, S.G., Reid, F.M.H., and Robertson, K.J. 1986. Chemical and microbiological studies of sea-surface films in the southern Gulf of California and off the west coast of Baja *California. Mar. Chem.,* 19: 17-98.

3 - Falkowska, L. 2001. 12-hour cycle of matter transformation in the sea surface microlayer in the offshore waters of the Gdansk Basin (Baltic Sea) during spring. *Oceanologia*, 43: 201-222.

4 - Kuznetsova, M., and Lee, C. 2001. Enhanced extracellular enzymatic peptide hydrolisis in the sea-surface microlayer. *Mar. Chem.,* 73: 319-322 Herndl, G.J., Muller-Niklas, G., and Frick, J. 1993. Major role of ultraviolet-B controlling bacterioplankton growth in the surface layer of the ocean. *Nature*, 361: 717-719.

5 - Obernosterer, I., Reitner, B., and Herndl, G.J. 1999. Contrasting effects of solar radiation on dissolved organic matter and its bioavailability to marine bacterioplankton. *Limnol. Oceanogr.,* 44: 1645-1654.

HETEROTROPHIC BACTERIOPLANKTON DYNAMICS IN RELATIONSHIPS TO ENVIRONMENTAL FACTORS SPECIFIC FOR THE ROMANIAN BLACK SEA COAST

Elena Stoica

National Institute for Marine Research and Development "Grigore Antipa", Bd. Mamaia 300, Constanta, Romania, RO-900581, ellena_stoica@yahoo.co.uk

Abstract

The heterotrophic bacterioplankton dynamics and their relationship with the environmental factors characteristic for Romanian Black Sea coastal zone were investigated during the year 2002. Bacteriological parameters exhibited more or less distinct temporal variations over the whole investigation period, with usually higher values during summer. Water temperature varied between 8.3-28.2°C and salinity between 2.47-17.07‰. Bacterial abundance, assessed by the MPN method, ranged from 3.8 x 10^4 cell ml^{-1} to 9.2 x 10^7 cell ml^{-1}. A strong relationship between bacterial properties and temperature was found with clear seasonal trends. Also bacterial properties were strongly related to changes in salinity, particularly for the Romanian coast.

Keywords: bacterioplankton dynamics, environmental factors, Black Sea

Introduction

Microorganisms, especially heterotrophic bacterioplankton, play an important role in processing of organic matter (1). However, there are several environmental factors (such as biological, as well as physical and chemical factors) involved in the control of the dynamics and bacterial distribution in the coastal zone (2).

Due to its location, the Romanian Black Sea coast is a dynamic regions characterized by gradients in temperature, salinity and nutrient concentrations. Moreover, during the past four decades, the Romanian Black Sea coast has been affected by eutrophication due to increasing input of anthropogenically-derived nutrients (3).

Therefore, in this study, spatial and temporal patterns of heterotrophic bacterioplankton abundance and biomass were investigated and related to environmental factors potentially controlling bacterial abundance and production. Bacterioplankton abundance and biomass were determined along the Romanian coast during spring, summer and autumn 2002 at five sites: Sulina, Sf. Gheorghe, Portita, Constanta and Manglia. These sites cover two areas of the Romanian the Black Sea coast with a high anthropogenic impact: the northern sector (between Sulina and Portita) is under the influence of the Danube river, and the southern sector (from Constanta to Vama Veche) is affected by industrial and domestic discharges.

The MPN technique on liquid ZoBell medium was used for the determination of heterotrophic bacterial abundance and is expressed as cell ml^{-1} after 7 days of incubation of 21°C. Bacterial biomass (BB) was calculated from abundances using 20 fg C $cell^{-1}$ (4). Chemical (salinity), physical (temperature) and biological (total phytoplankton density) analyses of sea water were also performed (3, 5).

Results and disscution

The results of the microbiological observations along the Romanian coast at the 5 stations are summarized in Table 1.

Table 1. Heterotrophic bacterioplankton abundance and biomass and environmental factors in seawater samples (Romanian Black Sea coast)

Station	Month	Bacteria (cells ml^{-1})	Bacteria (µg C l^{-1})	Temp (°C)	Salinity (g ‰)	phytoplankton (cells l^{-1})
Sulina	April	47000	0.94	9.75	16.17	88320
Sulina	July	160000	32	28.18	12.75	2880100
Sulina	September	160000	32	22.25	7.42	3017200
Sf. Gheorghe	April	1600000	32	8.92	15.99	1127000
Sf. Gheorghe	July	1600000	32	27.6	15.5	2117720
Sf. Gheorghe	September	1600000	32	22.03	2.47	255350
Portita	April	3500000	70	9.97	14.61	642550
Portita	July	1600000	32	nd	nd	1075000
Portita	September	nd	nd	nd	nd	2872600
Constanta	April	920000	18.4	12.45	9.95	1091820
Constanta	July	1600000	32	25.38	14.25	21350
Constanta	September	1600000	32	23.47	14.1	6025380
Constanta	October	2400000	48	18.32	17.07	nd
Mangalia	April	92000000	1840	11.82	11.96	484660
Mangalia	July	38000	0.76	25.73	15.25	262800
Mangalia	September	nd	nd	nd	nd	496440
Mangalia	October	16000000	320	17.53	16.38	nd

Heterotrophic bacterial abundance and biomass in the surface waters along the entire Romanian Black Sea coast were generally higher in the year 2002 than in previous years (data not shown).

The annual maximum and minimum of heterotrophic bacterial abundance and biomass in all studied stations was observed in April (9.2 x 10^7 cell ml^{-1} and 1840.0 µg C l^{-1}, respectively) and in July (3.8 x 10^4 ml^{-1} and 0.76 µg C l^{-1}), respectively, at Mangalia station (Table 1). The abundance and biomass of heterotrophic bacteria in the northern sector (under the Danube river influence) was similar to those of the southern sector (under the sewage discharges influence).

Bacterial abundance and biomass exhibited more or less distinct seasonal variations. The differences in abundance of bacteria imply different limiting factors for bacterial populations along the coastal waters (substrate and nutrients, temperature, oxygen conditions). During the investigation period, periodical oscillations in the main biotic and abiotic factors were observed. These fluctuations seemed to be interrelated in many instances.

One of the most important factors influencing the seasonal distribution of bacteria in the shallow waters of the Black Sea was temperature. The pattern of total heterotrophic bacteria correlated significantly with that of temperature over the entire year.

Besides temperature, organic matter concentration was another important factor affecting the distribution of the heterotrophic bacteria. Ours results indicate that in Romanian coastal waters the sources for organic matter for heterotrophic bacteria are allochthonous input (continental sources) and autochthonous sources (produced directly by phytoplankton exudation or indirectly after cell lysis subsequent to stress conditions).

The enrichment with allochtonous organic material from the land, led to an increase in heterotrophic bacterial abundance in the stations at the southern area (Constanta and Mangalia) as well as at the northern area (Sulina, Sfantu Gheorghe, Portita). Furthermore, the availability of organic compounds released by primary producers (phytoplankton) led also to a high level of bacterial population density (in both coastal area) during the decline of the spring and autumn algal blooms. Heterotrophic bacteria and total phytoplankton density were also significant correlated.

References

1 - Azam F., Fenchel J.G., Grey J.S., Meyer-Reil L-A., Thingstad F., 1983. The ecological role of watercolumn microbes in the sea. *Ecol. Progr. Ser.*, 10: 257-263.

2 - Day J.W. Jr, Hall C.A.S., Kemp W.M., Yanez-Arancibia A., 1989. Estuarine ecology. John Wiley and Sons, New York.

3 - Cociasu, A., Dorogan, L., Humborg, C., Popa, L., 1996. Long-term ecological changes in the Romanian coastal waters of the Black Sea. *Mar. Poll. Bull.*, 32: 32-38.

4 - Lee S., Fuhrman J.A., 1987. Relationships between biovolume and biomass of naturally derived marine bacterioplankton. *Appl. Environ. Microbiol.*, 53:1298-1303.

5 - Bodeanu N., 1993. Microbial blooms in the Romanian area of the Black Sea and contemporany eutrophication conditions. Pp: 203-209. In: Smayda T.J. and Shmizu Y. (eds.), Toxic phytoplankton blooms in the sea. Elsevier, Amsterdam.

EXPERIMENTAL STRATEGIES RESPECTING DEEP-SEA CONDITIONS: TOWARDS A RELIABLE MEASUREMENT OF THE IN SITU ACTIVITY OF DEEP-SEA PROKARYOTES

Christian Tamburini [1] *, Jean Garcin [1], Francis de Bovee [2], Laura Giuliano [3] and Armand Bianchi [1]

[1] Laboratoire de Microbiologie Marine, CNRS – INSU, COM, UMR 6117, Université de la Méditerranée, Campus de Luminy, Marseille, France - * ctambu@com.univ-mrs.fr

[2] OSU de Banyuls-sur-mer, CNRS-Université de Paris VI, Banyuls-sur-mer, France

[3] Consiglio Nazionale delle Ricerche, Istituto dell'Ambiente Marino Costiero Sez. Messina, Italy

Abstract

High-pressure and low temperature conditions are the main characteristic of deep-sea environments. So, we developed special gears to collect and incubate samples without decompression. Data from deep-seawater (1) as well as from deep hypersaline anoxic basins show that each step involved in the organic matter degradation is carried out by prokaryotes adapted to the ambient conditions. Conversely decompression of near-bottom water provokes an overestimation relative to the rates measured *in situ* using a benthic lander (2). Such an opposite behavior facing pressure conditions is likely due to different origins of prokaryotes in the water column and at the water-sediment interface.

Keywords: Microbial ecology of mesopelagic and bathypelagic zones; High-Pressure conditions; deep-sea prokaryotes

In deep-sea, prokaryotes are submitted to external factors (low availability of nutrients, low temperature, high-pressure), all able to limit their metabolism (4-9). Some environments, as the deep hypersaline anoxic basins (DHABs) of the eastern Mediterranean, offer even more severe conditions for life: hypersalinity (up to 300), anoxia, extreme concentrations for Mg, SH_2, and high pressure (~35 MPa). Therefore it is important to measure microbial activities in the deep-sea as closely as possible to the *in situ* conditions. So, we developed special gears to collect and incubate samples without decompression (Fig. 1).

Station	Month	Bacteria (cells ml^{-1})	Bacteria ($\mu g\ C\ l^{-1}$)	Temp (°C)	Salinity (g ‰)	phytoplankton (cells l^{-1})
Sulina	April	47000	0.94	9.75	16.17	88320
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Mangalia	July	38000	0.76	25.73	15.25	262800
Mangalia	September	nd	nd	nd	nd	496440
Mangalia	October	16000000	320	17.53	16.38	nd

Fig. 1. Diagrammatic representation of the high-pressure bottles (HPBs) in configuration of samples filling

When the filling valve is opened, the natural hydrostatic pressure pushes down the floating piston and the seawater enters into the upper chamber of 2 HPBs. The distilled water is flushed out from the lower chamber of the syringes to the exhaust tanks, through a nozzle that acts as an hydraulic brake. During retrieval, hydrostatic pressure is maintained thanks to a check valve that avoids any decompression within the 'high pressure' HPBs, in contrast to the 'decompressed' one without check valve (8).

Compiled data from stratified water columns show that each step involved in the organic matter degradation is carried out by prokaryotes adapted to the ambient pressure condition. Metabolic rates measured on decompressed samples are underestimated by a factor equal to 3.6 ± 4.3 (mean ± S.D.; n=99). Because the pressure effect is highly variable, a single factor cannot be used to correct rates measured on decompressed samples (1).

During the EU program BIODEEP (contract n° EVK3-2000-00042), we measured diverse metabolic rates maintaining all the characteristics of DAHBs during sample retrieval and incubation. All the measured rates (peptidase, phosphatase, assimilation and respiration of glutamate; bacterial biomass production) were higher under ambient conditions (×12.5 ± 23.6; mean ± S.D., n = 6) than those obtained on the decompressed samples. Hence, we demonstrated that DAHBs' prokaryotic populations are adapted to extreme ambient conditions and may actively participate in the biogeochemical cycles in these basins. Several strains of potential industrial interest have been cultivated, some of which exhibiting very unusual morphological and physiological features. Some newly described bacterial catabolic genes with potential application in bioremediation have also been retrieved and they are under investigation.

Although decompression of deep-sea water and DHABs samples leads to an underestimation of microbial activities, decompression of near-bottom water samples provokes an overestimation (by 1 order of magnitude) relative to the actual rates measured *in situ* using a benthic lander (2). This apparent contradiction can be due to the difference in origin for deep-sea water and benthic water microbial populations.

A large fraction of the bacterial consortia are transported into the deep-sea by settling particles (9).

Since attached bacteria plays an important role in the mineralization of particles (8, 10, 11) and in the recycling of biogenic elements (silicate and carbonate), we did an experiment to simulate the fall of particles through the whole water column. This experiment demonstrates that metabolic rates of bacteria attached to the sinking phytoplankton aggregates are slowed down by increasing pressure. The gear we developed for this experiment will allow to precize calculations for mineralization and dissolution rates of particles sinking throughout the water column.

The experimental approaches we used to study deep-sea waters, sinking particles and benthic waters, respecting the main conditions of these deep-sea environments, and so permit to study the quantitative and qualitative evolution of the chemical composition of the organic matter, concomitantly with the evolution of microbial diversity, from the sea surface to the bottom.

Reference

1 - Bianchi, A., Tamburini, C. and Garcin, J., submitted. Effect of pressure conditions on microbial activity measurements in deep-sea water: a review. *Deep-Sea Research I* .

2 - Tamburini, C., De Bovée, F. and Garcin, J. Microbial activities at the deep-sea water-sediment interface of the NW Mediterranean: in situ versus on board measurements. *Journal of Geophysical Research.*

3 - Turley, C. and Lochte, K., 1990. Microbial response to the input of fresh detritus to the deep-sea bed. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 89: 3-23.

4 - Poremba, K., 1994. Impact of pressure on bacterial activity in water columns situated at the european continental margin. *Netherlands Journal of Sea Research,* 33: 29-35.

5 - Yayanos, A.A., 1995. Microbiology to 10,500 meters in the deep-sea. *Ann. Rev. Microbiol,.* 49: 777-805.

6 - Tholosan, O., Garcin, J. and Bianchi, A., 1999. Effects of hydrostatic pressure on microbial activity through a 2000 m deep water column in the NW Mediterranean Sea. *Marine Ecology Progress Series*, 183: 49-57.

7 - Tamburini, C., Garcin, J., Ragot, M. and Bianchi, A., 2002. Biopolymer hydrolysis and bacterial production under ambient hydrostatic pressure through a 2000 m water column in the NW Mediterranean. *Deep-Sea Research II,* 49: 2109-2123.

8 - Tamburini, C., Garcin, J. and Bianchi, A., 2003. Role of deep-sea bacteria in organic matter mineralization and adaptation to hydrostatic pressure conditions in the NW Mediterranean Sea. *Aquatic Microbial Ecology,* 32: 209-218.

9 - Turley, C.M. and Mackie, P.J., 1995. Bacterial and cyanobacterial flux to the deep NE Atlantic on sedimenting particles. *Deep Sea Research I,* 42: 1453-1474.

10 - Cho, B.C. and Azam, F., 1988. Major role of bacteria in biogeochemichal fluxes in the ocean's interior. *Nature,* 332: 441-443.

11 - Smith, D. C., Simon, M., Alldredge, A. L. and Azam, F., 1992. Intense hydrolytic enzyme activity on marine aggrgates and implications for rapid particle dissolution. *Nature,* 359: 139-142.

MICROAUTORRADIOGRAPHY AND CATALYZED REPORTER DEPOSITION FLUORESCENCE *IN SITU* HYBRIDIZATION (MICRO-CARD-FISH) FOR STRUCTURE-FUNCION ANALYSIS OF PROKARYOTES IN DEEP WATERS.

Eva Teira * and Gerhard J. Herndl

Dept. of Biological Oceanography, Royal Netherlands Institute for Sea Research, P.O. Box 59, 1790 AB, Den Burg, The Netherlands
* teira@nioz.nl

Abstract

Only recently, fluorescence in situ hybridization (FISH) became sufficiently sensitive to allow the enumeration of prokaryotes even in oligotrophic waters by using catalyzed reporter deposition (CARD-FISH). Penetration of the horseradish peroxidase (HRP)-labeled oligonucleotide probes into prokaryotic cells needs careful adaptation to the target microoganisms. We refined the CARD-FISH protocol for detection of marine Archaea substituting lysozyme by proteinase-K as permeabilization treatment. Detection rates of Archaea with proteinase-K (65±6 % of total DAPI counts) were twice higher than with lysozyme (32±6%). Combining CARD-FISH with microautoradiography, we determined the uptake of specific organic compounds by the major prokaryotic groups in deep water samples.

Keywords: FISH, microautoradiography, Bacteria, Archaea, deep ocean.

Introduction

Over the last decade, our knowledge on the richness of marine prokayotic communities including the deep ocean has increased considerably through the application of molecular tools as fingerprinting techniques, cloning and sequencing. An exciting result derived from the application of these molecular approaches was the discovery of the widespread presence of archaea in marine plankton (1, 2). However the assesment of the actual abundance of specific groups or populations of prokaryotes is more difficult. Basically the only direct method available is the fluorescence *in situ* hybridization (FISH), which yielded very low recovery of Bacteria and Archaea as compare to nucleic acid-stained in oligotrophic environments.

Only recently, the use of polynucleotide probes allowed the assessment of the abundance of Archaea in the meso- and bathypelagic waters of the Pacific (3). Unfourtunately, to tha date, the use of oligonucleotide FISH has not been succesfully applied in deep waters. The recently developed Catalyzed Reporter Deposition FISH (CARD-FISH) for the identification of marine bacteria (4) allows the use oligonucleotide probes labeled with horseradish peroxidase (HRP) with great recover efficiency. However, this protocol included a permeabilisation procedure with lysozyme. Archaeal cell walls do not contain murein (5), thus, Archaeal cells are not sensitive to lysozyme. In this study, we modified the CARD-FISH for detection of marine Archaea substituting the lysozime permeabilization treatment by proteinase-K treatment and we succefully combined CARD-FISH with Microautorradiography (MICRO-CARD-FISH) for the detection of uptake of specific organic compound by deep-water prokaryotic communities.

Results and discussion

We selected a total of 10 samples from deep waters (100-2750m) of the North Atlantic Ocean for comparison of permeabilisation procedures, tus covering a wide range of Archaeal abundance. The percentages of DAPI counts detected with specific Archaeal probes (Eury for Euryarchaeota; and Cren for Creanarcaeota) were considerably higher with proteinase-K than with lysozyme pre-treatment (Fig 1). The percentage of DAPI cells detected with Eury probe was 14 ± 2% (±SE, n=10) with lysozyme and 30 ± 2% (± SE, n =10) with proteinase K. Similarly, the rate of detection with Cren probe was 18 ± 2% (±SE, n=10) with lysozyme and 35 ± 5% (±SE, n=10) with proteinase-K. Overall, we were able to double our capacity for Archaeal detection by modifying the permeabilisation procedure.

We further combined microautorradiography with the refined CARD-FISH for detection of prokaryotic activity in meso- and bathypelagic waters. We used tritiated D- and L-Aspatic acid (Asp) as substrate, and three different probes for the major prokaryote groups: EUB for bacteria, and the two Archaeal probes described above (Eury and Cren)(Fig. 2). The percentage of active cells decreased with depth for the L-Asp both for bacteria and Archaea. However, the D-Asp showed contrasting uptake patterns between bacteria and Archaea. Whereas the percentage of active bacteria decreased with depth, the percentage of active Archaea increased from subsurface waters (100 m) to bathypelagic waters (1000-3000 m). Whereas in subsurface waters bacteria and Archaea seem to be qually active, in deeper water, a higher proportion of Archaea is actively taking up D- or L-Asp.

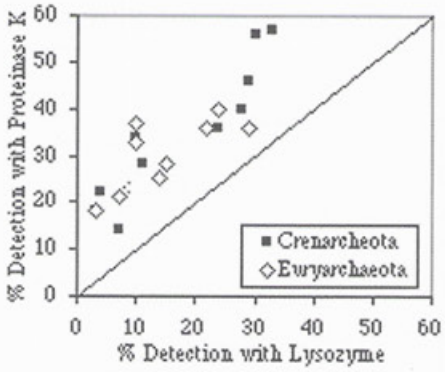

Fig. 1. Comparison of the detection rates (percentage of probe-hybridized cells normalized to total DAPI-stained cells) by CARD-FISH for Crenarchaeota and Euryarchaeota using lysozyme and proteinase-K treatment for cell wall permeabilization.

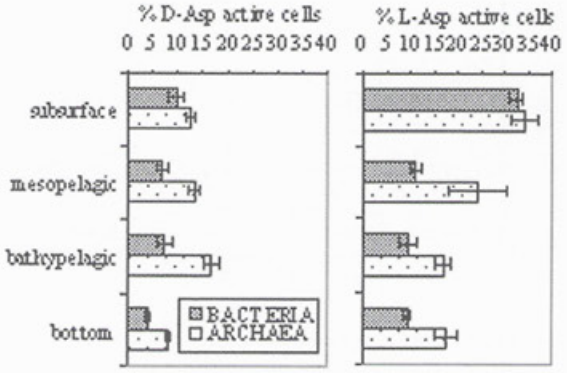

Fig. 2. Percentage of Bacteria, Eury- and Crenarchaea taking up D-and L-Asp normalized to the total number of each group, in different depth layers of the North Atlantic. Bars represent the mean (± SE) from 10 different stations.

Acknowledgements: this research was funded through a European Community Marie Curie Fellowship to E.T. and by the Dutch Science Foundation (NWO-ALW) to G.J.H.

References

1 - Fuhrman JA, McCallum K, Davis AA., 1992. Novel Major archaeobacterial group from marine plankton. *Nature*, 356:148-149.

2 - DeLong EF, Ying Wu K, Prézelin BB, Jovine RVM., 1994. High abundance of Archaea in Antartic marine picoplankton. *Nature*, 371: 695-697.

3 - Karner MB, DeLong EF, Karl DM., 2001. Archaeal dominance in te mesopelagic zone of the Pacific Ocean. *Nature*: 507-510.

4 - Pernthaler A, Pernthaler J, Amann R., 2002. Fluorescence In Situ Hybridization and Catalyzed Reporter Deposition for the identification of Marine Bacteria. *Appl. Environm. Microbiol.*, 68: 3094-3101.

5 - Kandler O., 1994. Cell wall biocemistry in Archaea and its physical implications. *J. Biol. Phys.*, 20: 3472-3481.

MESO- AND MICROZOOPLANKTON FEEDING RATES ON TOXIC AND NON-TOXIC DINOFLAGELLATES CULTURED AT DIFFERENT N/P RATIO

Dolors Vaqué *, Jordi Felipe, M. Montserrat Sala, Marta Estrada, Miquel Alcaraz
Institut de Ciències del Mar de Barcelona-CMIMA (CSIC). Catalonia, Spain - * dolors@icm.csic.es

Abstract
An experimental study was carried out to investigate meso- and microzooplankton (*Acartia margalefi* and *Oxyrrhis marina*) feeding rates on a toxic dinoflagellate (*Gyrodinium corsicum*) cultured at different N/P ratios. We tested whether P-limitation enhances dinoflagellate toxicity repressing grazing rates and inducing predator mortality. Feeding rates of *Acartia margalefi* on *G.corsicum* cultured at P-limitation conditions are lower than growing at Redfield N/P ratio, while *Oxyrrhis marina* did not graze on it at any N/P ratio. However, mortality and losses of motility of grazers were not detected at any N/P ratio.

Key words: micro-and mesozooplankton, toxic dinoflagellate, grazing rates, P-limitation.

Introduction

Copepods and Protozoa are considered potential grazers of dinoflagellates, and they can select their prey according to different factors, such as size, abundance, toxicity, etc. (1). Recent studies showed that toxic dinoflagellates found in systems with P-limitation conditions are more toxic than dinoflagellates living at Redfield N/P ratio (2). We tested whether two dinoflagellates: *Gyrodinium corsicum* (responsible for massive fish and zooplankton mortality in the Mediterranean sea) (3), and *Gymnodinium sp. 1* (a non-toxic algae) cultured at different N/P ratio were differently consumed by a phagotrophic dinoflagellate (*Oxyrrhis marina)* and a copepod (*Acartia margalefi*). Both of them are very common in semi-enclosed marine areas of the Catalan Sea (Barcelona harbour, Ebro delta bay). We hypothesized that predator feeding rates on *G. corsicum* at P-limitation conditions will be lower than at Redfield N/P ratio. Also, we should detect higher mortality and losses of motility of grazers in the presence of *Gyrodinium corsicum* at P-limitation conditions.

Material and Methods

The copepod *Acartia margalefi* (0.55 mm) and the phagotrophic dinoflagellate *Oxyrrhis marina* (22 µm) were isolated from Barcelona harbour. Strains of *Gyrodinium corsicum* and *Gymnodinium* sp1 (with similar size ~14 µm) were provided by the ICM phytoplankton collection and were cultured in f/2 media at different N/P ratios (Redfield N/P = 15; P-limitation N/P >15). Triplicate 75 ml tissue bottles were inoculated with 50 ml samples containing four different concentrations of each dinoflagellate species (100, 300, 1000, 2000 cells ml^{-1}) cultured at N/P =15 and N/P>15 ratios. These bottles were used as controls. The same experimental set up was repeated twice, in one set we added 300 cells ml^{-1} of *Oxyrrhis marina* and in the other 3 *Acartia margalefi* in each bottle. We enumerated at t_0 and t_{24} the abundance *of Gyrodinium corsicum*, Gymnodinium sp1, and the phagotrophic nanoflagellate *Oxyrrhis marina*. Subsamples were fixed with lugol acid and allowed to settle for 24 h in 50-ml sedimentation chambers. Dinoflagellates were counted in an inverted microscope (400X, Zeiss). *Acartia margalefi* were counted at the end of the experiment using a stereomicroscope. In extra tissue bottles we observed in live samples direct mortality or motility losses of grazers during the first 24 h under the stereomicroscope and microscope, respectively.

Results and Discussion

Oxyrrhis marina only ingested *Gymnodinium* sp1 cultured at NP = 15 (Fig. 1A), while *Acartia margalefi* showed similar feeding rates on *Gymnodinium* sp1 at different N/P ratios, and lower ingestion rates on *Gyrodinium corsicum* at P-limitation conditions than at Redfield N/P ratio (Fig.1 B). Indeed, the lowest response of ingestion to food concentration corresponded to *G. corsicum.* for both potential predators (Fig. 1). These results provide further evidences that *G. corsicum* is negatively selected by the considered predators (4). Nevertheless, an increase in mortality and losses of grazers' motility were not observed at any of the N/P ratio tested, suggesting that P-limitation did not increase toxicity sufficiently to induce fatal effects on grazers.

Acknowledgements

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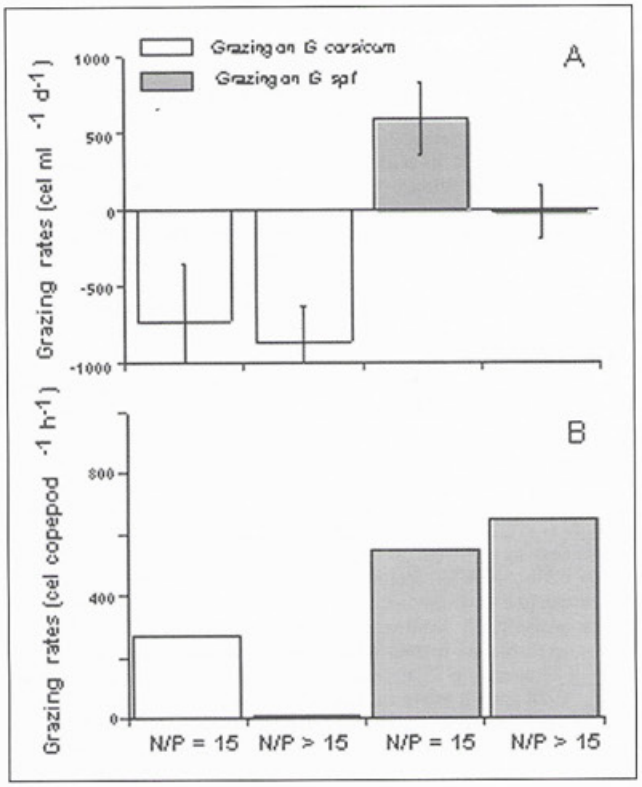

Fig. 1. Maximal grazing rates of *Oxyrrhis marina* (A) and *Acartia margalefi* (B) on *Gyrodinium corsicum* and *Gymnodinium* sp1 at different N/P ratios. Dinoflagellate food concentration: 2000 cells ml^{-1}

References

1 - Turner, J.T., and Tester, P.A., 1997. Toxic marine phytoplanktpn, zooplankton grazers and pelagic food webs. *Limnol Oceanogr.*, 42: 1203-1214.

2 - Boyer, G.L., Sullivan, J.J., Anderson R.J., Harrison, P.J., and Taylor, F.J.R., 1987. Effects of nutrient limitation on toxic production and composition in the marine dinoflagellate *Protogonyaulax tamarensis*. *Mar Biol.*, 96: 123-128.

3 - Delgado, M., and Alcaraz, M., 1999. Interactions between red tide microalgae and herbivorous zooplankton: the noxious effects of *Gyrodinium corsicum* (Dinophyceae) on *Acartia grani* (Copepoda: Calanoida). *J. Plank. Res.*, 21: 2361-2371.

4 - Vaqué, D., Felipe, J., Alcaraz, M., 2003. Effects of a toxic dinoflagellate on planktonic predators: repressed feeding and production rates on meso-and microzooplankton. Abstracts of EUROHAB meeting. Amsterdam March 2003.

INFLUENCE OF SMALL INCREASES IN TEMPERATURE ON PLANKTONIC BACTERIAL CARBON USE IN THE BLANES BAY (COASTAL NW MEDITERRANEAN)

Evaristo Vázquez-Domínguez *, Josep M. Gasol, Dolors Vaqué and Marta Estrada.
Institut de Ciències del Mar, CMIMA-CSIC, Passeig Marítim de la Barceloneta 37-49, Barcelona, Spain

Abstract
Bacterial production (BP) and respiration (BR) were measured seasonally in a Mediterranean coastal area (Blanes Bay) at two temperatures: ambient temperature (TA) and about two degrees above that temperature (T+2). Seawater samples were filtered through 0.8 µm to obtain a predator-free bacterioplankton assemblage and incubated for 48 hours at both temperatures. From production and respiration rates we derived bacterial growth efficiency (BGE). Production and respiration rates were positively affected by the increase in temperature, while BGE remained unchanged. Therefore, small increases of temperature might increase the amount of carbon passing through bacteria.

Keywords: Bacterial production. Bacterial respiration. Bacterial growth efficiency. Temperature.

Introduction

Due to human industrialization and deforestation the concentration of CO_2 has increased in the atmosphere [1], and this is expected to lead to an increase in Earth's average temperature of ~ 2.5 ºC in a century [2]. Temperature has an extremely important influence on biological processes such as bacterial production and respiration [3, 4]. As microbes are relevant actors in the transfer of carbon in aquatic ecosystems [5], there is an increasing interest in the effect of small temperature increases on microbial plankton [6]. The objective of this study is to test the effect of small increases in temperature (ca. 2ºC) on bacterial carbon use and growth efficiency in an oligotrophic coastal system (NW Mediterranean) and its implications for the planktonic carbon cycle.

Methodology

Experiments were done monthly (March-August 2003) with subsurface seawater collected from a fixed station in Blanes bay (41° 39' N, 2° 48' E), over 15 m depth and about half mile offshore. Seawater temperature was determined with a calibrated thermometer, and 25 liters were pre-filtered through 200 µm, placed on a carboy, and transported to the laboratory. The samples were then filtered through 0.8 µm (AAWP, Millipore), bacterial production rates determined by ^{3}H-Leucine uptake [8] and converted to bacterial carbon with a standard factor of 3.1 Kg C mol^{-1}. Filtered water was also distributed in 48 borosilicate glass bottles (ca. 130 ml), of which 8 were immediately fixed with Winkler reagents (t0). The remaining bottles were placed in two temperature-controlled chambers, set at ambient temperature (TA) and ~ 2 degrees above this temperature (T+2). At 24 and 48 hours we fixed the remaining 40 bottles, 10 each time for each temperature. Dissolved oxygen was determined with an automatic titrator based on potentiometric endpoint detection [7]. Respiration rates were obtained by linear regression of oxygen concentration vs. time, and were transformed to carbon units assuming a respiration quotient of 1. Bacterial carbon use is BP+BR and bacterial growth efficiency (BGE) is BP/(BP + BR) [9].

Results and discussion

Seawater temperature varied twelve degrees in Blanes bay, between 13 ºC in March and 25 ºC in August. Initial bacterial productions varied between 1.3 µg C l^{-1} d^{-1} in June and 150 µg C l^{-1} d^{-1} in July, increasing exponentially at 24 hours during the incubations and showing a clear shift-up in the T+2 samples (Fig. 1), The average increase of bacterial production ((BP_{TA} - BP_{T+2})/ BP_{TA}) was 36 (± 12) %. BP's at both temperatures were positively correlated, BP_{T+2} = 15.3 (± 20.3) + 1.1 (± 0.1) BP_{TA} (n = 18, r^2 = 0.8, p< 0.01). Respiration rates at ambient temperatures varied between 9.2 µg C l^{-1} d^{-1} in May and 102.1 µg C l^{-1} d^{-1} in March. The average increase of respiration rates at the higher temperature was 27 (± 11) %. Both respiration rates were significantly related, BR_{T+2} = 3.2 (± 2.7) + 1.1 (± 0.05) BR_{TA} (n = 18, r^2 = 0.99, p< 0.01). Finally, bacterial growth efficiencies varied between 4.7 and 95 %, , and were not influenced by the small increase in temperature, BGE_{T+2} = 4.5 (± 3.7) + 0.95 (± 0.05) BGE_{TA} (n = 18, r^2 = 0.95, p< 0.01). Adding the values up, it can be calculated that a small temperature increase could enhance bacterial carbon use by near a 60 %.

We obtained experimental data that agree with modeling studies in which small increases in temperature had a positive effect on bacterial production, respiration and carbon demand [3, 4], but no influence on BGE [9]. Therefore, small changes in temperature will have an effect on the microbial components of aquatic systems [6] significantly increasing the amount of carbon processed by bacteria.

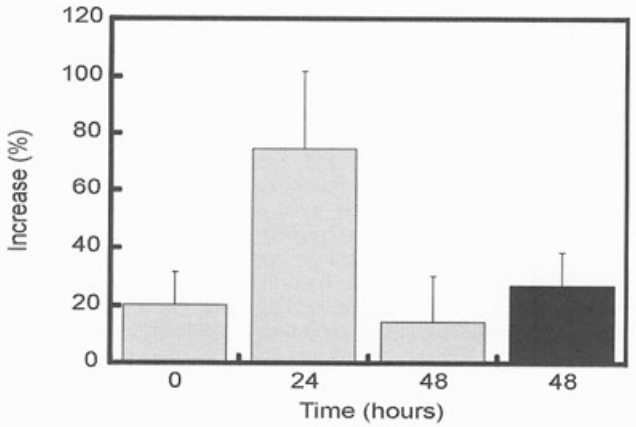

Fig. 1. Average increase in BP and BR at time 0, 24 and 48 hours (BP, gray columns) and during 48 hours (BR, black column).

Acknowledgments
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References

1 - Siegentaler U. and Sarmiento J.L. Atmospheric carbon dioxide and the ocean. *Nature*, 365: 119-125.
2 - Houghton J., 1997. Global warming: the complete briefing. 251 pp. *In*: Houghton J. (ed.), Cambridge University Press. Cambridge, U.K.
3 - Pomeroy L.R. and Wiebe W.J., 2001. Temperature and substrates as interactive limiting factors for marine heterotrophic bacteria. *Aquat. Microb. Ecol.*, 23: 187-204.
4 - Rivkin R.B. and Legendre L., 2001. Biogenic carbon cycling in the upper ocean: Effects of microbial respiration. *Science*, 291: 2398-2400.
5 - Azam F., Fenchel T., Field J.G., Gray J.S., Meyer-Reil L.A., Thingstad F., 1983. The Ecological Role of Water-column Microbes in the Sea. *Mar. Ecol. Prog. Ser.*, 10: 257-263
6 - Petchey O.L., McPhearson P.T., Casey T.M., Morin P.J., 1999. Environmental warming alters food-web structure and ecosystem function. *Nature*, 402: 69-72.
7 - JGOFS. (Joint Global Flux Study) 1994. Protocols for the JGOFS core measurement. In: Knap A., Michaels A., Close A., Ducklow H., Dickson A. (eds.) JGOFS Rep. No 19.
8 - Smith D.C. and Azam F., 1992. A simple, economical method for measuring bacterial protein synthesis rates in seawater using ^{3}H-leucine. *Marine Microbial Food Webs*, 6: 107-114.
9 - del Giorgio P.A. and Cole J.J., Bacterial growth efficiency in natural aquatic systems. *Annu. Rev. Ecol. Syst.*, 29: 503-541.

BACTERIA OF THE GENUS *VIBRIO* ISOLATED FROM WILD DISEASED FISH IN GREECE

M. Yiagnisis *, M. Alexis, I.N.Vatsos

National Centre for Marine Research, Institute of Marine Biological Resources, Agios Kosmas, Elliniko, 16604 Athens, Greece
* mayia@ncmr.gr

Abstract

The presence of different species of *Vibrio* isolated from wild diseased marine fish was investigated. *Photobacterium damselae* subsp. *damselae* (previous *Vibrio damsela*) was isolated and identified from the fish species *Boops boops*, *Pagellus erythrinus*, *Lisa aurata* and *Conger conger*. In addition, *Vibrio ordalii* was isolated from *Serranus scriba* and *Vibrio splendidus* was isolated from *Diplodus annularis*. These *Vibrio* species are pathogens of farmed fish as *Sparus aurata*, *Dicentrarchus labrax* and *Puntazzo puntazzo*. Interestingly, there were no reports of simultaneous infection of the local farmed fish by the same pathogens. It is suggested that the infected wild fish could act as reservoir for these bacteria.

Keywords: Vibrio, diseases, wild marine fish, farmed fish, reservoir

Introduction

Several species of the genus *Vibrio* cause diseases in marine fish populations, both wild and cultured (1). *Vibrio* species are gram-negative, halophilic, non-spore-forming bacteria and autochthonous inhabitants of the marine environment. It is still debatable whether these bacteria behave as opportunistic or obligatory fish pathogens in marine environments. Susceptibility to *Vibrio* infections is related to several environmental and other factors, which cause stress to fish (2).

Photobacterium damselae subsp. *damselae* (previously named *Vibrio damsela*) causes skin ulcers or systemic disease in a wide range if fish, including blacksmith damselfish, yellowtail, turbot, gilthead sea bream, and brown shark (3).

Vibrio ordalii is one of the major causes of vibriosis in wild and cultured marine salmonids in Japan and the Pacific Northwest of the United States (4). This bacterium causes a bacterial hemorrhagic septicemia. In addition, bacterial microcolonies are formed in muscle, gill and gastrointestinal tract (5).

Vibrio splendidus has been isolated from cultured turbot in Spain, Atlantic salmon in Scotland, turbot and European sea bass in Norway (6, 7). It causes a typical bacterial septicemia. In Greece it was reported for the first time in sea bass and red porgy (8).

In this study we report six different cases of diseased wild fish, which were examined in the fish pathology laboratory of National Center for Marine Research. Diagnosis was based on the clinical appearance of the disease and the laboratory isolation and identification of the bacterium.

Materials and Methods

During the period of 1997-2001, samples of diseased wild fish (*Lisa aurata, Mugil cephalus, Pagellus erythrinus, Serranus scriba, Diplodus annularis and Boops boops*) from different regions of Greece were tested bacteriologically. Bacterial isolation was made from the head kidney. Specimens were cultured in tryptone soy broth, tryptone soy agar and Cholera medium ?CBS (code CM333 OXOID), all supplemented with 2% NaCl at 22° C for 24-48h. After incubating the plates at 22° C for 24-48 h the isolated pure colonies that appeared were used for the identification of the bacteria. The identification was done employing standard morphological and biochemical procedures and the Api 20E (Biomerieux) identification system according to Alsina & Blank (9).

Results and Discussion

Vibrios are facultive pathogens, which can affect marine fish causing serious pathological conditions known as vibriosis. All marine fish are probably susceptible to at least one species of *Vibrio* (10). The fish species that were examined and found infected with vibrios were *Lisa aurata, Mugil cephalus, Pagellus erythrinus, Serranus scriba, Diplodus annularis and Boops boops* (Table 1). It is the first time that these fish species were found infected with these *Vibrio* species in Greece. All fish examined exhibited external skin lesions (hemorrhages and skin ulcers) Most of the fishes that were found to be infected with *Ph. damselae subsp. damselae* also had fluid in the peritoneal cavity (ascites).

Although in most cases of vibriosis, cultured fish are mainly affected, in the present study no simultaneous infection of cultured fish in the same area was reported. It is possible, however, that there are disease interactions between wild and cultured fish, since the water and the wild fish can act as reservoir for these pathogens. The horizontal transmission through water of the disease, caused by the fish pathogen *Photobacterium damselae subsp. damselae*, as well as the role of the skin mucus in the initial steps of the infection have also been studied by Fouz *et al* (11).

This is the first report of vibriosis caused by vibrios other than *V. anguillarum* in wild fish of Greece. There is need for further investigation about the exact way of transmission of these bacteria from wild to cultured fish or the opposite, through water and sediment.

Table 1. Bacteria of the genus *Vibrio*, isolated from wild diseased fish.

Species of diseased wild fish/Case	Species of isolated bacterial pathogen	Date/Place
Boops boops (5 fish)	***Photobacterium damselae subsp. damselae***	Island of Paros, 2001
Pagellus erythrinus *(3 fish)*	***Photobacterium damselae subsp. damselae***	1999
_ugil cephalus, Lisa aurata *(4fish)*	***Photobacterium damselae subsp. damselae***	Araxos area,1997 Pagasiticos gulf, May 1999
Conger conger*(1 fish)*	***Photobacterium damselae subsp. damselae***	Peloponnisos, 2001
Serranus scriba*(2 fish)*	***Vibrio ordalii***	Pagasiticos gulf, May 1999
Diplodus annularis *(1fish)*	***Vibrio splendidus***	Pagasiticos gulf, May 1999
Sea water from a mussels aqua farm	***Photobacterium damselae subsp. damselae***	Thermaikos gulf, 2000

References

1 - Colwell, R.R., Grimes, D. J., 1984. Diseases of marine organisms. Pp. 265-287. In: Helgolander Meeresuntersuchungen. Hamburg, 37,1-4.

2 - Anderson, D.P., 1990. Immunological indicators: Effects of environmental stress on immune protection and disease outbreaks. *American Fishery Science Society Symposium,* 8: 38-50.

3 - Fouz, B., Larsen, J.L., Nielsen, B., Barja J. L., Toranzo, A. E., 1992. Characterization of *Vibrio damsela* strains isolated from turbot *Scophthalmus maximus* in Spain. *Diseases of Aquatic Organisms*, 12(3): 155-166.

4 - Actis, L.A., Tolmaasky, M.E., and Crosa, J. H., 1998. Vibriosis. Pp. 523-557. In: P.T.K. Woo and D. W. Bruno, (eds.), Fish Diseases and Disorders, Vol.3, Viral, Bacterial and Fungal Infections. CAB International Wallingford, Oxon/New York.

5 - Ranson, D.P., Lannan, C.N., Rohovec, J.S., and Fryer, J.L., 1984. Comparison of histopathology caused by *Vibrio anguillarum* and *Vibrio ordalii* in three species of Pacific salmon. *Journal of Fish Diseases,* 7: 107-115.

6 - Lupiani, B., Dopazo, C.P., Ledo, A., F, B., Barza, J.L., Hetrick, F.M., Toranzo, A.E., 1989. New syndrome of mixed bacterial and viral etiology in cultured turbot *Scophthalmus maximus. Journal of Aquatic Animal Health*, 1(3): 197-204.

7 - Austin, B., and Austin, D.A., 1993. Bacterial Fish Pathogens: Diseases in farmed and wild fish, 2nd edit. Ellis Horwood Ltd, Chichester, UK.

8 - Yiagnisis, M., Christofilogiannis, P., Rigos, G., Koutsodimou M., Andriopoulou, A., Anastasopoulou, G., Nengas, I. and Alexis, M., 1999. Review of bacterial isolates in Greek mariculture during the period of 1995-1998. Abstract book 060p. 9th International Conference "Diseases of Fish and Shellfish", 19-24 September 1999, Rhodes, Hellas.

9 - Alsina, M. and Blanch, A., 1994. A set of keys for biochemical identification of environmental Vibrio species. *Journal of Applied Bacteriology*, 76: 79-85.

10 - Noga E.J. 2000. Fish Diseases, Diagnosis and Treatment. Iowa State University Press, 367 p.

11 - Fouz, B., Toranzo, A. E., Marco-Noales, E., Amaro, C., 1998. Survival of fish-virulent strains of *Photobacterium damselae* subsp. *damselae* in seawater under starvation conditions. *FEMS Microbiology Letters,* 168: 181-186.

VARIABILITY OF ENZYMATIC ACTIVITIES IN THE IONIAN SEA

Zaccone R. *, Monticelli L. S., Zampino D.

Istituto per l'Ambiente Marino Costiero, CNR, section of Messina. Spianata S. Raineri, 86, 98122 Messina, Italy - * zaccone@ist.me.cnr.it

Abstract

The variability of aminopeptidase (LAP), ß-glucosidase (GLU) and alkaline phosphatase (AP) enzymatic activities in the water masses of the Ionian Sea was studied during two SINAPSI cruises. In the surface layer, we found a significant increase of all enzymatic activities during spring. The AP values were 1.5-2.9 times higher than LAP, indicating a faster regeneration of P during the productive season. In the intermediate and deep (DW) layers the values showed a sharp decrease. In the bottom layer (BBL) we observed an increase of LAP and AP enzymatic activities during winter. The winter high AP/LAP ratio (2.9 and 1.73, respectively) in the DW and BBL layers indicated that AP plays an important role for deep bacteria not only as P source.

Key words: Enzymes, Mediterranean Sea, deep bacteria.

Introduction

The Ionian Sea represents a crossing region between the Western and the Eastern Mediterranean Sea and is one of the sites most affected by the outflow of Adriatic water and the changes in water composition and dynamics caused by the Eastern Mediterranean Transient. These changes have produced an adaptation of microorganisms related to nutrient sources and/or temperature increase.

In the euphotic zone, the heterotrophic microbial activity is particularly intense and is derived from adaptation of a very wide spectrum of nutritional sources produced by autotrophic processes. In the deep sea, life depends on the availability of reduced carbon in the form of particulate organic matter (POM) and dissolved organic carbon (DOC) (1).

Previous investigations have been carried out so far, on microbial activities in the Mediterranean Sea, mainly in coastal and euphotic zones. Information on the deep sea is very scarce and predominantly collected in the open ocean (2).

The aim of the work was to study the variability of the hydrolysis processes of aminopeptidase (LAP), ß-glucosidase (GLU) and alkaline phosphatase (AP) enzymatic activities in the water masses of the Ionian Sea.

Materials and Methods

The study was carried out during two SINAPSI (Seasonal Interannual and decAdal variability of the atmosPhere, oceans and related marine ecosystems) cruises (winter 1999 and spring 2002). Samples were collected at eleven pelagic stations, distributed at different depths (from surface to 4985 m) within a triangular area whose vertices are defined by the following coordinates (19.2°E, 40.3°N; 14.5°E, 35.3°N; 22.0°E, 35.3°N).

Microbial activities of aminopeptidase (LAP), ß-glucosidase (ß-GLU) and alkaline phosphatase (AP) were determined by the use of the fluorogenic substrates leucine-7-amido-4-methyl-coumarin (Leu-MCA), methylumbelliferyl-ß-glucoside (MUF-ß-GLU) and MUF-phosphate (MUF-AP) according to Hoppe (3), incubating the samples in the dark at in situ temperature. All bacterial extracellular enzyme activities were measured as potential activities (V_{max}) (4).

We grouped the water masses into five layers, according to their distribution and characteristics. The surface layer (ISW) extended up to 100 m, the intermediate layer, mainly occupied by the Levantine Intermediate Water (LIW) spanned over the depth interval 200-600 m, the transition layer with depths from 700 to 1500 m, the deep layer (DW) for depths >2000 m and the benthic boundary layer (BBL) about 10 m from seafloor.

Results and Discussion

The condition of the water column showed a beginning of stratification of waters with peaks of fluorescence at 50-100 m, although the spring mean values of temperature were similar to those in winter, varying from 15.30°C (ISW) to 13.97°C (BBL) in winter and from 15.33°C (ISW) to 13.32°C (BBL) in spring.

Results showed a high variability and a significant increase during spring of all enzymatic activities in the surface layer (LAP and β-GLU: $P<0.05$, AP: $P<0.01$, ANOVA test).

The mean values of LAP in the surface layer (with the exception of the Adriatic station) ranged from 0.37 to 4.34 nmol l^{-1} h^{-1} in winter 1999 and from 1.73 to 2.95 nmol l^{-1} h^{-1} in spring 2002, indicating the influence of the Adriatic waters in the northern stations of the Ionian Sea. AP mean values in the surface layer ranged from 0.2 nmol l^{-1} h^{-1} to 6.44 nmol l^{-1} h^{-1} in winter 1999 and from 3.1 nmol l^{-1} h^{-1} to 10.35 nmol l^{-1} h^{-1}. β-GLU mean values ranged from 0.04 nmol l^{-1} h^{-1} to 0.32 nmol l^{-1} h^{-1} in winter, and from 0.11 nmol l^{-1} h^{-1} to 2.55 nmol l^{-1} h^{-1} in spring.

In the intermediate and deep waters the values showed a sharp decrease, with similar values in the two seasons and only in the deep waters, the LAP was significantly different between seasons ($P<0.05$, ANOVA test).

During winter, an increase of all enzymatic activities was observed at the BBL, in correspondence to the increase of bacteria. LAP and AP activities showed a high variability among stations. This trend was confirmed in the spring sampling, while ß-GLU showed opposite behaviour.

As observed in other temperate areas, LAP production always exceeded β-GLU activity showing a different LAP/β-GLU ratio among all layers from 1.2 to 17.1 in winter and from 1.5 to 29.4 in spring.

In the surface layer during spring, AP activity was higher (1.5-2.9 times) than LAP. This suggested that AP may be an indicator of fast regeneration of P during the productive season to sustain both bacteria and phytoplankton growth in oligotrophic waters. The potential remineralization rate of phosphorus was 5.01 µg P dm^{-3} per day.

In winter the potential remineralization rate of phosphorus (up to 1.14 µg P dm^{-3} per day), recorded at the BBL, was similar to the surface rate (1.55 µg P dm^{-3} per day). A high AP/LAP ratio (2.9 and 1.73, respectively) was observed in the DW and BBL layers. In these layers, despite of the availability of inorganic P, the high AP activity indicated that phosphatase plays an important role for deep bacteria not only as P source, but it also could represent an alternative C source for bacterial nutrition in accordance with Hoppe *et al.* (2). They suggested, in fact, that phosphatase was probably related more to C limitation of deep bacteria than P limitation and that the AP activity was a prerequisite for a more efficient C utilization. In conclusion the spatial and seasonal variability in microbial enzymatic activities, related to the different water masses of the Ionian Sea, could be considered an indicator of the main microbial processes in the oligotrophic waters.

References

1 - Azam F., Smith D.C., Steward G.F. and Hagstrom A., 1993 Bacteria-organic matter coupling and significance for carbon cycling. *Microb. Ecol.*, 28: 167-179.

2 - Hoppe H.G., Arnosti C., and Herndl G., 2002. Ecological significance of bacterial enzymes in the marine environment. Pp. 73-107. *In:* Burns R.G. and Dick R.P. (eds) Enzymes in the environment. Marcel Dekker Inc., New York.

3 - Hoppe H.G., 1983. Significance of exoenzymatic activities in the ecology of brackish water: measurements by means of methylumbelliferyl-substrates. *Mar. Ecol. Prog. Ser.,* 11: 299-308.

4 - Zaccone R., Monticelli L.S., Seritti A., Santinelli C., Azzaro M., Boldrin A., La Ferla R., and Ribera d'Alcalà M., 2003. Bacterial processes in the intermediate and deep layers of the Ionian Sea in winter 1999: vertical profiles and their relationship to the different water masses. *J. Geophys. Res.,* in press.

ORGANIC MATTER DEGRADATION IN THE VENICE LAGOON SEDIMENTS BY AEROBIC ETEROTHROPHIC MICROBIAL COMMUNITIES STUDIED WITH BIOLOG™.

F. Zecchini [1], R. Pastres [2], F. Baldi [1, 3*]

[1] Consorzio Interuniversitario Nazionale la Chimica per l'Ambiente, Via della Libertà, 5/12. I-30175 Marghera, Venezia, Italy
[2] Dipartimento di Chimica Fisica, Università Cà Foscari, Calle Larga S. Marta Dorsoduro, 2137. I-30121 Venezia, Italy
[3] Dipartimento Scienze Ambientali, Università Cà Foscari, Calle Larga S. Marta Dorsoduro, 2137. I- 30121 Venezia, Italy
* baldi@unive.it

Abstract
The sediments of Venice Lagoon differ greatly in their composition according to geographic location, yielding changes in microbial degradation of organic matter. The cellobiose (the dimer of cellulose) was chosen as model molecule to study the degradation of organic matter in the lagoon. Cellulose is quite hardly biodegradable and is abundant in the lagoon being the main component of algae wall. The microbial degradation of the algae biomass was the main cause of past anoxia in sediments and waters. The study of metabolic profiles coupled with statistical analysis (PCA) and respirometric tests characterised microbial populations according to their degrading activity.

Keywords: bacteria, Biolog Ecoplate, PCA, oxygen consumption, cellobiose

Venice and its Lagoon are under continuous surveillance by national and European scientific committees, this yielded an enormous database of physical, chemical, sedimentological and meteorological values. In the last ten years many studies regarding the biological diversity of upper organisms were carried out. Conversely, microbial populations and their activity are less investigated.

In the framework of CORILA project, microbial communities have been studied. The sediments in Venice Lagoon are heterogeneous and differ in the total content of carbon, nutrients, chlorophyll, and pollutants, also redox potential and pH are variable. So, changes in microbial degradation of organic matter was expected in different locations of the lagoon. Cellobiose was chosen as prototype molecule to study the degradation of the algae walls, mainly composed by cellulose. This polymer is relatively resistant to microbial attack in sea water under aerobic conditions and is the most abundant organic compounds in the lagoon. In the past, the microbial degradation of dead algae biomass was the main cause of extended anoxia in sediments and waters.

Metabolic profiles of microbial communities was investigated with Biolog-Ecoplate™ system, a 96 well-plate with 31 carbon sources plus one control with distilled water (three replicates); a non-coloured redox dye indicator turns to purple if the molecule is reduced (formazan). Among the carbon sources there were lipids, sugars, amino acid, metabolic intermediates and multifunctional compounds. Bacteria were removed from sediments by overnight (18 h) shaking in a slurry phase with 2 g of sediment in 24 ml of a very diluted medium containing only yeast extract (0.05 % w/v) and distilled water. After shaking, the sediment was allowed to settle, then 150 µl of the supernatant of the culture were used for inoculation of each well and the plate was incubated at 28°C for 72 h. The microbial oxidation in single wells was revealed and quantified by colour intensity using image analysis (Kodak DC 120 and NIH software). Seventeen sediment samples were collected in spring and summertime 2002. Twelve samples were from the North and Middle Venice Lagoon, four from a lagoon which lies adjacent to North of the delta of the Po river; one sample coming from an industrial area was used as an external control. Four stations were selected for thorough studies on the base of cluster analysis.

In general, each sediment presented a different microbial metabolic profile. Using the statistical analysis of principal components (PCA), appreciable differences were found in heterotrophic microbial communities of collected sediments if compared to those collected in summer. In particular four metabolic profiles were representative of all microbial populations. A scarce consume of carbon sources by bacteria in summer was due to nutritional stress, due to the lack of nutrients and carbon. A similar result was obtained in superficial waters containing oil-degrading bacteria in the Venice lagoon [1]. In fact, in summer oxygen consumption in the presence of amended hydrocarbons stopped after three days of incubation.

A different behaviour of active microbial populations (spring and summer) was observed in one sediment sample (SFR-154). An experiment was performed using this sediment in a gas-proof microcosm, where the microbial activity was continuously monitored for oxygen uptake for five days at 20°C using Oxytop™ system. Different experimental conditions were used: i) in natural conditions, ii) adding nutrients such as nitrogen (NH_4-NO_3, 1 g l^{-1}) and phosphorus (KH_2PO_4) 2 g.l^{-1}, Na_2HPO_4 (3 g.l^{-1}), iii) adding nutrients and cellobiose (2 g. l^{-1}, a β-linked glucose dimer of cellulose) as sole carbon source, iv) only with cellobiose after microbial adaptation to this molecule (2 g. l^{-1}).

The most important response to cellobiose additions was found in the sediment (SFR-154) collected in summer 2002 (Fig. 1), where Dese outflow enters the lagoon in front of Venice airport. Oxytop system showed an high O_2 consumption in natural sediments (without any addition), this levelled off after 2.5 days (line 1), due to a depletion of bio-available carbon sources. Addition of nutrients (line 2) alone was unsatisfactory, because microbial population were mainly carbon starving. On addition of cellobiose as carbon source, after three days of incubation, the microbial population was induced to consume this soluble sub-unit of cellulose (line 3). Further additions of cellobiose resulted in a lower carbon consumption, in this case probably due to nutrient depletion (line 4).

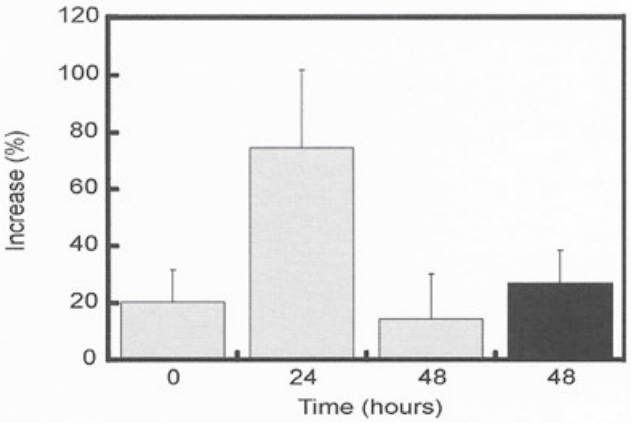

Fig. 1. Biological oxygen demand (5 days at 20°C). Cellobiose (line 3) stimulates microbial growth.

In conclusion the metabolic profile of the microbial populations changes according to period of collection. Variations in the metabolic profile in the studied sediments can be grouped in four typical profiles. In summer microbial communities seemed carbon and nutrients depleted, except sediments in the station SFR-154, which received freshwaters from Dese river. After addition of cellobiose to sediments, bacteria consumed the carbon source and nutrients quite quickly.

During summer, when both carbon sources and nutrients are lacking, heterotrophic microbial populations of the lagoon are less active respect to the ones coming from samples collected in spring at the same point.

References

1 - Baldi, F., Pepi, M., Fani, R., Di Cello, F., Da Ros, L. and Fossato, V., 1997. Complementary degradation of n-paraffins by aerobic gram-negative bacteria isolated from Venice Lagoon. *Croat. Chem. Acta*, 70: 333-346.

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SIZE SELECTIVITY OF TRAMMEL NETS USED IN THE COMMON SOLE, *SOLEA SOLEA*, FISHERY IN THE THRACIAN SEA (NE MEDITERRANEAN).

A. Adamidou [1] *, A. Kallianiotis [1], R. Holst [2]

[1] Fisheries Research Institute, NAGREF, 64007 N. Peramos, Kavala, Greece - * fri@otenet.gr
[2] ConStat, Groenspaettevej 10, DK-9800 Hjoerring, Denmark - rene@constat.dk

Abstract

The size selectivity of trammel nets used in the Thracian Sea (Greece) sole fishery was estimated using catch-at-length data from five mesh sizes (44, 56, 68, 84, 110 mm full mesh). Selectivity of nets and variation between vessels were calculated using standard selectivity software. The bi-modal curve provided the best fits. The modal length for largest retention was 3.5 times mesh size. The optimum mesh sizes were compared to commercial practice. No significant difference between the vessels' fishing efficiency was shown.

Keywords: Selectivity; Trammel net; Solea solea, Greece

Introduction

The common sole, *Solea solea (Linaeus, 1758)* is one of the most commercially important flatfish for the Greek fisheries. The main proportion of sole catches (>70%) is fished in the N. Aegean Sea, mostly by trammel nets (60%-95%) (National Statistical Service of Greece). Few studies are available on the selectivity parameters of passive gears in Greek waters [1, 2, 3] and none of them concerns the flatfish fishery.

Materials and Methods

Experimental trials were conducted, in April and July 2001 by three equally sized vessels at depths ranging from 16.5 to 25 m. Ninety nets with 5 mesh sizes in random order were used (inner panel: 44, 56, 68, 84, 110 mm full mesh; outer panel: 220, 280, 272, 336, 330 mm full mesh). All nets were made of 210/3 denier multifilament twine, had equal length and height. The float lines were 100 m long having 20 g/m buoyancy. The lead lines were about 2% longer and weighted 150-180 g/m. The hanging ratio was 0.50 on headline and 0.51 on lead line. The fleets were deployed simultaneously according to commercial practices. The average soak time was 12.5 h. The catches were sorted by species and mesh size, measured (total length, body girth, in mm) and weighed (total weight, g). The standard selectivity software "Gillnet" and "EC model" (Constat) was used for estimating selectivity of the nets and variation between vessels [4, 5].

Results and Discussion

During April, 376 individuals were caught. Soles were mainly gilled and wedged and secondary entangled or trapped by the outer panels. The mean total length of sole ranged from 236 to 317 mm and increased with the mesh size. The 68 mm mesh caught the highest proportion by number (27.9%) and the 84 mm mesh by weight (29.3%).The catch below the minimum landing size (MLS=200 mm) was 4.8% and 0% for the 68 and 84 mm mesh sizes, respectively.

In July, 210 individuals were fished. The mean length ranged from 203 to 282 mm, increasing with the mesh size. The 56 mm mesh caught the highest proportion of the total catch (33.3% by number, 28.4% by weight). However, individuals of lengths <MLS composed 34.3% of the catches by number and 21.7% by weight. In contrast for the 68 mm mesh, which accounted for 27.1% of the total catch by number and 27.6% by weight, the proportion of individuals of lengths < MLS was considerably lower (5.3% by number and 2.9% by weight).

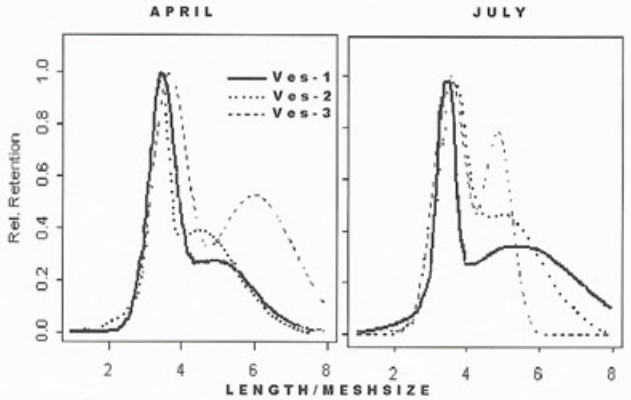

Fig. 1. Mean selectivity curves per vessel for both trials.

Selectivity was estimated using the bootstrap technique based on pooling catch data across all sets. Different functional forms were assessed and selectivity for sole was adequately described by a bi-normal selection curve [4, 5]. The location and the spread of the primary mode had good correspondence between the vessels and the two seasonal trials while the location and the spread of the second mode were more variable (Fig. 1, Table 1).

For the length range of sole that was fished, the most efficient mesh sizes were 68 and 84 mm. They had the largest catches and the amount of catch below MLS was ≤ 5%. The aforementioned mesh sizes are the ones most commonly used in the commercial fishery. The fish length for larger retention is 3.5 times the mesh size. There appeared to be no effect of vessel-factors in nets' selectivity for same type vessels. Also the seasonal difference of trials did not seem to affect selectivity.

Table 1. Bootstrap mean parameter estimates per vessel for both trials (α_1, α_2 = the location of the primary and secondary mode respectively, β_1, β_2= the spread of the primary and secondary mode respectively, ω= is a constant scaling the height of the second curve relative to the first).

	Parameter Estimates				
April	α_1	β_1	α_2	β_2	ω
Vessel 1	3.46	0.350	4.93	0.103	0.310
Vessel 2	3.38	0.217	4.47	1.071	0.512
Vessel 3	3.66	0.464	6.01	1.086	0.553
July	α_1	β_1	α_2	β_2	ω
Vessel 1	3.45	0.233	5.42	1.685	0.417
Vessel 2	3.61	0.354	4.98	1.103	0.584
Vessel 3	3.53	0.442	4.86	0.384	0.774

References

1 - Petrakis G., and Stergiou K.I, 1995. Gill net selectivity of *Diplodus annularis* and *Mullus surmuletus* in Greek waters. *Fish. Res.*, 21: 455-464.
2 - Petrakis G., and Stergiou K.I, 1996. Gill net selectivity for four fish species (*Mullus barbatus, Pagellus erythrinus, Pagellus acarne* and *Spicara flexuosa)* in Greek waters. *Fish. Res.*, 27: 17-27.
3 - Stergiou K.I, and Erzini K., 2002. Comparative fixed gear studies in Cyclades (Aegean Sea): size selectivity of small hook longlines and monofilament gillnets. *Fish. Res.*, 58: 25-40.
4 - Constat, 1998. GillNet Software, Denmark.
5 - Constat, 1998. EC Model Software, Denmark.

PCB TRENDS IN STRIPED DOLPHINS FROM THE WESTERN MEDITERRANEAN SEA

Alex Aguilar * and Asunción Borrell

Dept. of Animal Biology, University of Barcelona, 08071 Barcelona, Spain - * aaguilar@ub.edu

Abstract

The aim of the study was to investigate timetrends in PCB loads in the offshore waters of the western Mediterranean Sea. As bioindicator we selected the striped dolphin, a long-lived oceanic species, and analysed blubber samples obtained during 1987 2002 from 186 freeranging individuals by means of biopsy techniques. Concentrations of PCBs decreased throughout the period. This decline in oceanic waters is consistent, albeit not always, with trends observed in coastal surveys. Dolphins and other top predators are thus proposed as useful indicators to assess long-term trends of pollutants in oceanic ecosystems and large water masses.

Keywords: PCBs, striped dolphin, western Mediterranean Sea, temporal trends, bioindicator

Introduction

The use of PCBs was worldwide discontinued in the 1980s but, due to the stability of these compounds, they have remained as ubiquitous pollutants in marine environments. PCBs are usually monitored through coastal organisms and therefore information on offshore water masses is scarce or nonexistent. Here we investigate the use of dolphins as bioindicators of PCB pollution in oceanic ecosystems.

Material and methods

Between 1987-2002, with the exception of 1990 and 1994-1999, we collected blubber samples from 186 striped dolphins in the offshore waters between mainland Spain and the Balearic Islands. The tissue was excised from bow-riding dolphins using a biopsy dart (1) and preserved in deep freeze. Quantification of PCBs was made by gas chromatography with electron capture detector and SPB 5 capillary column. Data were log-transformed (base 10) and temporal trends investigated through regression analyses.

Results and conclusions

PCB concentrations (mean=199, SD= 150, in mg PCBs /kg lipid tissue?) were of the same order of magnitude as those reported by previous studies on the same species in north-western Mediterranean Sea (2, 3), but about 2-10 times higher than those found in other less polluted water masses (4).

Mean PCB concentrations declined significantly ($p<0.0001$) from 342 mg/kg in 1987 to 76 mg/kg in 2002 (Fig. 1):
log PCB=112.1-0.0552t (R^2=0.707, SE (slope)=0.003, SE(intercept)=5.23)

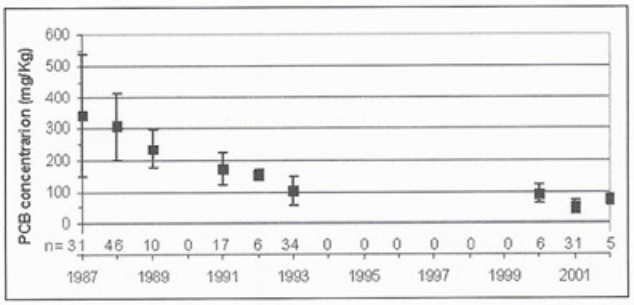

Fig. 1. Mean ± standard deviation of PCB concentrations, expressed as mg/Kg lipid basis for each sampling year (n= number of samples per year).

The observed decrease reflects the reduction of PCB inputs into the Mediterranean Sea since the 1980s and the subsequent decomposition/dispersion process undergone by the pollutant. The European countries bordering the western Mediterranean Sea manufactured in the past large quantities of PCBs; production in France, Italy and Spain alone was about 300.000 t during 1954-1984 (5). Since the mid-1980s, PCBs were much restricted though large quantities remained in uncontrolled disposal sites or were recycled. A significant fraction of the PCBs released ended up in the sea. Monitoring of marine ecosystems has been typically made using widely distributed coastal organisms, such as mussels, other shellfish, and inshore bottom fish, as bioindicators (5). Although results from short-term coastal surveys undertaken between the 1970s and the early 1990s tend to show either stabilization or a decreasing trend in PCBs (5), data are not consistent (6, 7, 8, 9). Comparable information on the oceanic water masses is scarce or nonexistent, mostly because appropriate indicators are not available. Given that organochlorines are bioaccumulative and magnify through food chains, mobile –though resident- top predators such as dolphins, porpoises and seals, have been proposed as indicators (10). Our results show that the environmental levels of PCBs in the oceanic waters of the Western Mediterranean have decreased significantly during the last 15 years and suggest that data from coastal studies, particularly those from sediments (9), reflect only local, small-scale processes and may be non-informative of the long-term, wide-scale variation in the pollutant loads of large water masses, particularly oceanic.

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References

1 - Aguilar A. and Borrell A., 1994. Assessment of organochlorine pollutants in cetaceans by means of skin and hypodermic biopsies. Pp. 245-267. *In:* Fossi, C. and Leoncio C. (eds), Nondestructive Biomarkers in Vertebrates. Lewis, Boca Raton, FL.

2 - Aguilar A., 2000. Population biology, conservation threats, and status of Mediterranean striped dolphins (*Stenella coeruleoalba*). *J. Cetacean Res. Manag.*, 2: 17-26.

3 - Marsili, L., Casini, S., Marini, L., Regoli, A., and Focardi, S., 1997. Age, growth and organochlorines (HCB, DDTS and PCBs) in Mediterranean striped dolphins *Stenella coeruleoalba* stranded in 1988-1994 on the coasts of Italy *Mar. Ecol. Prog. Ser.,* 151: 273-282.

4 - O'Shea T. J. and Aguilar, A., 2001.Cetaceans and Sirenians. Pp. 427-496. *In:* Shore, R. F. and Rattner B. A. (eds), Ecotoxicology of Wild Mammals, John Wiley & Sons, Chichester, UK.

5 - Tolosa I., Readman J. W., Fowler S. W., Villeneuve J. P., Dachs J., Bayona J. M., and Albaiges J., 1997. PCBs in the western Mediterranean. Temporal trends and mass balance assessment. *Deep-Sea Res. II*, 44: 907-928.

6 - Villeneuve J. P., Carvalho F. P., Fowler S. W., and Cattini, C., 1999. Levels and trends of PCBs, chlorinated pesticides and petroleum hydrocarbons in mussels from the NW Mediterranean coast: comparison of concentrations in 1973/1974 and 1988/1989. *Sci. Total Environ.*, 237/238: 57-65.

7 - Burns A., Villeneuve J. P., and Fowler S. W., 1985. Fluxes and residence times of hydrocarbons in the coastal Mediterranean, how important are the biota? *Estuar. Coast. Shelf Sci.*, 20: 313-330.

8 - Solé M., Porte C., Pastor D., and Albaigés, J., 1994. Long-term trends of polychlorinated biphenyls and organochlorinated pesticides in mussels from the Western Mediterranean Coast. *Chemosphere*, 28: 897-903.

9 - Tolosa I., Bayona J. M., and Albaigés J., 1995. Spatial and temporal distribution, fluxes, and budgets of organochlorinated compounds in Northwest Mediterranean sediments. *Environ. Sci. Technol.*, 29: 2519-2527.

10 - Aguilar A., Borrell A., and Reijnders P. J. H., 2002. Geographical and temporal variation in levels of organochlorine contaminants in marine mammals. *Mar. Environ. Res.* 53: 425-452.

VARIATIONS IN OTOLITH MICROSTRUCTURE OF SEA-BASS *(DICENTRARCHUS LABRAX L.)* LARVAE UNDER DIFFERENT FOOD REGIMES

Aguilera B.*, Palomera I., Olivar M. P.

Institut de Ciències del Mar (CMIMA – CSIC), Passeig Marítim de la Barceloneta 37-49, 08003 Barcelona, Spain
* aguilera@cmima.csic.es, isabel@cmima.csic.es, polivar@cmima.csic.es

Abstract

After validating daily deposition for sea-bass larval otoliths, we found that different feeding regimes did not affect increment deposition periodicity, although they affected their width. We calculated different condition indices based on otolith microstructure and noticed that, for the food deprivation experienced by the larvae, all otoliths recovered their size in days.

Keywords: condition index, daily growth, Dicentrarchus labrax, larvae, otolith

Sea-bass *(Dicentrarchus labrax L.)* larvae were reared for the first month of life under different food regimes [fed, 1 to 3 days of (late) food deprivation, starved and delayed feeding] to set a condition index for this species based on the otolith microstructure. Previously, a marking experiment with alizarine, following the protocol of Blom *et al.* (1) was carried out to validate increment deposition.

We observed daily increment deposition beginning the second day after hatching (Fig. 1). The different food regimes applied did not affect increment deposition periodicity, but they did affect increment width (ANOVA, $p<0.05$). Thus increment width was used for estimating a condition index (2), which is independent of body size (3).

Starved larvae showed significantly (ANOVA, $p<0.05$) smaller otoliths than fed larvae, but no variation in the number of increments was observed.

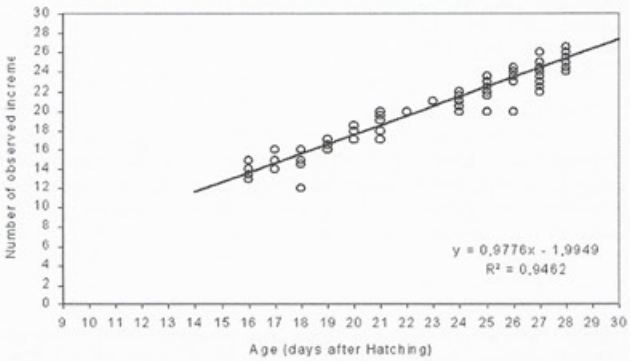

Fig. 1. Relationship between larval age and number of otolith increments in fed larvae. Plotted data are the average counts of both sagittae (n = 155).

When food was supplied to the delayed feeding larvae (i.e., not fed until the second week of life), a progressive increase of increment width was observed and after one week of feeding they attained similar values to those for fed larvae (Fig. 2).

A late food deprivation experiment (i.e., 1 to 3 days with no food) was conducted on the third week of larval life. We noticed a delay from the day in which larvae were not fed until it was reflected on their otoliths. They formed narrower increments the second day after the initiation of food deprivation, but they recovered their normal width the day after they were fed again (Fig. 2).

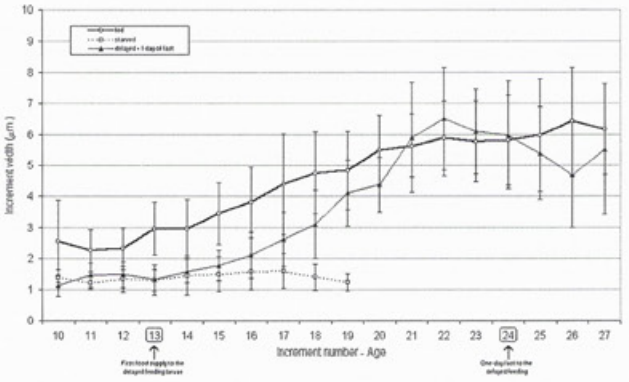

Fig. 2. Absolute increment width of the starved and delayed feeding larvae versus fed larvae.

We calculated a condition index based on the width of the last three complete growth increments: Recent Otolith Growth Index (4). This index is based on the residuals between the logarithm of the three outermost increments sum and the logarithm of the radii, as a measure of how much an individual separates from the normal condition (Fig. 3).

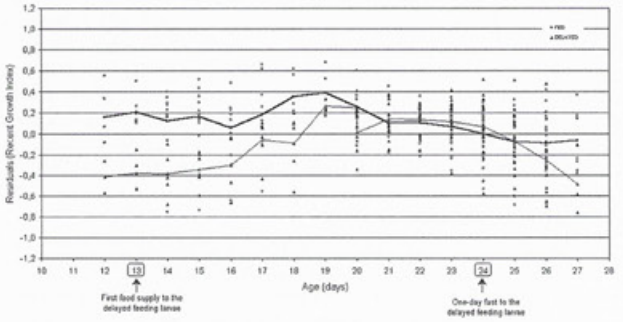

Fig. 3. Plotted residuals (Recent Otolith Growth Index) of the fed *versus* delayed treatments.

References

1 - Blom G., Nordeide J. T., Svasand T. and Borge A., 1994. Application of two fluorescent chemicals: alizarin complexone and alizarin red S, to mark otoliths of Atlantic cod, *Gadus morhua L. Aquacult. Fish. Manag.*, 25 (Suppl. 1): 229-244.

2 - Karakiri M., 1989. Daily growth patterns in otoliths of early stage plaice: preparation techniques and interpretation of readings. *In:* Schröeder, J. (ed.) New trends in ichthyology. Paul Parey Verlag, Hamburg.

3 - Suthers I. M., 1998. Bigger? Fatter? Or is faster growth better? Considerations on condition in larval and juvenile coral-reef fish. *Australian J. Ecol.*, 23: 365-273.

4 - Hovenkamp, F., and Witte, J. IJ., 1991. Growth, otolith growth and RNA/DNA ratios of larval plaice *Pleuronectes platessa* in the North Sea 1987 to 1989. *Mar. Ecol. Prog. Ser.*, 70: 105-116.

SHORT-TERM VARIABILITY OF ZOOPLANKTON BIOMASS AND SIZE STRUCTURE IN THE NORTHWESTERN MEDITERRANEAN

M. Alcaraz [1] *, A. Calbet [1], X. Irigoien [2], I. Trepat [1] and E. Saiz [1]

[1] Institut de Ciències del Mar, CSIC, Barcelona, Spain - * miquel@icm.csic.es
[2] AZTI, Herrera Kaia portualdea z/g 20110 Pasaia (Gipuzkoa), Spain

Abstract

The short-term variability of phyto- and mesozooplankton biomass and size structure was estimated at different time and space scales in the NW Mediterranean. Three stations representative of contrasting hydrographic structures were repeatedly sampled for zooplankton, hydrographic parameters and phytoplankton (chlorophyll a) in a 12 day period. Although the variability for all the parameters was higher at the shorter time- and space scales (hours, meters), the rate of change at larger scales must be carefully considered.

Key Words: Plankton biomass, variability, Catalan Sea

Introduction

Plankton production models require reliable parameterisations of extensive properties like biomass and size spectrum, both known to display changes at broad time and space scales. At some scales, variability can be interpreted according to Stommel's classical diagram of plankton variability (1). In the case of zooplankton, part of this variability, mainly that derived from predictable sources (i.e., tidal currents, light-induced activity rhythms, etc.) is generally considered to be avoided by adequate sampling schedules, while other sources of variability are seldom considered. In this study, the variability at different spatial (meters - tens of Km) and temporal (hours - weeks) scales of phyto- and zooplankton biomass and size are estimated and discussed in the light of the contrasting hydrographic properties related to a persistent density front in the Catalan Sea (NW Mediterranean).

Study area and methodology

Plankton was studied along a transect (VARIMED-95 cruise, June 1995) off Barcelona (Fig. 1), crossing the Catalan density front (2). Three stations, representative of contrasting hydrographic structures (Coastal **C**, Frontal **F**, and Offshore **O** stations, Fig. 1), were sampled every four days during the 12 days cruise, at 4-6 hr interval. Zooplankton was collected using a Longhurst-Hardy Plankton Recorder net fitted with 200 µm-mesh. Four to seven depths from surface to 100 m were sampled in each cast. Hydrographic data were simultaneously obtained with a Seabird CTD installed in the net. Chlorophyll a (Chl a) data were obtained from the *in vivo* fluorescence profiles after adequate fluorometer calibration.

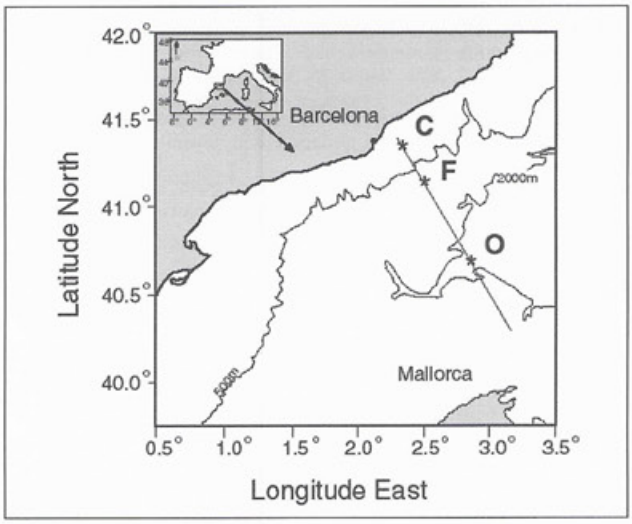

Fig. 1. Map showing the position of Coastal, Frontal Offshore stations in the study area.

Zooplankton biomass (as organic C and N) was analysed on aliquots from the corresponding depth-samples obtained on each cast using a Carlo-Erba C – H - N analyser. Zooplankton community size structure was obtained by image analysis. Zooplankton biomass data have been expressed as µg C l^{-1}, and average individual size as µgC/ind., according the distribution of organisms in 13 biomass-classes in a doubling scale (log_2) (3).

Results and discussion

Zooplankton biomass and individual size showed similar trends, increasing from coastal to offshore stations (Table 1), while the highest concentrations of chlorophyll corresponded to the front. All structural properties here considered (Table 1) were significantly more variable at front, as expected by the higher dynamism in frontal areas as observed and discussed in (4).

Table I. Average values and variability (C.V., %, in parenthesis) at the Coastal (C), Frontal (F) and Offshore (O) stations for Zooplankton biomass (µgC/l), Individual size (µgC/ind) and Chlorophyll a (µg/l), at time- and space scales of 102 h and 102 m).

VARIABLE	C	F	O	Total
Zoo (µg/l)	1.48 (28)	1.50 (79)	2.75 (3)	1.90 (37)
Size (µgC/ind)	7.29 (67)	11.18 (126)	23.10 (3)	12.25 (97)
Chlorophyll (µg/l)	0.238 (3)	0.251 (21)	0.201 (12)	0.230 (11)

Zooplankton and Chl a tended to vary inversely with time and space scales, the first being less variable during the night than during daylight hours (Table 2). At all time and space scales, the highest variability corresponded to individual size, particularly for 12 hr –tens of meters time-space scales due to the arrival in the sampling area of larger individuals during the night (vertical migration). Apart from this relatively high frequency variability, other variability sources acting at different time- and space scales are particularly important, and must be carefully considered in plankton production models.

Table II. Variability (C.V., %) of Zooplankton biomass (µgC/l), Individual size (µgC/ind) and Chlorophyll a (µg/l) at different time- and space scales. In parenthesis (day – night) values.

SCALES		PARAMETERS		
Time h	Space m	Zoo biomass (µgC/l)	Chloropyll a (µg/l)	Size (µgC/ind)
4-6 h	10 m	59 (66 – 55)	48 (44 – 50)	70 (69 – 65)
12 h	10^2 m	38	47	81
10^2 h	10^2 m	24	36	58
10^2 h	10^4 m	18	32	56

Acknowledgements

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References

1 - Haury I.R., Mc Gowan J.A., and Wieve P.H., 1978. Patterns and processes in the time-space scales of plankton distributions. *In*: Steele J.H. (ed.), Spatial pattern on plankton communities. Plenum Press, N.Y.

2 - Estrada M., and Margalef R., 1988. Supply of nutrients to the Mediterranean photic zone along a persistent front. *In*: Minas H.J., and Nival P. (eds.), Océanographie pélagique méditerranéenne. *Oceanol. Acta.*

3 - Alcaraz M., Saiz E., Calbet A., Trepat I. and Broglio E., 2003. Estimating zooplankton biomass through image analysis. *Mar. Biol.*, 143: 307-315.

4 - Calbet A., Alcaraz M., Saiz E. and Estrada M., 1996. Planktonic herbivorous food webs in the Catalan Sea (NW Mediterranean): temporal variability and comparison of indices of phyto-zooplankton coupling based in state variables and rate processes. *J. Plankton Res.*, 18: 2329-2347.

MANAGEMENT OF MEDITERRANEAN FISHERIES AND IMPACT ON THE MARINE ECOSYSTEM: HOW TO ACCOUNT FOR TOP PREDATORS?

José Manuel Arcos [1, 2] *, Maite Louzao [2] and Daniel Oro [2]

[1] IBLS, Graham Kerr Building, University of Glasgow, G128QQ Glasgow, Scotland, UK - * j.m.arcos@bio.gla.ac.uk
[2] IMEDEA (CSIC-UIB), C/Miquel Marquès 07190 Esporles, Mallorca, Spain

Abstract

We review different types of interactions between fisheries and top predators, particularly seabirds, in the Mediterranean. Fisheries affect top predators in a variety of ways, resulting from strongly detrimental (mortality caused by long-lines and other activities) through beneficial effects (at least in the short term, consumption of discards). These interactions should be studied in detail and taken into account when designing managing strategies, in order to reduce collateral effects over the marine ecosystem.

Keywords: conservation; discards; ecosystem-based management; long-lining; seabirds

Fisheries have for long been regarded as an extracting activity only affecting their targeted fish stocks, but their impact over the whole marine ecosystem is now receiving increasing attention (1-3). Top predators, due to their high position in the food webs, can be particularly affected by the deterioration of the ecosystem. In this report, we review the interactions between top predators and fisheries in a low productive and highly diversified sea, the Mediterranean, with particular attention to seabirds. We also suggest possible ways of taking these organisms (often of high conservation concern) into account when managing fisheries.

The Mediterranean is a sea of relatively low production (4), holding relatively low developed fisheries, primarily of artisanal type (5), and modest populations of top predators, though in some cases (e.g. seabirds) of particular conservation concern due to their diversity and often restricted distribution. The degree of interaction between predators and fisheries seems high and diverse in nature, ranging (considering the predator's point of view) from directly prejudicial (mortality caused by some fishing activities) to potentially beneficial (discards).

• **Interactions causing direct mortality**: Two fishing techniques are particularly prejudicial for their undesired but direct effect on top predators, drift-netting (officially banned) and long-lining. Long-lines are responsible for high mortality rates of seabirds, cetaceans, sea turtles and sharks worldwide (1, 3). Since most top predators are long-lived organisms, with low reproductive rates that are counterbalanced by high survival, this additional factor of mortality can strongly influence their population dynamics and, in some cases, lead to near-extinction. This seems to be the case of the endemic and critically endangered Balearic shearwater *Puffinus mauretanicus* (6). In any case, few studies have addressed this problem for the Mediterranean (7), where the diversity of fishing gears employed and the artisanal nature of the fleets could make the implementation of mitigating measures (e.g. timetable changes, line weighting and the use of bird-scaring lines) difficult.

• **Competition**: Top predators often share target species with fisheries, thus leading to a potential conflict. This seems to be negligible for the fisheries in most occasions, but the reverse could not be true. In the Mediterranean, the decline in some pelagic fish stocks, e.g. anchovy *Engraulis encrasicolus*, could bring about a severe reduction in food resources for some seabirds, though other clupeoids that seem to be in better situation (e.g. sardine *Sardina pilchardus*) (8), could mitigate such a reduction. Although there is no consensus about the relative importance of fishing and climate in driving clupeoid fluctuations, it seems reasonable to suppose that fisheries could reduce stocks significantly (2). Particular attention should be drawn to purse-seine fisheries, since they target species (i.e. small- and medium-sized epipelagic fish) which serve as prey for many top predators (particularly large pelagic fish and seabirds). Management strategies could range from reductions in effort through temporal (already carried out) and spatial closures of the fishery.

• **Scavenging**: Several fishing activities, particularly trawling, provide large amounts of discards that are consumed by a variety of scavengers, from invertebrates to seabirds and large predatory fish. Recent energetic estimations reveal that seabirds consume over 80% of these discards in some Mediterranean areas, and this resource seems to meet up to 75% of the energy requirements of some seabird populations (9), including those of endangered species (10). Thus, although the reduction of discards is desirable (11), management strategies directed to attain this should take into account seabirds and try to minimise the impact on them. There is the example of trawling moratoria, a management strategy already in use, appearing to affect negatively some threatened seabirds through temporal food shortage coinciding with their breeding season, thus reducing their reproductive success (9). Nevertheless, this is a short-term effect that would probably be reversed into neatly beneficial in the long term if the fish stocks and the ecosystem in which they are embedded will actually benefit from such moratoria. However, little effort has been directed to assess this potential benefit for the fish stocks (12). Monitoring programs need to be developed in order to maximise the positive effects of trawling moratoria over fish stocks and the whole ecosystem. Potential impacts on seabirds should be considered and, if not detrimental for other organisms, reduced.

Concern on the impact of fisheries on ecosystems, and particularly on top predators' conservation, is important. Although fish stocks lie at the heart of fisheries management, considering other organisms will help preserving the ecosystem.

References

1 - Moore G., and Jennings S., 2000. Commercial fishing: the wider ecological impacts. Blackwell, London.
2 - Pauly D., Christensen V., Guenette S., Pitcher T.J., Sumaila U.R., Walters C.J., Watson R., and Zeller D., 2002. Towards sustainability in world fisheries. *Nature*, 418: 689-695.
3 - Myers R.A., and Worm B., 2003. Rapid worldwide depletion of predatory fish communities. *Nature*, 423: 280-283.
4 - Estrada M., 1996. Primary production in the northwestern Mediterranean. *Sci. Mar.*, 60 (Supl. 2): 55-64.
5 - Farrugio H., Oliver P., and Biagi F., 1993. An overview of the history, knowledge, recent and future trends in Mediterranean fisheries. *Sci. Mar.*, 57 (2-3): 105-119.
6 - Oro D., Aguilar J.S., Igual J.M., and Louzao, M., 2003. Modelling demography and extinction risk in the endangered Balearic shearwater. *Biol. Conserv.* (*in press*).
7 - Cooper J., Baccetti N., Belda E.J., Borg J.J., Oro D., Papakonstantinou C., and Sánchez, A. 2003. Seabird mortality from longline fishing in the Mediterranean Sea and Macaronesian waters: a review and a way forward. *Sci. Mar.*, 67 (Supl. 2): 57-64.
8 - Abad R., Miquel J.; Iglesias M., Álvarez F., 1996. Acoustic estimation of abundance and distribution of sardine in the northwestern Mediterranean. *Fish. Res.* 34: 239-245.
9 - Arcos J.M. 2001. Foraging ecology of seabirds at sea: significance of commercial fisheries in the NW Mediterranean. PhD Thesis, Universitat de Barcelona. (http://tdcat.cesca.es/TDCat-0219102-114337).
10 - Arcos J.M., and Oro D., 2002. Significance of fisheries discards for a threatened Mediterranean seabird, the Balearic shearwater *Puffinus mauretanicus*. *Mar. Ecol. Prog. Ser.*, 239: 209-220.
11 - FAO 1995. Code of conduct for responsible fisheries. FAO, Rome.
12 - Martín, P. 1995. Effect of a two months closed season on monthly catches of hake (Merluccius merluccius) and red mullet (*Mullus* spp.) in a restricted area off the Catalan Coast (NW Mediterranean). *Rapp. Comm. Int. Mer Médit.*, 34: 249.

PRELIMINARY RESULTS ON EARLY GROWTH AND HABITAT PREFERENCE OF YOUNG WILD GREY MULLET (*MUGIL CEPHALUS* LINNAEUS, 1758) ALONG THE EAST ADRIATIC COAST (CROATIA)

Bartulović V. [1] *, Conides, A. [2] and Glamuzina B. [1]

[1] Department for Aquaculture, University of Dubrovnik, Croatia - * vlasta@vdu.hr
[2] Hellenic Centre for Marine Research, Agios Kosmas, Hellinikon, Athens, Greece

Abstract

In this paper we present results on habitat preference and early growth rates of young wild grey mullet along the south-eastern Adriatic coast. Grey mullets juveniles showed preference and better growth rates in eutrophic urban areas than in other natural areas and lagoons. After reaching a total length of 16-17 mm, they migrate to adjacent areas of low salinity.

Keywords: Mugil cephalus, appearance, growth

Introduction

Mugilids are commercially important for the Mediterranean [1]. The grey mullet, *Mugil cephalus*, represents an important commodity due to good meat quality and high-priced dried roe. However, the biology and ecology of this species along the Eastern Adriatic coast is relatively unknown [2]. They usually change habitat several times during their life so their appearance can be random [3].

Materials and Methods

A total number of 526 young grey mullets were caught during August-November 2002 using small nets (mesh size 2 mm), at three stations in Neretva River estuary (the Port of Ploče and Blace village as marine sites and Rogotin village as a low salinity site) and one reference station in Bistrina Bay located 30-km from the estuary. Ploče, Blace and Bistrina are typical coastal marine ecosystems with salinity fluctuating between 25-38 psu. Rogotin is a typical estuarine site located adjacent to a small torrent (Crna Rijeka) with salinity fluctuating between 2-20 psu. All individuals caught were counted and measured for total length (TL, mm). Growth rates (in mm/day) was related to TL as follows [3,4]:

$$G = a\frac{1}{L} - b$$

Results

TL increased in a linear form. The relationships between TL and time were positive for Ploče and Bistrina and negative for Rogotin. However the low abundance of grey mullets in Bistrina and Rogotin did not allow for applying regression analysis (few data points). For Ploče, the relationship between TL and time was significant (r^2=0.911). Juveniles appeared firstly in the Ploče area early in August and after almost one month in Bistrina lagoon and finally at Rogotin and Blace with lower numbers. Juveniles remained in coastal waters for one month, and started to migrate in freshwater bodies only when they reached more than 16-17 mm TL. The highest number of juveniles was observed in Ploče (355 individuals) and lower in Bistrina (14 individuals), Blace (74 individuals) and Rogotin (83 individuals).

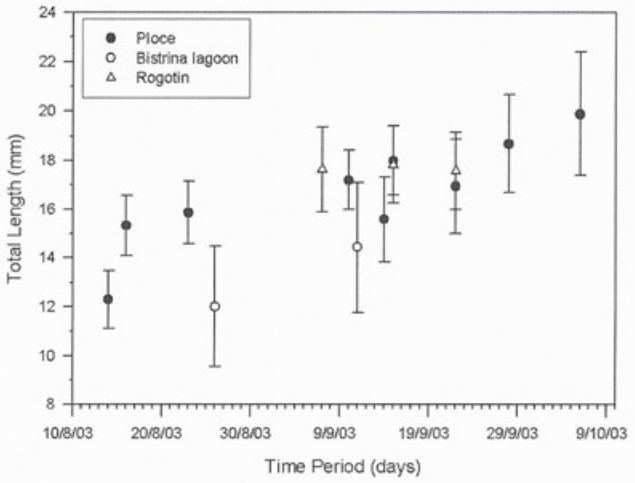


Fig. 1. Temporal distribution of total length of grey mullet juveniles, *Mugil cephalus* in Ploce, Bistrina and Rogotin sampling areas.

The relationship between daily growth rates and TL and time (days) is illustrated in Figure 2. Growth rates were higher (t-test=2.1, df=8, a=5%) in Ploče than in Rogotin. Inadequate data from the other areas did not allow statistical comparisons.

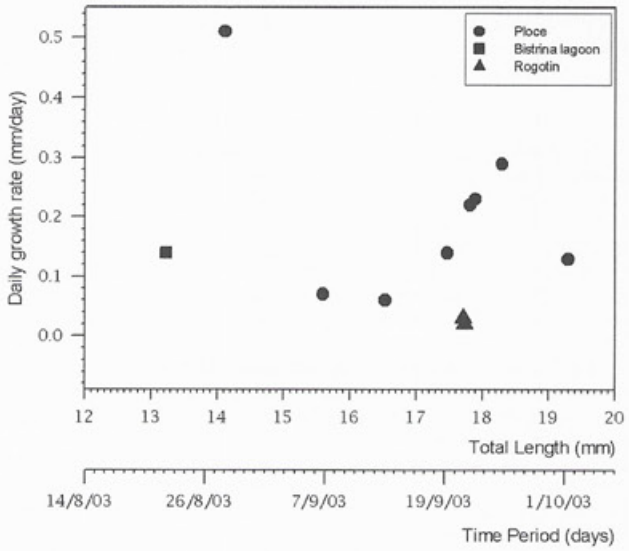


Fig. 2. Relationship between daily growth rate, total length and time for grey mullet, *Mugil cephalus* juveniles in the estuary of Neretva River.

Discussion

The grey mullet juveniles showed clear preference to firstly appear and inhabit urban areas such as Ploče port. The species prefers to appear first in Ploče port and then Bistrina Bay within the period of 1 month and then distribute laterally to Rogotin and Blace whereas at Bistrina its appearance is considered as by chance. Their appearance pattern seems to be size-related and divided in two phases: at first they spend at least one month in the marine coastal waters until they reach 16 mm TL and afterwards start migrating upstream in the estuary in areas of lower salinity where they appear when TL > 16 mm.

References

1 - FAO, 1987. Mugilidae, pp. 1190-1194. *In*: Fischer, W., and Schneider, M., (eds.), Fiches FAO d'identification des espèces pour les besoins de la *pêche*, Méditerranée et *m*er Noire, Zone de *Pêche* 37, révision 1, volume II, *Vertébrés*.

2 - Modrušan, Z.,Teskeredžić, E. and Jukić, S., 1987. Biology and ecology of Mugilidae species on the eastern Adriatic coast (Sibenik Bay). *FAO Fishery Report,* 394: 159-167.

3 - Conides, A., Anastasopoulou, K., Fotis, G., Koussouris, Th., and Diapoulis A., 1992. Growth of four Mugilidae species in Western Hellas lagoons. Proceedings of the 27th EMBS, Dublin, Ireland, 7-11 September 1992.

4 - Bayley, P.B., 1977. A method of finding the limits of application of the von Bertalanffy growth model and statistical estimates of the parameters. *J. Fish. Res. Bd Can.*, 34(8): 1079-1084.

MORPHOMETRIC VARIABILITY BETWEEN NORTH AND SOUTH ADRIATIC POPULATIONS OF *SAGITTA ENFLATA*

Mirna Batistic

Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik, Croatia - mirna.batistic@labdu.izor.hr

Abstract

Results of a biometric study of *Sagitta enflata* from two different ecological areas – one in the North and the other in the South Adriatic – demonstrate differences in body dimensions. This may represent adaptations to different environmental variables experienced by the two populations, especially as regards seasonal changes in water temperature and food availability.

Keywords: Chaetognatha, Sagitta enflata, morphometric variability, Adriatic Sea

Introduction

Sagitta enflata is an oceanic or semi-neritic chaetognath typical of surface waters and especially abundant over continental shelves. It is eurythermic and euryhaline, but it prefers temperature ranges between 18 and 21 °C and salinity above 35 ppt (1).

This study investigated morphological differences in populations of *Sagitta enflata* in two different ecological areas. The North Adriatic is shallow (average depth ~ 50 m) and influenced by river discharge, especially that of the Po. The South Adriatic, on the other hand, is the deepest (max. 1242 m) and most oligotrophic part of the Adriatic (2). It is influenced mainly by warm Mediterranean waters in the central and eastern parts of its basin (3).

Material and methods

Plankton was collected on four cruises of R/V Andrija Mohorovičić from 1974 to 1976 (Table 1). Morphometric measurements were made on adult specimens isolated from five stations in the North Adriatic (above the Ancona - Lošinj transect), and three stations in the eastern South Adriatic (Dubrovnik - Bari transect).

Table 1. Temperature and salinity ranges in the North (from surface to bottom) and South Adriatic (0-50 m).

	North Adriatic		South Adriatic	
	T (°C) min-max	Salinity min-max	T (°C) min-max	Salinity min-max
Sep.-Oct. 1974	15.5-22.2	36.3-38.9	14.9-21.5	38.3-38.6
February 1976	8.9-10.0	37.7-38.3	13.6-14.2	38.6-38.7
Apr.-May 1975	10.0-17.2	23.6-38.4	13.7-16.2	38.5-38.7
July 1976	10.5-24.8	36.8-38.4	14.8-25.8	38.1-38.8

Body length (**L**) – the top of the head to the tip of the tail fin – was measured with a stereomicroscope at 25x. Maximum width (**W**), length of head (**Lh**), width of head (**Wh**), length of ovaries (**Lov**), tail length (**Lt**), and tail width (**Wt**) were measured with a Wild microscope at 100x.

Student's t-test was used to test differences between populations.

Temperature and salinity data may be found in "Reports and Results of Oceanographic Research in the Adriatic Sea (1974 - 1976)", published by the Hydrographic Institute, Split (Croatia).

Results and discussion

Morphometric characteristics of *Sagitta enflata* are presented in Table 2.

In both the North and South Adriatic in February and April-May, periods in which temperature was low (Table 2), individuals were longer than in July and September-October. This agrees with findings for other chaetognaths (*c.f* 4). Further, the longest individuals were found when copepod – the main food of chaetognaths – was greatest (5). Rao and Kelly (6) found a similar situation for *S. enflata* in the Indian Ocean.

Regardless of the temperature and food conditions, there was a significant difference ($p<0.05$) in body dimensions between individuals from the North and South Adriatic for all cruises: Chaetognaths from the south were always larger in all body dimensions than those from the north.

These morphological differences between North and South Adriatic populations may reflect an adaptation to the significantly different environmental conditions to which each of these populations is exposed.

Table 2. Morphometric characteristics of *Sagitta enflata* in the North and South Adriatic.

		North Adriatic		South Adriatic	
		min-max	avg±std	min-max	avg±std
Septem.-Octob. 1974, n=50	L	9.0-13.0	11.7±1.2	12.0-16.5	14.5±1.3
	W	0.87-1.35	1.11±0.12	1.06-1.82	1.40±0.17
	Lh	0.46-0.86	0.63±0.08	0.73-0.96	0.82±0.05
	Wh	0.43-0.89	0.66±0.10	0.73-1.22	0.94±0.10
	Lo	0.20-0.89	0.46±0.19	0.33-1.72	0.99±0.39
	Lt	1.45-1.98	1.77±0.14	1.72-2.48	2.13±0.20
	Wt	0.36-0.56	0.46±0.05	0.46-0.63	0.55±0.05
February, 1976 n=44	L	8.5-16.0	12.6±2.1	13.0-19.0	15.9±1.7
	W	0.67-1.33	0.96±0.20	1.00-1.82	1.51±0.20
	Lh	0.40-0.90	0.61±0.14	0.53-0.93	0.78±0.08
	Wh	0.47-0.90	0.69±0.12	0.73-1.13	0.93±0.12
	Lo	0.17-1.10	0.54±0.27	0.43-1.33	0.85±0.28
	Lt	1.40-2.46	1.92±0.29	2.00-2.90	2.50±0.22
	Wt	0.30-0.53	0.41±0.08	0.37-0.73	0.60±0.08
April-May, 1975 n=45	L	11.0-15.0	12.4±1.3	12.0-19.0	15.7±1.5
	W	0.82-1.85	1.05±0.26	0.93-2.00	1.51±0.28
	Lh	0.49-0.91	0.66±0.11	0.53-1.00	0.78±0.12
	Wh	0.53-1.35	0.68±0.26	0.60-1.76	0.97±0.28
	Lo	0.23-0.67	0.40±0.13	0.27-2.06	0.96±0.42
	Lt	1.73-2.30	1.99±0.12	1.15-3.33	2.47±0.42
	Wt	0.34-0.63	0.48±0.11	0.40-0.80	0.60±0.10
July 1976 n=43	L	8.5-12.5	10.0±1.1	10.0-14.0	11.8±1.2
	W	0.67-1.13	0.90±0.12	0.90-1.60	1.18±0.15
	Lh	0.50-0.67	0.56±0.05	0.53-0.77	0.67±0.06
	Wh	0.53-0.83	0.66±0.07	0.63-1.03	0.82±0.09
	Lo	0.23-0.67	0.37±0.13	0.23-0.87	0.44±0.14
	Lt	1.20-2.00	1.55±0.22	1.43-2.20	1.87±0.18
	Wt	0.33-0.50	0.39±0.05	0.23-0.57	0.47±0.07

References

1 - Marazzo A., Nogueira C.S.R., 1996. Composition, spatial and temporal variations of Chaetognatha in Guanabara Bay, Brazil. *J. Plankton Res.*, 18: 2367-2376.

2 - Faganeli J., Gačić M., Malej A., Smodlaka N., 1989. Pelagic organic matter in the Adriatic Sea in relation to winter hydrographic conditions. *J. Plankton Res.*, 11: 1129-1141.

3 - Zore-Armanda M., 1968. The system currents in the Adriatic Sea. *Stud. Rev. Gen. Fish. Counc. Medit.*, 34: 1-48.

4 - Andreu P., Riera T., 1990. Morphometric relationships in the Chaetognath *Sagitta setosa* Müller 1847: within population *versus* between population variability. *Scient. Mar.*, 54: 101-105.

5 - Hure J., Ianora A., Scotto di Carlo B., 1980. Spatial and temporal distribution of copepod communities in the Adriatic Sea. *J. Plankton Res.*, 2: 295-316.

6 - Rao T. S. S., Kelly S., 1962. Studies on the Chaetognatha of the Indian Sea. VI. On the biology of *Sagitta enflata* Grassi in the waters of Lawson's Bay, Waltair. *J. zool. Soc. India.* 14: 219-225.

DISCARD COMPOSITION OF THE EUROPEAN HAKE *MERLUCCIUS MERLUCCIUS (LINNAEUS, 1758)* BOTTOM TRAWL FISHERY IN TWO AREAS OF THE NW MEDITERRANEAN SEA, NORTHERN TYRRHENIAN SEA AND CATALAN SEA

P. Belcari [1] *, C. Viva [1] and P. Martín [2]

[1] Dipartimento Scienze dell'Uomo e dell'Ambiente, Università di, Pisa, Italy - * belcari@discat.unipi.it
[2] ICM-CSIC. Barcelona, Spain

Abstract

This study provides data on the discard composition of the European hake bottom trawl fishery in two different areas of the NW Mediterranean, paying special attention to the non-charismatic species. On board sampling was conducted monthly from February to July 2001. The total number of species caught was 189 (163 discarded, 68 commercial) in the northern Tyrrhenian Sea and 246 (207 discarded, 78 commercial) in the Catalan Sea.

Keywords: discards, Merluccius merluccius, bottom trawling, Mediterranean Sea

Introduction

Historically, fisheries management has been based on the results of single-species stock assessment, without considering the ecology of the species under management (e.g., habitat requirements, predation, competition, discards, by-catch). Only in recent years the environmental impacts of fishing have received increasing attention. The reduction of discards and incidental by-catch is a priority in the Common Fishery Policy of the European Union (1). Available studies on discards in NW Mediterranean generally address the most important commercial species (2, 3). The present study provides data on the discard composition associated with the European hake trawl fishery in two areas of the NW Mediterranean sea, with a special attention to the less charismatic species.

Material and methods

The study was conducted in the northern Tyrrhenian and Catalan seas (4). Sampling was carried out from February 2001 to July 2001. A total of 60 commercial hauls was carried out on hake fishery grounds (80-350 m depth). Scientific observers performed fishing trips on board commercial trawlers every month, for three consecutive days. The fishing zones were decided daily by fishers. Total catch was analysed, the taxonomic composition was determined to species level and the commercial and discarded fractions were recorded and weighted.

Results and discussion

During the study period, 189 species were caught in the northern Tyrrhenian Sea and 246 along the Catalan coast, indicating the multispecies nature of the bottom trawling fishing activity (Table 1). The commercial fraction was composed of 68 and 78 species in each area, while discards consisted of 163 and 207 species, respectively. Note that the same species could be discarded or commercialised. Discarding depends mostly on the absence of commercial value of the species and/or the occurrence of damaged or undersized (not commercial) specimens. For some species, a minimum landing size is in force.

Table 1. List of taxonomic groups caught in hake trawl fishery from the two studied areas. Same species could be discarded or commercialised.

	Area					
	Northern Tyrrhenian Sea			Catalan Sea		
Taxon	N of species	N discarded species	N commercial species	N of species	N discarded species	N commercial species
Bivalvia	10	10		10	9	1
Brachiopoda	1	1				
Cnidaria	3	3		4	4	
Echinoderma	12	12		17	16	1
Gasteropoda	12	12		19	18	1
Porifera	3	3		4	4	
Tunicata	2	2		4	4	
Crustacea	36	36	4	51	47	11
Ostheichthyes	83	64	43	105	85	48
Cephalopoda	20	13	17	27	15	12
Chondrichthyes	7	7	4	6	5	4

In both areas, the commercial part was composed of species belonging mainly to four taxonomic groups (Table 2). Off the Catalan coast, *Stichopus regalis* enjoyed high prices at the auction, despite its low landings. The presence of *Bolinus blandaris*, a target species of a particular artisanal fishery, and *Pecten jacobeus* can be considered accidental in the trawl catches. A marked dominance of *Osteichthyes* both in terms of number of species (63% in the northern Tyrrhenian, 62% in the Catalan Sea) and biomass (72.3 and 89% respectively) was observed. It was the highest catch of blue whiting in the Catalan coast that determined the differences in the hourly yields within this group in the two study areas.

Tab. 2. Mean abundance (kh/h) and standard error (SE) of the taxonomic groups associated to hake fishery for the two studied areas.

area	Northern Tyrrenian sea				Catalan sea			
taxon	discarded	SE±	commercialised	SE±	discarded	SE±	commercialised	SE±
Bivalvia	0.014	0.050			0.013	0.010	0.001	0.001
Brachiopoda	0.003	0.176						
Cnidaria	0.023	0.039			0.162	0.035		
Echinoderma	0.209	0.044			0.342	0.079	0.037	0.018
Gasteropoda	0.074	0.009			0.025	0.008	0.003	0.002
Porifera	0.095	0.710			0.028	0.018		
Tunicata	0.005	0.052			0.162	0.077		
Crustacea	0.833	0.059	4.323	1.542	0.822	0.132	4.077	0.497
Ostheichthyes	4.755	0.127	18.328	0.829	14.391	7.846	72.006	11.664
Cephalopoda	0.447	0.091	2.310	0.218	0.0464	0.100	3.375	0.440
Chondrichthyes	0.278	0.232	0.235	0.554	0.664	0.193	0.941	0.380

With respect to discards, *Osteichthyes* dominated in terms of number of species and by weight (39.0 and 70.4% of the total discards, respectively, in the northern Tyrrhenian Sea; 41 and 84%, in the Catalan Sea). The most abundant species always discarded in the northern Tyrrhenian sea were the invertebrates *Macropipus tuberculatus*, *Plesionika heterocarpus*, *Octopus salutii*, *Astropecten irregularis pentacanthus*, *Cassidaria echinofora*, *Alcyonum palmatum* and the fishes *Gadiculus argenteus argenteus*, *Capros aper* and *Scyliorhinus canicula*. Most of the species discarded were similar to those from the Catalan Sea, where, apart from the large number of benthic invertebrates discarded, the highest discards were those of blue whiting.

References

1 - COM (2002) 656. Commission of the European Communities. Communication from the Commission to the Council and the European Parliament on the Community Action Plan to reduce discards of fish.

2 - Carbonell A., Martin P., De Ranieri S. and WEDIS team, 1998. Discards of the western Mediterranean Trawl fleets. *Rapp. Comm. Int. Mer Médit.*, 35: 392-393.

3 - Sartor P., Biagi F., Mori M., and Sbrana M., 1999. Analisi dello scarto di importanti specie ittiche nella pesca a strascico del mar Tirreno Settentrionale. *Biol. Mar. Medit.*, 6(1): 605-608.

4 - Martin P., Carbonell A., Belcari P., 2001. Estimation of trawl discards in the Western Mediterannean Sea. European hake (*Merluccius merluccius*) as case study. Final Report, DG Fisheries Study 00/009.

MORPHOLOGICAL VARIABILITY AMONG POPULATIONS OF *DIPLODUS VULGARIS* (PISCES, SPARIDAE) IN THE MEDITERRANEAN SEA

Beltrano A. M. [1] *, A. Kallianiotis [2], L. Cannizzaro [1], M. Scalisi [3], S. Vitale [1], G. Bono [1], P. Vidoris [2], A. Milazzo [1]

[1] IRMA-CNR, Mazara del Vallo, Italy - * annamariabeltrano@hotmail.com

[2] FRI-NAGREF, Greece

[3] MIUR, Italy

Abstract

Morphological differentiations among *Diplodus vulgaris* populations from Italy (Licata and Mazara) and Greece (Alexandroupolis, Nea Peramos and Stavros) were investigated using multivariate morphometric analysis. MANOVA and all pairwise contrasts among the populations revealed significant differences (P<0.0001). The Greek and Italian populations were discriminated, as showed by discriminant analysis and Mahalanobis distances.

Key words: Diplodus vulgaris, morphology, population discrimination

Introduction

Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817), lives in coastal waters, on rocky or sandy bottoms, down to a depth of 130 m. The common two-banded seabream constitutes an important resource of commercial and artisanal fishery in Sicily (Italy), the Thracian Sea (Greece), Adriatic Sea and Egypt (1; 2). The importance of identifying different populations and stocks is essential for managing this resource.

In this study we examined the variability of some morphometric characters of *Diplodus vulgaris*, from Italian and Greek fishing grounds, differing in prevailing environmental characteristics, in order to discriminate populations.

Materials and methods

Diplodus vulgaris (N=868) were collected, of five localities of Italy (total length TL=95-304 mm; $\overline{TL}$=80 mm) and Greece (TL=70-317 mm; $\overline{TL}$=175 mm) by artisanal fishery, from October 1987 to September 1999.

Five morphometric measurements were recorded to the nearest 0.1 mm: Total length (TL), Fork Length (FL), Predorsal distance (EPrD), Anal distance (AD), and Maximum body depth (MxBD).

MANOVA was used to test differences among the areas, based on the mean values of the morphometric characters (log transformed). Discriminant Analysis was performed on logarithms of standardised data on a random sub-sample of equal sample size (N=110) (DA) and on a sub-sample of homogeneous size (TL=190-220 mm) (DA*) to each investigated population. The importance of each variable was estimated by a canonical variables standardised coefficient. An unweighted pair-group medium averages (UPGMA) dendrogram was used, based on the Mahalanobis distances.

Results

MANOVA presented a significant difference (Wilk's λ = 0.27; $F_{(20, 2750)}$ = 66.525; p<0.0001). All pairwise contrasts among the five populations were highly significant (p<0.0001), except those between Alexandroupolis and Stavros (p<0.01). Canonical analysis indicated three discriminant significant (p<0.0001) functions (root). The first two cumulatively accounted for the 96.96 % of the explained variance (Fig. 1). The 1st root discriminated Greek from Italian populations.

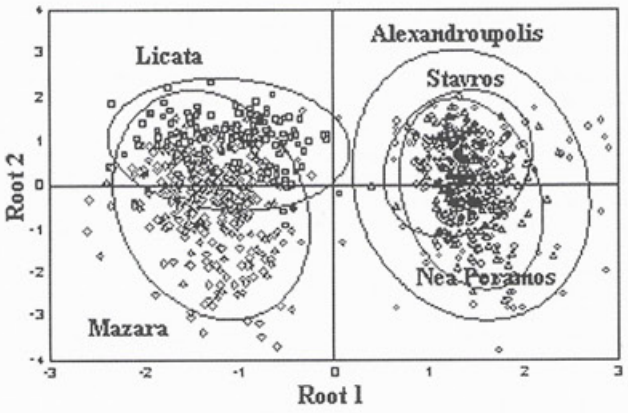


Fig. 1. Discriminant analysis plot of five populations. The first root discriminates Greek from Italian populations.

The 1st root suggest that, with high FL and low TL values, probably the fish belongs to Greek populations (Table 1). The 2nd root discriminated mainly Licata and Alexandroupolis populations from the Nea Peramos and Mazara ones; if the values of MxBD and EPrD are high and AD and FL are low, probably the fish comes from the Licata or Alexandroupolis areas. Moreover, the DA* showed that the size did not discriminate so much to cover the effects related to other morphological variables.

Tab.1. Discriminant analysis canonical roots of morphometric characters.

Characters	Root 1	Root 2	Root 3
TL	-2.63	-0.34	-1.53
FL	3.04	0.06	-0.01
EPrD	0.01	-0.42	-0.46
AD	-0.14	0.14	-0.11
MxBD	-0.11	-0.54	2.03
Cumulative proportion of variation	83.56 %	96.96 %	100.00 %

The UPGMA showed two major groups the Greek and Italian populations. Specifically, the Alexandroupolis population was closer to Stavros, though Nea Peramos was geographically located between the two areas.

Discussion

The applied methods highlighted that the Italian and Greek populations are morphometrically discriminated. Furthermore, the analysis indicated that the FL and TL values discriminated the two populations more than the other characters. Since phenotypic characters may reflect either genetic differences or environmental and ecological differences (3), we can consider the possibility that these populations show ecophenotipic variations. There are many environmental differences among the study areas. Particularly, the Sicilian coast is dominated by cold Atlantic currents that create a lower mean temperature (15.5 °C) (4) than in the Thracian Sea (21.3 °C) (5) and upwelling phenomena.

Moreover, distance among Greek populations, showed through the UPGMA, is likely due not to geographic distances, but to environmental differences. In fact, Evros and Strimonas rivers seem to determine similar habitats in Alexandroupolis and Stavros areas, respectively (5).

References

1 - Fischer W., M.L. Bauchot, M. Schneider, 1987. Fisches FAO d'identification des espèces pour les besoins de la pêche. Méditerranée et mer Noire. Zone de pêche 37. Vol. 2. FAO, Rome, pp. 761-1530.

2 - Wassef, E.A., 1985. Comparative biological studies of four *Diplodus* species (Pisces, Sparidae). *Cybium*, 9 (2): 203-215.

3 - Vidalis, K., G. Markakis, N. Tsimenidis, 1997. Discrimination between populations of picarel (*Spicara smaris* L., 1758) in the Aegean Sea, using multivariate analysis of phenetic characters. *Fish. Res.*, 30: 191-197.

4 - Picco, P., 1990. Climatological atlas of the western Mediterranean. ENEA. La Spezia.

5 - Kallianiotis A., E. Koutrakis, A. Kokkinakis, 2000. Fisheries in the Kavala Prefecture. The current situation-tendencies and impacts on coastal areas. *TERRA-CMZ:* 1-29.

CONTRIBUTION À L'ÉTUDE DE QUELQUES RÉCENTES MIGRATIONS D'ESPÈCES EXOTIQUES DANS LES EAUX TUNISIENNES

Ben Souissi Jamila [1] *, Jeanne Zaouali [1], Mohamed Rezig [2], Mohamed Nejmeddine Bradai [3], Jean Pierre Quignard [4] et Bill Rudman [5]

[1] Institut National Agronomique de Tunisie, Tunis-Mahrajène. Tunisie - * bensouissi.jamila@inat.agrinet.tn
[2] Laboratoire d'écologie littorale, Faculté des Sciences de Tunis, Campus Universitaire, Tunis, Tunisie
[3] Institut National des Sciences et Technologies de la Mer, Sfax, Tunisie - Mednejmeddine.bradai@instm.rnrt.tn
[4] Laboratoire d'Ichtyologie, Université de Montpellier II, France
[5] The Australian Museum, Sydney, Australia - billr@seaslugforum.net

Résumé

L'étude de la biodiversité marine des côtes tunisiennes réalisée au cours de la période (1990-2003) nous a permis d'inventorier parmi la faune récoltée les espèces exotiques *Hemigrapsus sanguineus*, *Rhithropanopeus harrisii*, *Pilumnopeus vauquelini, Eucrate crenata, Sphaeroma walkeri, Paradella dianae, Favorinus ghanensis, Chromodoris quadricolor, Fistularia commersonii* et *Parexocoetus mento*. Le présent travail constitue une première mention des Crustacés Décapodes *Hemigrapsus sanguineus* et *Rhithropanopeus harrisii* et des Mollusques Nudibranches *Favorinus ghanensis* et *Chromodoris quadricolor*.

Mots-clés : Migration lessepssienne, Espèces invasives, Première mention, Tunisie

Introduction

En Méditerranée, le rythme de bioinvasion a connu une nette accélération au cours des dernières décennies, probablement en raison de l'intensification du trafic maritime, des introductions accidentelles, des transferts intentionnels et des eaux de ballast [1]. La Tunisie, vu sa position géographique charnière entre les bassins occidental et oriental de la Méditerranée est particulièrement concernée par ce phénomène de bioinvasion. Ceci se concrétise par un nombre grandissant de découvertes d'espèces exotiques, notamment d'origine lessepssienne.

Méthodologie de travail

Les prospections ont été réalisées au cours de la période (1990-2003) et ont particulièrement intéressé le golfe de Gabès, la lagune Sud de Tunis et celle des Bibans ainsi que certaines enceintes portuaires (Radès et la Skhira).

Résultats et discussion

Les résultats des investigations ont montré l'apparition d'espèces marines n'appartenant pas à la faune répertoriée jusqu'à ce jour en Tunisie. Dans ce qui suit nous étudierons les quelques espèces invasives que nous avons récoltées.

Hemigrapsus sanguineus est un crabe originaire de l'Océan Pacifique. Sa présence en Méditerranée est à la fois rare et récente puisqu'un unique spécimen a été signalé pour la première fois en 2001 au nord de l'Adriatique (Croatie)[2]. En Tunisie, nous avons récolté au printemps 2003, trois individus (2 femelles dont une ovigère et 1 mâle mesurant entre 17 et 24 mm) dans la lagune sud de Tunis et le port de Radès.

Rhithropanopeus harrisii : Cette espèce de crabe euryhalin est originaire de l'océan Atlantique. Elle a été trouvée pour la première fois en Méditerranée en 1994 en Italie (Delta du Pô)[2]. Depuis, de nombreuses signalisations se sont succédées dans les milieux saumâtres notamment dans la lagune de Marano (Italie) et l'étang de Berre (France)[2]. En Tunisie, nous avons ramassé 2 individus femelles mesurant respectivement 7 et 12mm en septembre 2003 à l'entrée de la lagune sud de Tunis.

Pilumnopeus vauquelini : Ce crabe originaire du golfe Persique et de mer Rouge n'a, jusqu'alors, été signalé que dans la seule Méditerranée orientale. Sa présence dans la lagune Sud de Tunis constitue donc, après sa signalisation faite en 1924 en Egypte[2] sa seconde mention en Méditerranée méridionale. Cette espèce exotique est essentiellement représentée dans la lagune sud de Tunis par des individus femelles [3].

Eucrate crenata : Ce crabe originaire du golfe Persique et de mer Rouge s'est introduit depuis 1927 en Méditerranée orientale, mais ce n'est qu'en 1992 qu'il a été signalé par l'un d'entre nous en Tunisie. Identifié sur l'ensemble du littoral du golfe de Gabès, depuis le début des années 1990, il n'a pas été, à ce jour, signalé en Tunisie septentrionale en dehors de sa récente apparition dans le lac Sud de Tunis [3].

Sphaeroma walkeri : Cet Isopode cosmopolite, originaire de l'océan Pacifique est signalé depuis une trentaine d'années en Méditerranée (Egypte). Il n'a pas été répertorié, jusqu'à ce jour, en d'autres points des côtes méditerranéennes. Sa présence conjointement dans la lagune sud de Tunis et le port de Radès constitue, en conséquence, sa première signalisation non seulement en Tunisie mais aussi en Méditerranée occidentale. *Sphaeroma walkeri* a vraisemblablement été véhiculé au milieu des salissures biologiques des navires accostant dans le port de Radès et son acclimatation dans les eaux tunisiennes est très récente [3].

Paradella dianae : A l'instar de l'Isopode originaire de Californie, *Paracerceis sculpta*, mentionné par l'un d'entre nous pour la première fois en Méditerranée en 1978, dans la lagune de Tunis, *Paradella dianae* a été probablement introduit par le trafic maritime et semble s'être bien acclimaté à tel point qu'il a concurrencé l'Isopode autochtone *Sphaeroma serratum* [4].

Favorinus ghanensis : Depuis sa description pour la première fois pour la Science en 1968[5], cette espèce n'a jamais été signalée en dehors du Ghana. Nous avons ramassé massivement ce Nudibranche caractéristique du fouling pendant les saisons hivernale et printanière 2003, dans la lagune sud de Tunis et le port de Radès parmi la Chlorophycée *Ulva rigida*. Le présent travail constitue non seulement une première mention de l'espèce en Tunisie mais également en Méditerranée.

De façon à peu près concomitante, mais avec une moindre fréquence et abondance que l'espèce précédente, on note l'apparition dans la lagune des Bibans du Nudibranche exotique *Chromodoris quadricolor*.

Chromodoris quadricolor : Cette espèce a été signalée pour la première fois en Méditerranée en 1982 près du cap Martola (Italie). Nous avons récolté 2 spécimens de ce Nudibranche au mois de mai 2003 dans la lagune de Bibans située au sud est de la Tunisie à la frontière avec la Libye. *Chromodoris quadricolor* a été ramassé à 5m de profondeur dans une zone totalement recouverte par un herbier de posidonie où abondent de nombreuses espèces de Porifères. La présente signalisation de l'espèce en Méditerranée orientale rend l'hypothèse de migration lessepssienne initialement écartée plus probable.

Fistularia commersonii et ***Parexocoetus mento*** : Le nombre de migrations lessepssiennes réussies d'espèces ichtyologiques en Tunisie ne cesse de s'accroître. Les dernières en date sont celles de *Parexocoetus mento* et *Fistularia commersonii* pêchées respectivement en février 1999 dans l'archipel de Kerkennah et en septembre 2002 à Zarzis (sud du golfe de Gabès). Depuis, 11 spécimens de *F. commersonii* ont été récoltés entre les régions de Sfax et de Kélibia.

Conclusion

La faune marine tunisienne actuelle montre des modifications importantes qui se traduisent par l'établissement et l'acclimatation réussie d'espèces exotiques dont le nombre a considérablement augmenté au cours des dernières décennies. Les prospections que nous avons réalisés ont permis, d'une part, de signaler pour la première fois la présence de 4 espèces exotiques et, d'autre part, d'apporter des éléments de réponses quant à la migration et la propagation le long des côtes tunisiennes des espèces invasives initialement cantonnées dans le golfe de Gabès.

Références

[1] - Zibrowius H., 1992. Ongoing modification of the Mediterranean fauna and flora by the establishment of exotic species. *Mésogée* [Bulletin du Muséum d'histoire naturelle de Marseille] 51 : 83-107.

[2] - Galil B., Froglia C., Noël P., 2002. CIESM Atlas of exotic species in the Mediterranean. Vol. 2. Crustaceans : decapods and stomatopods. CIESM Publishers, Monaco, 192 p.

[3] - Ben Souissi J., Rezig M., Zaouali J., 2003. Appearance of invasive species in the southern lake of Tunis. Proceedings of Sixth International Conference on the Mediterranean *Coastal Environment*, Vol.2: 911-922.

[4] - Bey A., Rezig M., Ben Souissi J., Dridi M.S., 2001. Première mention de *Paradella dianae* (Menzies, 1962) (Crustacé Isopode) dans le lac sud de Tunis. Etude morphologique et écologique de l'espèce. *Bull. Soc. zool. Fr.*, 126(1-2) : 220-223.

[5] - Edmunds M., 1968. Opisthobranchiate Mollusca from Ghana. *Proceedings of the Malacological Society of London*, 38: 83-100.

PHYSICAL-BIOLOGICAL INTERACTIONS IN SURFACE WATERS OF THE NORTHERN CATALAN SHELF-SLOPE (NW MEDITERRANEAN) AT THE END OF SPRING

Elisa Berdalet *, Cristina Roldán, Mikel Latasa, Cèlia Marrasé, Montse Vidal, Marta Estrada, Andrea Malits, Jordi Salat, Mikhail Emelianov, Ana Sabatés

Institut de Ciències del Mar (Centre Mediterrani d'Investigacions Marines i Ambientals, CSIC), Barcelona, Catalunya, Spain - * berdalet@icm.csic.es

Abstract

We studied physico-chemical (temperature, salinity, inorganic nutrients) and biological (phytoplakton pigment composition, bacterial numbers, protein, DNA, RNA, and POM) characteristics of a hydrographically diverse area of the northern Catalan sea during the stratification period (June 2000). The sampled stations were affected by a) continental shelf (coastal waters), and b) low salinity surface waters from the Gulf of Lions influenced by the Rhone runnoff (called *Plume*), carried by the shelf-slope Catalan current. We compared these areas with oceanic waters. The relative fertilising effect of the Plume for the plankton communities is discussed.

Keywords: nutrients, pigments, plankton, Rhone plume

The objective of the cruise was to study the fertilising effect of Rhone influenced waters on plankton communities structure and function at the end of the spring. Such water masses may constitute a nutrient input to otherwise nutrient depleted layers when the seasonal thermocline is well stablished (1).

Three drifters launched at the northern part of the Gulf of Lions were used to identify the presence of low salinity surface waters (above 10 m depth) from the Gulf of Lions influenced by the Rhone runnoff, carried by the shelf-slope Catalan current (2). Samples for biological, physical and chemical parameters were taken from 0-100 m depth. The study presented here concerns only the samples collected at 5 m, where the Rhone Plume waters were clearly identified.

As expected, higher nitrate and phosphate concentrations along with higher chlorophyll concentrations were found at the coastal and Plume waters (Fig. 1). Surprisingly, low silicate concentrations were measured at the Plume and coastal waters, likely related to a high development of diatoms (fucoxanthin estimated by HPLC, 3). In oceanic waters, relatively low diatom and high dinoflagellate (i.e., oxyperidinin) biomasses were observed. Cyanobacteria (i.e., zeaxanthin) and diatom abundance showed similar patterns with highest abundances in the Plume, especially in the northermost sites and decreasing towards the south. Haptophytes (i.e. 19'hexanoiloxyfucoxanthin) were more abundant in both coastal and Rhone Plume waters than in oceanic ones. The highest bacterial numbers (epifluorescence microscopy counts) were found in the relatively nutrient rich coastal waters, specially southwards (in front of Barcelona). Taken together, the relative distribution of different phytoplankton groups, bacterial numbers and inorganic nutrients indicate ecological preferences and competition processes resulting in characteristic zonal patterns and a temporal sucession within the Plume.

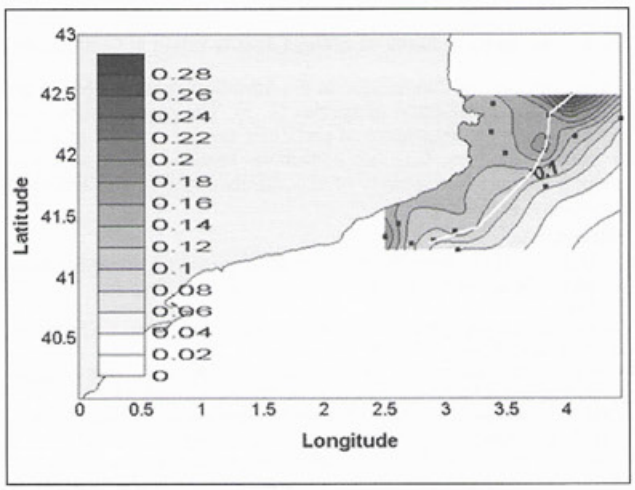


Fig. 1. Distribution of chlorophyll concentrations (i.e. monovinyl-chlorophyll a plus chlorophyllide a, estimated by HPLC) at 5 m depth. The Plume is indicated by the white line.

The concentrations of POC, PON, protein and DNA (biomass indicators, 4, 5, 6) and RNA (activity indicator) in the seston were estimated. Protein concentration distribution matched the autotrophic biomass, specially that of diatoms, while DNA were more related to bacterial abundances (Fig. 2). RNA were higher at the coastal and southwards stations, associated to bacteria.

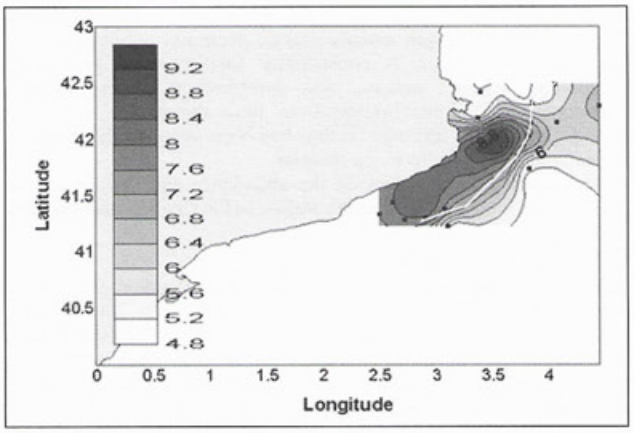


Fig. 2. Distribution of the DNA concentrations at 5 m depth. The Plume is indicated by the white line.

The data obtained from this cruise showed that at surface (above 10 m) the waters affected by the Rhone Plume had similar or slightly higher biomass than the coastal waters, and in any case higher than the closer oceanic stations. It suggests the Rhone Plume contribution to the enlargement of the coastal zone production in the Catalan sea area. Further sudies must be conducted in the area to understand the temporal and spatial variability of the Rhone input in the NW Mediterranean waters.

References

1 - Estrada M., 1985. Deep phytoplankton and chlorophyll maxima in the Western Mediterranean. Pp. 247-277. *In*: Moraitou-Apostolopoulou M. and Kiortsis. V. (eds), Marine Mediterranean Ecosystems. Plenum Press, New York and London.

2 - Font J., Salat J., Tintoré J., 1988. Permanent features of the circulation in the Catalan Sea. *Oceanol. Acta.* SP: 51-57.

3 - Zapata M., Rodríguez F., Garrido, J.L., 2000. Separation of chlorophylls and carotenoids from marine phytoplankton: a new HPLC method using reversed phase C-8 column and pyridine-containing mobile phases. *Mar. Ecol. Prog. Ser.*, 195: 29-45.

4 - Ehrhardt M., Koeve W., 1999. Determination of particulate organic carbon and nitrogen. Pp. 437-444. *In*: Grasshoff, K., Kremling, K., Ehshardt, M. (ed.) Methods of Seawater analysis.

5 - Lowry O.H., Rosenbrough N.J., Farr A.L., Randall, R.J., 1951. Protein measurement with the Folin Phenol reagent. *J. Biol. Chem.*, 193: 265-275.

6 - Berdalet E., 2002. Quantization of nucleic acids in marine microplankton samples. Pp. 269-289. *In*: Subba Rao D.V. (ed.), Pelagic Ecology Methodology. A.A.Balkema Publishers, Lisse, Abindong, Exton (PA), Tokyo.

FAMILY CANDACIIDAE (COPEPODA, CALANOIDA) IN THE CENTRAL AND SOUTH ADRIATIC SEA

Dubravka Bojanić

Institute of Oceanography and Fisheries – Split, Laboratory of Plankton Ecology, Dubrovnik, Croatia - dbojanic@labdu.izor.hr

Abstract

The family Candaciidae was investigated during nine cruises in the Central and South Adriatic. Six species of adults and their copepodites, all of which were present in low abundance, were found typically in subsurface layers of coastal stations. These are the first data on the abundance and distribution of the copepodites of this family in the Adriatic Sea.

Keywords: Zooplankton, Candacia, Paracandacia, Adriatic Sea

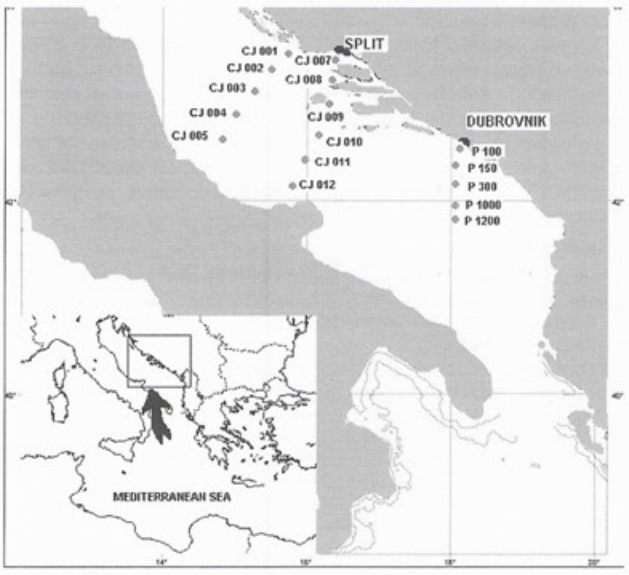
Introduction

Investigations of planktonic copepods in the Adriatic Sea began at the end of the 19th Century, but were restricted to the Northern Adriatic (1). Graeffe (2), among others, mentioned three species of Candaciidae: *Candacia longimana* (Claus, 1863), *C. melanopus* (Claus, 1863) [*syn. C. ethiopica* Dana, 1849], and *C. bispinosa* (Claus, 1863). Steuer (7) found *C. pectinata* (Boeck, 1873) near Silba Island and Dubrovnik, and *C. bispinosa* and *C. simplex* (Giesbrecht, 1889) in the vicinity of Dubrovnik. Nine species were collected from 1974-1976 during cruises of R/V Andrija Mohorovičić: *C. aethiopica*, *C. armata* (Boeck, 1873), *C. bipinnata* (Giesbrecht, 1889), *C. elongata* (Boeck, 1873), *C. longimana*, *C. teniumana* (Giesbrecht, 1889), *C. varicans* (Giesbrecht, 1889), *Paracandacia bispinosa*, and *P. simplex* (6). *Candacia armata* and *C. pectinata* previously were regarded as synonyms. A consistently smaller form, previously considered to be *C. armata*, was described as a new species, *C. giesbrechti* (3). Later investigations have shown that the larger form, *C. armata*, is very rare. It thus has been assumed that most of the previous data refer to *C. giesbrechti*.

This paper adds new data on the abundance and distribution of Candaciidae, including life-history stages, in the Central and Southern Adriatic.

Materials and methods

Zooplankton was sampled at 17 stations during nine cruises in the Central and South Adriatic Sea (May 2002, June – July 2002, August 2002, September 2002, December 2002, April 2003, May 2003, June 2003, August 2003). Eleven stations were set along two transects in the Central Adriatic (CJ stations) and six, in the eastern South Adriatic Pit (JJ stations) (Fig. 1). August 2002 was the only cruise when station P-1100 was visited. In December 2002 two new stations (P-150 and P-1200) were introduced.



A total of 196 samples were collected with a Nansen-type net (diameter 57 cm, length 255 cm, mesh 200 mm) equipped with a closing mechanism. Vertical hauls were taken in depth intervals of 50 or 100 m. Organisms were preserved in buffered formaldehyde. The entire samples were examined in the laboratory using a Wild microscope at a magnification of 400X. All copepodites and adults of the family Candaciidae were counted. Adults were identified to the species level. Results are presented as individuals per cubic metre.

Results and discussion

Six species of Candaciidae were collected: *Candacia giesbrechti, C. varicans, C. tenuimana, C. longimana, Paracandacia simplex*, and *P. bispinosa*. All were present in small numbers; in some cases only a single speciman was found. The number of species decreased from the south to the central Adriatic.

C. giesbrechti, the most abundant species (<3 ind/m^3), was collected mostly in subsurface layers of coastal stations. The same was true of *C. varicans*, which always was less abundant (<2 ind/m^3). *P. bispinosa* was found at open-water stations along the Palagruža transect and in the South Adriatic (<1 ind/m^3). *P. simplex*, was encountered only in the South Adriatic, and was most abundant at P-100 (<0.5 ind/m^3). *C. longimana* and *C. tenuimana* were rare in the deep layers of the South Adriatic (<0.1 ind/m^3). All copepodite stages were found at all stations throughout the entire water column. Highest values (<6 ind/m^3) were collected at the coastal Central Adriatic stations.

Based on average density and species composition, stations JJ-1000, JJ-1100, and JJ-1200 were clustered in one group with great similarity. They were associated with CJ-003 and CJ-004, which are also open-sea stations. CJ-008, CJ-012, and especially CJ-007 were separated by higher values, as is typical of coastal stations (Fig. 2).

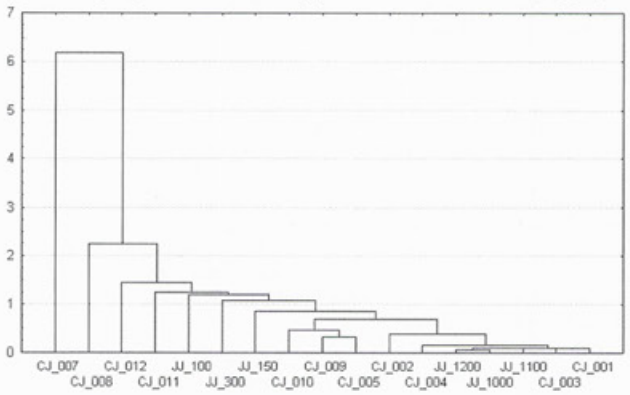


Fig. 2. Tree diagrams based on average density values of Candaciidae.

Available data on Candaciidae in the Adriatic Sea relate only to the frequency and distribution of species (4, 5). The present work adds information on the abundance of particular species, and the first data for their copepodites. This thus contributes baseline data essential to planning future investigations of this family's spatial and temporal distributions in this region.

References

1 - Claus, C., 1881. Neue Beiträge zur Kenntniss der Copepoden unter besonderer Berücksichtigung der Triester Fauna. *Arb. Zool. Inst. Wien*, 3: 313-332.

2 - Graeffe, E., 1900. Übersicht Fauna des Golfes von Triest, V. Crustacea. *Arb. Zool. Inst. Wien*, 13: 33-80.

3 - Grice, G.D., Lawson, T.J., 1977. *Candacia giesbrechti*, a new calanoid copepod from the Mediterranean Sea. *Vie Milieu*, 27: 263-271.

4 - Hure, J., Kršinić, F., 1998. Planktonic copepods of the Adriatic Sea. Spartial and temporal distribution. *Nat. Croat.*, 7, suppl. 2: 1-135.

5 - Hure, J., 1955. Distribution annuelle verticale du zooplancton sur une station de l'Adriatique méridionale. *Acta Adriat.*, 7: 1-72.

6 - Hure, J., 1980. Zooplankton – Copepoda. Izvještaj i rezultati oceanografskih istraživanja Jadranskog mora, Hidrografski Institut, Split, pp. 187-202.

7 - Steuer, A., 1910. Adriatische Planktoncopepoden. Sitzungsber. K. Akad. Wiss. Wien Math. –nat. Kl., 119: 1005-1039.

ABUNDANCE AND BIOMASS OF NONLORICATE CILIATE POPULATIONS IN KASTELA BAY (ADRIATIC SEA)

Natalia Bojanić
Institute of Oceanography and Fisheries, Split, Croatia - bojanic@izor.hr

Abstract
Seasonal distributions of nonloricate ciliates (NLC) density and biomass were investigated in the north-eastern part of the Kaštela Bay, Croatia. The highest NLC abundance (2040 ind.l^{-1}) and biomass (6.844 µgC l^{-1}) were recorded in June 1999 at the surface, and in October 1999 at 10 m depth, respectively.

Keywords: zooplankton, biomass, Adriatic Sea

Introduction

Ciliated protozoa are undoubtedly an important component in marine ecosystems, because they participate in the flow of energy and carbon from bacterioplankton and phytoplankton to large zooplankton organisms [1, 2]. On the other hand, phytoplankton releases the dissolved organic matter, which is returned to the main food chain via the "microbial loop" [3]. In such circumstances ciliated protozoa could act as a link between classic herbivorous food chains and microbial food web [4]. Due to those reasons, the study of temporal fluctuations of nonloricate ciliate (NLC) abundance and biomass in the north-eastern part of Kaštela Bay has been carried out. These are the first results for this part of the Bay as well as the biomass data, that are one of very few available for the whole Adriatic Sea.

Material and methods

Samples were collected at one station (43°32.5' N; 16°24.4 E), on a monthly basis from July 1998 until November 1999, at 0, 5, 10 and 28 m depth, using 1.7 l Nansen bottles (Fig. 1). Organisms were preserved in buffered formaldehyde, final concentration 2.5%. The material was sedimented, decanted down to 20 ml [5] and counted using microscope at magnifications of x200 and x400. The biovolume of nonloricates (NLC) was calculated applying the geometrical method. After measurement of organism dimensions, NLC populations were divided into four size categories: NLC I <10^3 µm^3, II – 10^3-10^4 µm^3, III – 10^4-10^5 µm^3, IV >10^5 µm^3. Conversion factor used to transform these volumes into carbon biomass values was 0.14 pgC µm^{-3} [6].

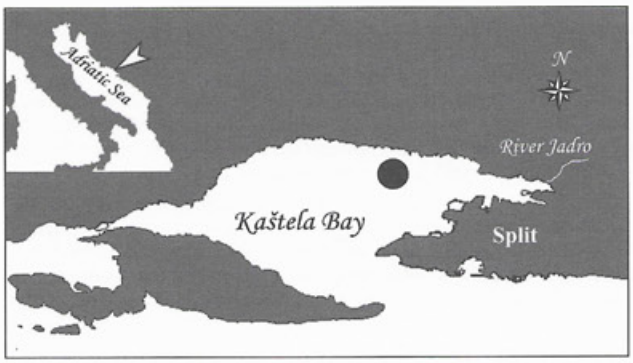


Fig. 1. Study area (Kastela Bay) with the sampling station.

Results and discussion

Seasonal distribution of nonloricate (NLC) abundance showed the highest density during the summer, with the maximum of 670±928 ind.l^{-1} in June 1999. In the remaining period of the year average density values were less then 290 ind.l^{-1} (Fig. 2). The majority of NLC populations (72%) remained in the layer above 5 m depth and the highest abundance of 2040 ind.l^{-1} was noticed at the surface in June 1999, when was recorded the intensive inflow of fresh water. Such fluctuations corresponded with variability of NLC II (10^3-10^4 µm^3) that contributed to the total NLC number with 50%. High summer NLC abundance is characteristic of eutrophicated ecosystems [7].

Biomass of NLC varied from 0.233±0.267 to 2.544±3.013 µgC l^{-1} in November 1998 and October 1999, respectively (Fig. 2). The values were rather uniformly distributed (<1,623 µgC l^{-1}) from July to November 1998. The period from February to July 1999 was characterised by increase of biomass in the upper 5 m, where ~60% of NLC biomass were concentrated. In October 1999 was recorded the highest biomass of 6.844 µgC l^{-1} at 10 m depth. This variability was particularly affected by NLC >10^4 µm^3, which participate in total NLC biomass with 87%. Similar biomass data are found in the Gulf of Trieste [8].

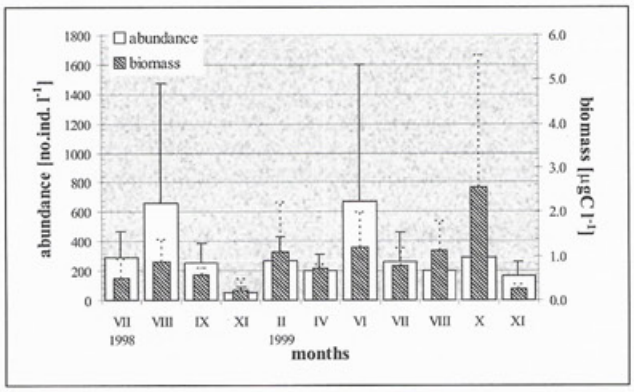


Fig. 2. Temporal variability in abundance and biomass of nonloricates in the Kastela Bay.

High abundance and biomass values of NLC populations point the importance of these organisms in the secondary production of the Kaštela Bay.

References

1 - Bernard C., Rassoulzadegan F., 1993. The role of picoplankton (cyanobacteria and plastidic picoflagellates) in the diet of tintinnids. *J. Plankton Res.*, 15: 361-373.
2 - González J.M., 1999. Bacterivory rate estimates and fraction of active bacterivores in natural protist assemblages from aquatic systems. *Appl. Environ. Microbiol.*, 65: 1463-1469.
3 - Azam F., Fenchel T., Field J.G., Gray J.S., Meyer-Reil L.A., Thingstad F., 1983. The ecological role of water - column microbes in the sea. *Mar. Ecol. Prog. Ser.*, 10: 257-263.
4 - Bojanić N., Šolić M., Krstulović N., Marasović I., Ninčević Ž., Vidjak O., 2001. Seasonal and vertical distribution of the ciliated protozoa and micrometazoa in Kaštela Bay (central Adriatic). *Helgol. Mar. Res.*, 55: 150-159.
5 - Kršinić F., 1980. Comparison of methods used in micro-zooplankton research in neritic waters of the Eastern Adriatic. *Nova Thalassia.*, 4: 91-106.
6 - Putt M., Stoecker D.K., 1989. An experimentally determined carbon:volume ratio for marine "oligotrichous" ciliates from estuarine and coastal waters. *Limnol. Oceanogr.*, 34: 1097-1103.
7 - Revelante N., Gilmartin M., Smodlaka N., 1985. The effects of Po River induced eutrophication on the distribution and community structure of ciliated protozoan and micrometazoan populations in the northern Adriatic Sea. *J. Plankton Res.*, 7: 461-471.
8 - Lipej L., 1992. Mikrozooplankton v prehranjevalni verigi južnega dela Tržaškega zaliva. MS thesis, University of Zagreb, Croatia.

ORGANOCHLORINE COMPOUNDS AND STABLE ISOTOPES DO NOT SUPPORT SEGREGATION BETWEEN WESTERN MEDITERRANEAN BOTTLENOSE DOLPHIN SUBPOPULATIONS

A. Borrell [1], A. Aguilar [1] *, V. Tornero [1], G. Fernandez [2] and F. Alegre [3]

[1] Dept of Animal Biology, University of Barcelona, Barcelona, Spain
[2] Marineland-Mallorca. Calvià, Spain
[3] CRAM, Marine Animal Rescue Center, Premià de Mar, Spain

Summary

To study the population structure of bottlenose dolphins and potential isolation of subpopulation units in the western Mediterranean, we investigated geographical variation in isotopic patterns ($\delta^{13}C$ and $\delta^{15}N$) and concentration of organochlorine (OC) compounds (PCBs, DDTs, and HCB) present in the body tissues of bottlenose dolphins (*Tursiops truncatus*) from different regions: Catalonia, Valencia and the Balearic Islands. No significant (P>0.05) differences were observed neither in the OC concentrations, $\delta^{13}C$, $\delta^{15}N$ nor in PCB profiles, thus giving no support to the existence of long-term segregation between the investigated putative subpopulations.

Keywords: Bottlenose dolphin, Mediterranean Sea, Organochlorines, Stable isotops

Introduction

In mammals, 90% of organochlorine intake is via food, for which reason their pollutant profile reflects that of the waters in which they live and feed. Therefore, populations inhabiting different geographical areas tend to show qualitatively and quantitatively different pollutant loads. In this study we determined stable isotopes and concentration and profile of the PCBs present in the blubber of bottlenose dolphins inhabiting different areas in the western Mediterranean with the aim of investigating regional variation and improving understanding on population structure.

Material and methods

Stranded bottlenose dolphins from the Mediterranean coasts of Spain [Catalonia (n=8), Valencia (n=10), Balearic Islands (n=7)] were sampled in 1990-2000. Sex and length of the individuals were recorded. Organochlorine compounds were measured in blubber by gas chromatography and electron capture detection. Concentrations were expressed as mg/kg calculated on the basis of extractable fat. Stable isotopes were analysed by EA-IRMS (elemental analyser isotope ratio mass spectrometry) in skin; results were expressed in standard δ notation relative to carbonate PeeDeeBelemnite and atmospheric nitrogen, where:

$\delta\ ^{13}C$ or $\delta^{15}N(‰) = (R_{sample}/R_{standard})-1)X1000)$ and $R=(^{13}C/^{12}C)$ or $(^{15}N/^{14}N)$, respectively.

Data were tested for normality with a Kolmogorov-Smirnov test of goodness of fit. As the data distributed normally, differences in lipid content and organochlorine compounds were examined between groups using analysis of variance (ANOVA). Discriminant analysis was used to test the significance of multivariate differences in PCB patterns (relative abundance of the various congeners in relation to the tPCB) between groups. All calculations were carried out using SPSSX statistical package.

Results and discussion

Figure 1 shows the mean and the standard deviation of the percentage of lipid extraction and organochlorine concentrations in blubber.

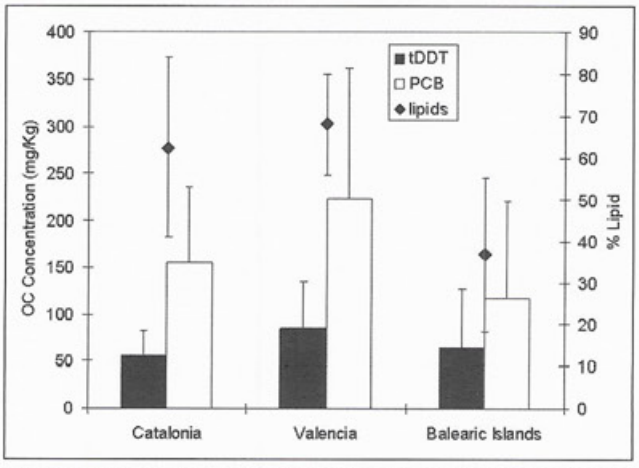


Fig. 1. Concentrations (mean + SD) of PCBs, tDDT and %lipid, in blubber samples of bottlenose dolphins from different Mediterranean areas.

Figure 2 shows the mean and the standard deviation of $\delta^{13}C$ and $\delta^{15}N$ in the skin of bottlenose dolphins, split by locality of sampling.

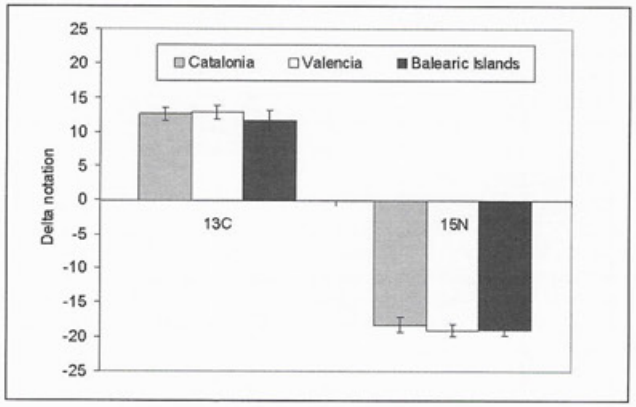


Fig. 2. Mean ± SD of δ13C and δ15N in skin samples of bottlenose dolphins from different Meditteranean areas.

No significant (anova, P>0.05) differences were found between areas either in the concentration of any of the OCs, $d^{13}C$, $d^{15}N$ or in the PCB profile. Dolphins from Catalonia and Valencia showed higher OC values than Balearic individuals, but the difference was not significant (P>0.05) because the variability within groups was very high. This high within-group variability is attributed to the heterogeneous age and sex composition of the sample, variables that strongly influence individual pollutant load (1).

The analyses failed to show any clear segregation between the Mediterranean subareas, although comparisons were statistically weak because of the high individual variability and insufficient number of samples in some subareas. Further research is needed to improve knowledge on bottlenose dolphin population structure in the region.

Acnowledgments. The present study was funded partially by the Spain Ministry of the Environment and the EU LIFE office, project NAT/E/7303. Samples supplied by the BMA Tissue Bank with the support of the Pew Fellows Program in Marine Conservation and Earthtrust.

References

1 - Aguilar A., Borrell A., and Pastor T., 1999. Factors affecting variability of persistent pollutant levels in cetaceans. *J. Cetacean Res. Manage.*, (Special Issue 1) : 83-116.

SUR L'ESTIMATION DE LA MORTALITÉ NATURELLE (M) PAR ÂGE ET PAR SEXE CHEZ DEUX ESPÈCES DE LA CÔTE ALGÉROISE: LE MERLU *MERLUCCIUS MERLUCCIUS* (LINNAEUS, 1758) ET LA SARDINELLE (*SARDINELLA AURITA* VALENCIENNES, 1847)

A. Bouaziz [1] *, A. Bennoui [2], M. Belaidi [3], B. Brahmi [4]

[1, 2, 3, 4] ISMAL ; Sidi-Fredj Staoueli, Alger, Algérie - abouaziz@yahoo.fr

Résumé

L'estimation de la mortalité naturelle par âge et par sexe chez deux espèces, l'une pélagique (*Sardinella aurita*) et l'autre démersale *Merluccius merluccius,* a été entreprise par la méthode de Pauly (1) pour chaque cohorte, correspondant chacune d'elle à un âge. Cette approche a permis de montrer que la mortalité naturelle (M) diminue rapidement jusqu'à l'âge deux, ensuite lentement tout en restant plus élevée chez les mâles, et ce pour les deux sexes.

Keywords : Fishes, Sardinella aurita, Merluccius merluccius, Natural mortality

Matériels et méthodes

L'ensemble des individus possédant des caractères communs transmissibles par hérédité constitue les différents âges (cohortes) d'un stock qui à son tour représente la fraction exploitable de la population d'une espèce donnée. L'approche qui a été utilisée a pour but l'estimation de la mortalité naturelle (M) par âge, c'est-à-dire pour chaque cohorte. Pour ce faire, la connaissance de K et de L_∞ s'impose.

Estimation de L_∞

La longueur asymptotique L_∞ a été estimée pour chaque âge comme suit: à partir de chaque longueur maximale (L_{max}), qui correspond a la dernière valeur incluse dans le calcul de la taille moyenne de chaque âge, une longueur asymptotique a été estimée par la formule: $\mathbf{L_\infty = L_{max}/0.95}$ (2).

Estimation de K

L'équation de von Bertalanffy

$\mathbf{L_t = L_\infty (1-e^{-K(t-t0)})}$ **1)**

peut s'écrire:

$\mathbf{-K(t-t_0) = Ln\ (L_\infty - L_t)/L_\infty}$ **2)**

A partir de l'équation 2), il a été déduit que

$\mathbf{K = [-Ln\ (L_\infty - L_t)/L_\infty]/t-t_0}$ **3)**

A partir de l'équation 3), on peut démontrer que K égale constante quel que soit l'âge du poisson.

Enfin, connaissant K, calculé par l'équation de von Bertalanffy pour la fraction exploitable du stock, et L_∞, donc le calcul de M peut se faire aisément (1):

$\mathbf{Log_{10}\ M = -0.0066 - 0.279\ Log_{10}\ L\infty + 0.6543\ Log_{10}\ K + 0.4634\ Log_{10}\ T}$

Où: T correspond à 13.5°C pour le merlu et 18°C pour la sardinelle.

6523 merlus (3269 femelles et 3245 mâles mesurant respectivement de 6.5 à 66.5 cm et de 6.5 à 46.5 cm) et 6676 sardinelles (3368 femelles et 3308 mâles mesurant respectivement de 6.5 à 25.5 et de 6.5 à 23.5 cm) ont été échantillonnés pour l'estimation de l'âge de la croissance et de la mortalité naturelle (M).

Résultats

Le calcul des paramètres de croissance linéaire de l'équation de von Bertalanffy conduit aux expressions suivantes:

Merlu femelle: $\mathbf{L_t = 80.64\ (1-e^{-0.139\ (t+o.442)})}$ (3)

Merlu mâle: $\mathbf{L_t = 48.72\ (1-e^{-0.321\ (t+o.0749)})}$ (3)

Sardinelle femelle: $\mathbf{L_t = 24.24(1-e^{-0.54(t-0.17)})}$ (4)

Sardinelle mâle: $\mathbf{L_t = 20.70\ (1-e^{-0.691\ (t-0.194)})}$ (4)

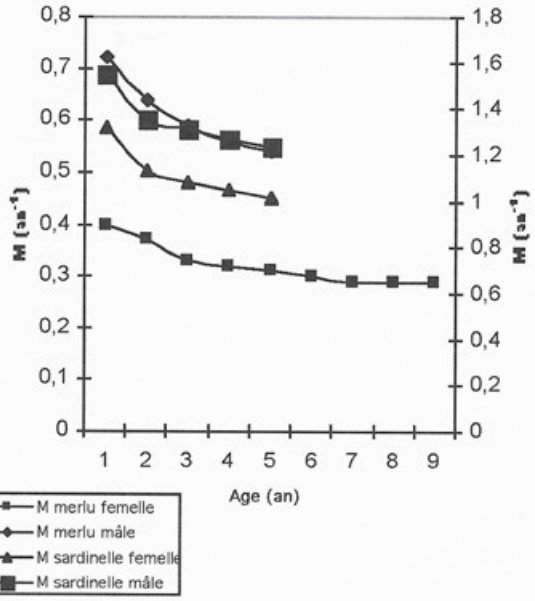
Les résultats portant sur la détermination de L_{max}, L_∞, et M consignés dans la Tab. 1.

Tab. 1. Estimation des longueurs asymptotiques et des mortalités naturelles des deux espèces par sexe et par âge.

	Merlu femelle			Merlu mâle		
Age (an)	L_{max}	L_∞	M (an^{-1})	L_{max}	L_∞	M (an^{-1})
1	17.5	18.42	0.40	15.5	16.32	0.72
2	23.5	24.74	0.37	23.5	24.74	0.64
3	33.5	35.26	0.33	31.5	33.16	0.59
4	39,5	41.58	0.32	37.5	39.47	0.56
5	43.5	45.79	0.31	41.5	43.68	0.54
6	47.5	50.00	0.30			
7	53.5	56.32	0.29			
8	57.5	60.53	0.29			
9	61.5	64.74	0.29			
	Sardinelle Femelle			Sardinelle mâle		
Age (an)	L_{max}	L_∞	M (an^{-1})	L_{max}	L_∞	M (an^{-1})
1	9.5	10.00	1.32	9.5	10.00	1.55
2	16.5	17.37	1.13	15.5	16.32	1.35
3	19.5	20.53	1.08	17.5	18.42	1.31
4	21.5	22.63	1.05	19.5	20.53	1.27
5	24.5	25.79	1.01	21.5	22.63	1.23

L'analyse de la Fig. 1 montre que la mortalité naturelle M diminue rapidement jusqu'à l'âge 2 ensuite lentement jusqu'au dernier âge, et ce pour les deux sexes. Ceci confirme le fait que les jeunes recrues sont très vulnérables aux changements éventuels des conditions de milieu d'une part, et surtout exposées à une forte prédation d'autre part. Enfin, il est intéressant de signaler que la mortalité naturelle, par âge, des mâles est beaucoup plus élevée que celle des femelles pour la sardinelle et le merlu des côtes algéroises.

Fig,1 - Estimation de M par âge et par sexe chez le merlu et la sardinelle.



Références

1 - Pauly D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 157 fish stocks. *J. Cons. CIEM*, 39 (2): 157-192.

2 - Taylor C.C., 1962. Growth equations with metabolic parameters. *J. Cons. CIEM 27* (1): 270-286.

3 - Bouaziz A., Semroud R, Djabali F., Maurin C., 1998. Estimation de la croissance du merlu *Merluccius merluccius* (Linnaeus, 1758) de la region centre de la côte algérienne par analyse des fréquences de tailles. *Cah. Options Méditerr.*,Vol. 35: 35-41.

4 - Bouaziz A., Semroud R. Brahmi B., Cheniti S., 1998. Estimation de la croissance de la sardinelle (*Sardinella aurita* Valenciennes, 1847) dans la région algéroise par analyse des fréquences de tailles. *Cah. Options Méditerr.*, Vol. 35: 43-49.

ETAT D'EXPLOITATION DE L'ANCHOIS *ENGRAULIS ENCRASICOLUS* (LINNÉ, 1758) DANS LA BAIE D'ALGER

A. Bouaziz *, A. Bennoui

ISMAL, Sidi-Fredj, Staoueli, Alger, Algérie - * abouaziz@yahoo.fr

Résumé

Dans la baie d'Alger, l'état du stock de l'anchois révèle, d'après l'évolution du rendement par recrue en fonction de F, un état de surexploitation. En outre, sa biomasse totale équilibrée (D), calculée à 14 820 tonnes en 1982, a connu un déclin significatif pour atteindre en l'an 2002 une masse de 546,06 tonnes environ estimée par le VIT.

Keywords: Fishes, pelagic, biomass, algerian basin

Introduction

Au cours de la campagne acoustique, entreprise par la *Thalassa* en 1982, la biomasse totale de l'anchois a été estimée dans la baie d'Alger à 14 820 tonnes, soit 60% de la biomasse pélagique totale (1) avec une production annuelle de 3 325 tonnes (3).

Cependant depuis quelques années, le tonnage annuel débarqué au port d'Alger a subi un déclin significatif pour atteindre en l'an 2002 une production annuelle de 315 tonnes, soit 5% de la production pélagique totale (données Laboratoires halieutique de l'ISMAL).

Afin de proposer les mesures indispensables à l'amélioration du rendement de cette espèce, l'étude de l'analyse virtuelle de *Engraulis encrasicolus* a été entreprise par le VIT (2).

Matériel et méthodes

Centre de classe (cm)	Effectif
7	1
7.5	7
8	12
8.5	10
9	48
9.5	123
10	202
10.5	230
11	238
11.5	408
12	854
12.5	1162
13	1342
13.5	998
14	701
14.5	440
15	257
15.5	161
16	220
16.5	24
17	7
17.5	3

Tab. 1. Distribution des fréquences de tailles de l'anchois algérois.

L'étude biologique de 7 448 individus, de tailles comprises entre 6,75 à 17,75 cm capturés dans la baie d'Alger entre janvier 1995 et décembre 2000, a fourni les résultats nécessaires pour l'analyse virtuelle de l'anchois par les fréquences de tailles (Tab. 1 et 2).

La méthode de Bhattacharya, l'équation de Pauly et la courbe de captures du programme FISAT (4) ont été utilisées respectivement pour le calcul de l'âge, de M et de F.

Résultats

Tailles et âges du stock

La taille et l'âge moyens de capture (respectivement 12,86 cm et 3,08 ans) demeurent supérieurs à la taille et à l'âge critiques du stock actuel (respectivement 11,75 cm et 2,46 ans). Encore faudrait-il signaler que l'analyse de la distribution des fréquences de tailles laisse apparaître que 88,31% des anchois, sexes confondus, pêchés dans la baie d'Alger ont atteint la taille de la première maturité sexuelle qui est de l'ordre de 11,3 cm. Ces résultats confirment le fait que c'est la fraction mature du stock qui est ciblée par les senneurs permettant ainsi la protection des juvéniles responsables ultérieurement du renouvellement et de la pérennité du stock.

Biomasse et état d'exploitation

Recrutement → Biomasse totale équilibrée (D) → **M**
99,21 T (18.17%) 231,06 T (42.31%)

Croissance → 546,06 tonnes (T) → **F**
446,85 T (81.83%) 315 T (57.69%)

Age (an)	1	2	3	4	5
Taille (cm)	8.11	10.64	12.88	14.51	15.88
$L_t = 21.59\ e^{-0.216\ (t+1..178)}$ (5)					
$W_t = 0.00402\ L_t^{3.15}$ (5)					
$M = 0.35\ an^{-1}$, multiplication de M par 0.6 (6)					
$Z = 2.08\ an^{-1}$					
$F = 1.73\ an^{-1}$					
Taille de la première maturité sexuelle (sexes confondus), $L_{50} = 11.3$ cm.					
Production annuelle de l'anchois dans la baie d'Alger pour l'an 2002 est de 315 tonnes.					

Tab. 2. Paramètres nécessaires pour le calcul de l'A.V.P. de l'anchois algérois.

La biomasse totale équilibrée de l'anchois algérois, estimée à 546,06 tonnes, est alimentée essentiellement par la croissance pondérale (446,85 tonnes soit 81,83%) devant le recrutement qui ne représente que 99.21 tonnes (18,17%). Cependant, les pertes sont causées surtout par la pêche qui représente 315 tonnes (57,69%) devançant ainsi la mortalité naturelle qui est de l'ordre de 231,06 tonnes (42,31%). Enfin, l'analyse du rendement par recrue en fonction de F (2) révèle un état de surexploitation du fait que l'optimum (Y/R), estimée à 5,236 g pour F = 0,9 an^{-1}, soit supérieur à Y/R (5,118 g) de capture pour F = 1,73 an^{-1}.

Conclusion

Suite à ces résultats, étayés par un taux de renouvellement (turnover) de *Engraulis encrasicolus* de la baie inférieur à 100% et qui est de l'ordre de 82,24%, il serait urgent de recommander :

- l'interdiction de l'activité des senneurs près de la côte,
- le déplacement de l'effort de pêche hors de la baie,
- la diminution de la puissance des senneurs.

Références

1 - I.S.T.P.M., 1982. Rapport de mission sur l'évaluation des ressources halieutiques de la marge continentale algérienne - stocks pélagiques, stocks demersaux exploitables au chalut. Campagne Thalassa, Ichthys, Joamy, 101 p.

2 - Lleonart J. and Salat J., 1999. VIT (Window's version) : software for Fisheries analysis. Inst. Tech. Sci. Mar., 116 p.

3 - Mouhoub R., 1986.Contribution à l'étude de la biologie et de la dynamique exploitée de la sardine (*Sardina pilchrdus* Walbaum, 1792) des côtes algéroises. Thèse de Magistère. Univ. Sc. Tech. Houari Boumediene, Alger, 163 p.

4 - Gayanilo F.C., Jr. and Pauly D., 1997. FAO-ICLARM Stock Assessment Tools (FISAT). Reference manual FAO Computerized Information Series (Fisheries). N° 8, Rome, FAO, 262 p.

5 - Saila S.B., Recksiek C.R. and Prager H., 1988.Basic Fishery Science Programms. A compendium of microcomputer programms and manual of operation. Elsevier, *Dev. Aquacult. Fish. Sci.*, 18 : 231.

6 - Pauly D., 1997. Méthodes d'évaluation de la mortalité naturelle. Pp.135-156. *In* : Cépaduès (ed.), Méthodes pour l'évaluation des ressources halieutiques. Collection Polytech I.N.P. Toulouse.

DONNÉES PRÉLIMINAIRES SUR LA BIOLOGIE DE *TRIGLOPORUS LASTOVIZA* (PISCES : TRIGLIDAE) DU GOLFE DE GABES

L. Boudaya *, A. Taktak, L. Neifar et A. Bouain

Laboratoire d'Ecobiologie et d'Ecophysiologie Animales, Faculté des Sciences de Sfax. Tunisie - * l_boudaya@yahoo.fr

Résumé

Trigloporus lastoviza (Bonnaterre, 1788) est un poisson benthique qui fréquente les fonds vaseux du golfe de Gabès. L'analyse du *sex-ratio* a montré que les mâles dominent les femelles pour les tailles inférieures à 15 cm. Ces dernières deviennent plus fréquentes à des tailles supérieures à 17 cm. La taille de première maturité sexuelle chez cette espèce est de 11,7 cm. La fécondité est comprise entre 5165 et 20909 ovocytes.

Mots clés: Trigloporus lastoviza, reproduction, golfe de Gabès

Introduction

Avec plus d'une centaine d'espèces connues de par le monde (1), les Triglidae ont colonisé toutes les mers tropicales et tempérées de la planète jusqu'à 500 m de profondeur. En Tunisie, longtemps considérés comme des poissons d'intérêt économique secondaire, aucun travail n'a été consacré à l'étude des Triglidae. Actuellement, avec la surexploitation des poissons dits nobles, les pêcheurs se sont dirigés vers d'autres ressources peu ou pas exploitées. Les Triglidae sont parmi ces poissons.

Nous avons donc jugé utile dans un travail préliminaire d'étudier quelques aspects de la biologie de l'une des espèces de Triglidae, la plus abondante dans le golfe de Gabès, *Trigloporus lastoviza.*

Matériels et méthodes

Cette étude a porté sur 870 individus de *T. lastoviza* ayant une longueur totale comprise entre 12,2 et 26,2 cm et provenant d'un échantillonnage mensuel durant la période allant de janvier 2001 à juillet 2002. Les poissons sont prélevés au hasard dans les caisses au débarquement des chalutiers du port de Sfax, le plus grand port du golfe de Gabès.

Pour chaque spécimen nous avons relevé le poids, avant et après éviscération, le poids des gonades, la longueur standard et la longueur totale. L'observation macroscopique des gonades, complétée parfois par l'observation microscopique, nous a permis de distinguer les mâles des femelles.

Pour déterminer la taille de première maturité sexuelle nous avons calculé la proportion des matures par classe de taille qui sera ajustée grâce à un logiciel FSAS (2). Les fécondités absolue et relative sont estimées par le comptage des ovocytes observé sous un microscope stéréoscopique.

Résultats et discussion

Sur 870 individus analysés, nous avons dénombré 456 femelles et 414 mâles représentant respectivement un taux de féminité de 52,41% et un taux de masculinité de 47,59%. Statistiquement, la dominance des femelles n'est pas significative ($p > 0,05$). Ce même résultat a été trouvé pour *T. lastoviza* en Atlantique (3). En revanche une dominance des femelles par rapport aux mâles a été observée chez *T. lastoviza* du golfe de Lion (4).

L'analyse des variations du *sex-ratio* en fonction de la taille des poissons groupés par classe montre une dominance des mâles pour les tailles comprises entre 12 cm et 15 cm et une dominance des femelles pour les tailles supérieures à 17 cm.

Dans cette étude nous avons trouvé que les individus de *T. lastoviza* dont la longueur standard est inférieure à 11 cm sont immatures. La proportion des matures augmente avec l'augmentation de la taille jusqu'à la taille de 15,5 cm à partir de laquelle tous les individus sont matures.

L'application de la fonction logistique a montré que les individus de cette espèce atteignent leur première maturité sexuelle à une longueur standard de 11,7 cm.

Les différents résultats obtenus par divers auteurs en Méditerranée (5, 6) et sur la côte est atlantique (3) montrent que la taille de première maturité sexuelle chez les mâles de *T. lastoviza* est beaucoup plus importante en Atlantique qu'en Méditerranée. Deux hypothèses peuvent expliquer cette variation: soit la pression de pêche qui est beaucoup plus importante en Méditerranée et *T. lastoviza* s'est adaptée à cette nouvelle situation de surpêche en diminuant sa taille de première maturité sexuelle, soit la croissance des populations méditerranéennes est plus modérée.

La première hypothèse est soutenue par le fait que dans le nord de la Méditerranée, Kartas (4) estime que la taille de première maturité sexuelle est comprise entre 19 et 21 cm, alors que Papaconstantinou (5), 15 ans après, estime qu'elle est de 14,2 cm.

L'étude de la fécondité a montré que chez *T. lastoviza* du golfe de Gabès la fécondité absolue varie entre 5165 et 20909 ovocytes avec une moyenne de 12286, pour des longueurs totales comprises entre 14,4 cm et 19,6 cm. Les fécondités relatives sont comprises entre 1470 et 3780 ovocytes par gramme d'ovaire et 126 et 288 ovocytes par gramme de masse corporelle.

Références

1 - Richards W.J., Jones D.L., 2002. Preliminary classification of the gurnards (Triglidae: Scorpaeniformes). *Mar. Freshwater Res.*, 53: 275-282.

2 - Saul B.S., Conrad W.R., Michael H.P., 1988. Basic fishery science program: a compendium Microcomputer Programs and Manuel operation. *Developments in aquacultures and fisheries sciences*, 18: 85-125.

3 - Baron J., 1985. Les Triglidés (Téléostéens, Scorpaeniformes) de la baie de Douarnenez 2. La reproduction de: *Eutrigla gurnardus, Trigla lucerna, Trigloporus lastoviza* et *Aspitrigla cuculus*. *Cybium*, 9 (3): 255-281.

4 - Kartas F., 1971. Les Triglidae de la mer Catalane. Distribution, croissance et reproduction. II. Genre *Lepidotrigla, Trigloporus lastoviza, Eutrigla gurnardus*. Thèse 3ème cycle, Fac. Sci., Paris, 173 p.

5 - Papaconstantinou C., 1986. The life history of rock gurnard (*Trigloporus lastoviza*, Bünn. 1768) in the Saronaikos gulf. *J. Appl. Icht,* 2: 75-86.

6 - Abdallah M., Faltas S.N., 1998. Reproductive biology of *Trigla lucerna* and *Trigloporus lastoviza* in the Egyptian Mediterranean waters. *Bulletin of the National Institute of Oceanography and Fisheries* (Egypt), 24: 285-304.

LISTE COMMENTÉE DES POISSONS EXOTIQUES RECENSÉS EN TUNISIE

Mohamed Nejmeddine Bradai [1] *, Rim Ktari [1], Jamila Ben Souissi [2], Nader Ben Hadj Hamida [2], Mohamed Ghorbel [1], Othmen Jarboui [1], Abderrahmen Bouain [3] et Hechemi Missaoui [2]

[1] Institut National des Sciences et Technologies de la Mer, Sfax, Tunisie - * mednejmeddine.bradai@instm.rnrt.tn
[2] Institut National Agronomique de Tunisie, Tunis-Mahrajène, Tunisie
[3] Faculté des Sciences de Sfax, Tunisie

Résumé

Quinze espèces de poissons exotiques sont recensés dans les eaux tunisiennes. Ces espèces proviennent de la mer Rouge et de l'Atlantique. L'incursion des espèces lessepsiennes intéresse principalement le golfe de Gabès.

Mots clés: Poissons exotiques, Golfe de Gabès, Tunisie

Introduction

Les espèces exotiques introduites intentionnellement ou accidentellement en Méditerranée suite aux activités humaines constituent actuellement un événement biogéographique très important. Les côtes tunisiennes en sont concernées et plusieurs espèces, originaires de l'Atlantique ou de la région Indo-Pacifique, sont signalées ou définitivement installées (1, 2). Dans ce travail, nous nous intéressons aux poissons. Nous passons en revue toutes les espèces tout en précisant principalement les dates d'apparition, leur distribution et leur abondance.

Espèces lessepsiennes

***Stephanolepsis diaspros* (Fraser–Brünner, 1940) (Monacanthidae):** les premières mentions de cette espèce dans le golfe de Gabès remontent aux années 1965-1966 (3). Ce baliste y est commun par faible profondeur et il se reproduit, il est observé également plus au nord dans le golfe de Hammamet. Les grands spécimens sont parfois commercialisés.

***Siganus luridus* (Rüppell, 1828) (Siganidae)**: est signalé pour la première fois dans le golfe de Tunis 1969 (4), puis dans le golfe de Gabès en 1974 (5). De 1986 à 2001, nous en avons pêché une centaine d'individus dans la région de Sfax principalement aux filets trémail et au mini-chalut opérant sur l'herbier de Posidonie. Cette espèce a été pêchée également au centre, au large de Mahdia. Les observations ne sont pas régulières d'une année à l'autre.

***Siganus rivulatus* Forsskål, 1775 (Siganidae):** est observé pour la première fois en 1974 dans le golfe de Gabès (5). D'autres observations ont été enregistrées en 1995 (1) et plus récemment en octobre 2001 à Kerkennah. Il est moins fréquent que *S. luridus*.

***Priacanthus hamrur* (Forsskål, 1775) (Priacanthidae):** un spécimen de 232 mm a été capturé pour la première fois en Méditerranée le 7 avril 1980 à Mahdia (6). Le spécimen est gardé dans la collection de l'INSTM.

***Parexocoetus mento* (Valenciennes, 1846) (Exocoetidae)**: cette espèce Indo-Pacifique est observée, pour la première fois, au sud des îles Kerkennah en juin 2000 (7).

***Pempheris vanicolensis* Cuvier, 1821 (Pempheridae)**: ce migrant lessepsien a été capturé pour la première fois sur les côtes tunisiennes, de septembre à novembre 2001 au chalut benthique et dans des "cherfia" à Kerkennah (7).

***Sphyraena chrysotaenia* Klunzinger, 1884 (Sphyraenidae),** observé pour la première fois en 2002 dans le golfe de Gabès (2). Depuis, et principalement de mai à octobre 2003, le débarquement de cette espèce, par les chalutiers, est devenu régulier. Elle est observée également au marché en petites quantités. L'espèce se reproduit dans le golfe de Gabès à la fin de l'été et en automne.

Fistularia commersonii Rüppell, 1835 (Fistularidae): sept spécimens, pêchés au chalut benthique dans le golfe de Gabès, ont été examinés au mois de septembre et octobre 2003. L'arrivée en masse de cette espèce, inconnue auparavant, était spectaculaire, tous les pêcheurs en parlent. Les captures étaient en effet nombreuses pendant cette période. Toutefois, il est à noter que deux spécimens de cette espèce ont été observés l'an 2002 dans le golfe de Gabès (Ben Souissi, com. pers.).

Espèces atlantiques

***Sphoeroïdes pachygaster* (Müller et Troschel, 1848) (Tetraodontidae)**: 3 spécimens de cette espèce, d'origine atlantique, ont été observés dans le golfe de Gabès le 25 mars 1992 (8). Tout en étant encore rare, il est régulièrement observé dans la région.

***Solea senegalensis* Kaup, 1858 (Soleidae)**: observée pour la première fois en Tunisie dans le golfe de Tunis en 1979 (9). Actuellement, elle est fréquente dans la région nord de la Tunisie et est pêchée également au centre et récemment dans le golfe de Gabès.

***Seriola carpenteri* Mather, 1971 (Carangidae):** connue en Atlantique de l'Est, a été signalée une seule fois à Lampedusa proche des côtes de la Tunisie (10).

***Chaunax suttkusi* Caruso, 1949 (Chaunacidae)**: connue à l'Est et à l'Ouest de l'Atlantique, a été signalée, à deux reprises, dans le détroit siculo-tunisien, donc proche des côtes tunisiennes (11).

***Seriola fasciata* (Bloch, 1793) (Carangidae):** cette espèce, abondante localement à Madère, a été capturée pour la première fois en mai 1996 dans la région du golfe de Gabès à La Skhira (7) puis dans les pêcheries de coryphènes à Monastir en 2000. Il s'agit d'individus juvéniles.

***Pisodonophis semicinctus* (Richardson, 1848) (Ophichthidae)**: nous l'avons pêchée, pour la première fois, dans le golfe de Gabès en 1998, puis dans le golfe de Tunis en 2000 (1).

Carcharhinus falciformis* (Bibron, 1839) (Carcharinidae): un spécimen est capturé dans le sud tunisien en août 2002 au palangre de fond travaillant sur les mérous. L'individu, de sexe mâle, mesure 1565 mm de longueur totale (2).*

Références

1 - Bradai M.N., 2000. Diversité du peuplement ichtyque et contribution à la connaissance des Sparidés du golfe de Gabès. Thèse d'Etat, Univ. De Sfax (Tunisie), 600 p.

2 - Bradai M.N., *Saïdi B.,* Ghorbel M., Jarboui O., Bouain A., El Abed A. et Hamza A., 2002. Statut des espèces exotiques signalées dans les eaux tunisiennes. *Bulletin de l'INSTM*, NS, 6 (sous presse).

3 - Chakroun F., 1966. Capture d'animaux rares en Tunisie. *Bull. Inst. nat. scient. tech. Océanogr. Pêche Salammbô,* N. S., 1: 75-79.

4 - Ktari-Chakroun F. et Bouhlel M., 1971. Capture de *Siganus luridus* (Ruppel) dans le golfe de Tunis. *Bull. Inst. natn. scient. tech. Océanogr. Pêche Salammbô,*2 (1): 49-52.

5 - Ktari F. et Ktari M.H., 1974. Présence dans le golfe de Gabès de *S. luridus* (Rüppel, 1828) et de *S. rivulatus* (Forskål, 1775) (poisson, Siganidae) parasités par *Pseudohaliotremato dides polymorphus. Bull. Inst. nat. scient. tech. Océanogr. Pêche Salammbô,* 3: 95-98.

6 - Abdelmouleh A., 1981. Capture d'un Priacanthe: *Priacanthus hamrur* (Forsskål, 1775) poisson indopacifique, dans les eaux tunisiennes. *Bull. Inst. nat. Scient. Tech. Océanogr. Pêche Salammbô,* 8: 111-114.

7 - Bradai M.N., Quignard J-P, Bouain A., Jarboui O., Ouannes-Ghorbel A., Ben Abdallah L., Zaouali J. et Ben Salem S., (article accepté). Poissons autochtones et exotiques des côtes tunisiennes: recensement et biogéographie. *Cybium.*

8 - Bradai M.N., Ghorbel M. et A. Bouain, 1993. Premières observations dans le golfe de Gabès (Tunisie) de *Sphoeroides cutaneus* (Tétraodontidae). Cybium, 17: 86-86.

9 - Goucha M. Et Ktari M.H., 1981. Présence de *Solea senegalensis* Kaup, 1858 sur les côtes du Nord de la Tunisie. *Rapp. Comm.int. Mer Médit.,* 27: 131-133.

10 - Pizzicori P., Castriota L., Marino G. et Andaloro F., 2000. *Seriola carpenteri*: a new immigrant in the Mediterranean from the Atlantic ocean. *Journal of Fish Biology*, 57: 1335-1338.

11 - Ragonese S., Giusto G.B. et Caruso J. H., 2001. Second record of the toadfish *Chaunax suttkusi* Caruso, 1989 in the Mediterranean Sea. *Journal of Fish Biology*, 58: 291-294.

SATELLITE REMOTE SENSING FOR SEAGRASS MAPPING IN THE LAGOON OF VENICE

Braga F. [1], Salviato S. [1], Alberotanza L. [1] *, Silvestri S. [2], Ramieri E. [3], Berton A. [3], Curiel D. [4], Rismondo A. [4]

[1] ISMAR - CNR, Venezia, Italy - federica.braga@ismar.cnr.it, stefania.salviato@ismar.cnr.it, * luigi.alberotanza@ismar.cnr.it
[2] MAV - Servizio Informativo, Venezia. Italy - sonia.silvestri@magisacque.it
[3] Thetis S.p.A., Venezia. Italy - ramieri.e@thetis.it, berton.a@thetis.it
[4] Selc, Marghera (VE). Italy - curiel@selc.it, rismondo@selc.it

Abstract

Seagrass play an important role in preserving lagoon morphology and providing an environment suitable for marine organisms. Seagrass mapping is therefore particularly relevant for a correct management of the lagoon system. Remote sensing allows the estimation of seagrass extension and distribution, providing high temporal and spatial resolution maps. Moreover, costs of satellite data are lower than those currently possible with *in situ* surveys. In order to investigate the spectral properties of submerged plants, a series of *in situ* radiance measurements were collected. This spectral library has been used to calibrate a survey system based on the elaboration of remote sensing data.

Keywords: Seagrass, Venice lagoon, Remote sensing

Introduction

In 2002 a research program was started in the framework of a monitoring project carried out by Consorzio Venezia Nuova, on behalf of Magistrato alle Acque, Venice. Part of the program consisted in mapping the distribution of seagrass through remote sensing.

For this purpose, the following activities were planned:
1. definition of a methodology for radiometric data acquisition on field;
2. construction of a spectral library for the different species of seagrass and macroalgae of the Venice lagoon. This is supposed to be representative of the spatial and temporal variability of the targets' spectral behaviour, due to changes in environmental factors as well as in phenological and growing conditions of plants;
3. calibration and validation of remotely sensed data with collected *in situ* measurements;
4. development of a procedure for mapping seagrass in the Venice lagoon based on the elaboration of remote sensing images.

Field survey

Experimental activities were carried out during six and five monthly field campaigns respectively held in spring-summer 2002 and 2003.

During the first year data were measured on six 100 m^2 plots:
- 3 "pure" plots with 100% coverage of *Zostera noltii*, *Zostera marina* and *Cymodocea nodosa* respectively;
- 1 plot with mixed coverage of *Cymodocea nodosa* and *Zostera marina*;
- 2 "pure" plots with discontinuous coverage (50%) of *Cymodocea nodosa* and *Zostera marina*.

The three 100% coverage – single species plots - were also sampled in 2003. In this period, radiance data were collected for complementary targets (macroalgae, bare substratum with different granulometric composition, canal) too.

Each monthly campaign lasted six days; i. e. one plot or target per day. 8 hourly measurements of spectral signatures and ancillary parameters (turbidity, depth, Chl-a fluorescence, chemical-physical parameters, water current intensity and direction, suspended matter, PAR) were collected in a fixed representative point in order to investigate the influence of the tide effect on the spectral behaviour of targets.

Additional signatures were randomly collected in other points to enlarge the spectral collection.

Radiance data were measured with a portable radiometer PR-650 and were taken above the water surface, following an update Sea Viewing Wide Field of View Sensor (Sea WiFS) protocol (1-3,5).

Monthly measures of phenological and growth data were also collected in the pure and mixed seagrass plots, in order to investigate their influence on seagrass spectral response.

Satellite data analyses

Satellite data were collected and used to derive distribution maps of the different seagrass species living in the shallow waters of the Venice lagoon. Four Landsat 7 ETM+ scenes were acquired during the 2002 field campaigns, and in particular the 18th May scene was used for the analyses. Data were radiometrically calibrated, atmospherically corrected - using ATCOR2 based on MODTRAN 4.2 - and, finally, georeferenced. Only the VIS and NIR bands were used for the analyses.

The analysis of spectral signatures of un-vegetated lagoon floor allowed calculating an exponential relation between reflectance and water depth. The reflectance of an imaginary lagoon without submerged vegetation was simulated using the exponential relation in the green portion of the electromagnetic spectrum and considering the water heights calculated by an hydrodynamic model. Difference between simulated reflectances and those obtained with Landsat ETM+ enabled to distinguish between vegetated and bare lagoon.

An ISODATA clustering was then applied on vegetated areas, using the reflectance standard deviations calculated on spectra collected in field (4). Matching cluster spectra with those obtained in the field, clusters were grouped into four vegetation classes. A good agreement between these results and a seagrass - macroalgae map obtained from detailed surveys undertaken on the whole lagoon during spring – summer 2002 was noticed.

Distinction between *Zostera marina* and *Ulva rigida* appeared to be complex, probably due both to the similarity of their spectral responses and to the fact that they usually grow on the same areas. *Zostera noltii* was not found, probably because it was at the beginning of its growing season. *Cymodocea nodosa* was well recognized in the central lagoon, while some disagreement with field survey was found in limited areas of the southern basin (Valle Millecampi and Chioggia).

Thanks to the 2003 field campaigns, a larger spectral signatures database will be available for the recognition of vegetation species, and hence a better distinction among species will be possible.

Results

Experimental activities enabled to collect a considerable quantity of spectral data of three seagrass species and complementary targets in the lagoon of Venice, in different environmental situations as well as phenological and growing conditions of plants. This led to create an original and rich spectral database.

The preliminary study of reflectance data pointed out the close correlation between spectral measurements of different targets, underlining the relevant influence that some environmental factors have on spectral responses. In fact, this can partially or totally mask the reflectance of submerged vegetation. Factors that seem to have the highest influence are:
- depth and thickness of the water column above the submerged vegetation;
- water turbidity;
- bottom characteristics.

Preliminary elaboration of satellite data confirmed that the created spectral collection represents a considerable experimental basis for the development and calibration of a remote sensing system for seagrass mapping based on satellite imagery.

Acknowledgment. A special acknowledgment to Consorzio Venezia Nuova, Servizio Ambiente, in particular to Arch. A. G. Bernstein and Ing. L. Montobbio.

References

1 - Hooker S.B., Lazin G., Zibordi G., McLean S., 2002. An evaluation of above- and in-water methods for determining water-leaving radiances. *Journal of Atmospheric and Oceanic Technology*, 19(4): 486–515.

2 - Mobley Curtis D., 1999. Estimation of the remote-sensing reflectance from above-surface measurements. *Applied Optics*, 38(36): 7442-7455.

3 - Mueller J.L., Austin R.W., 1995. Ocean Optics Protocols for Sea WiFS Validation, Revision 1. NASA Tech. Memo. 104566, Vol. 25, S.B. Hooker, E.R. Firestone, J.G. Acker (eds.); NASA Goddard Space Flight Center, Greenbelt, Maryland, 67 p.

4 - Silvestri, S., M. Marani, J. Settle, F. Benvenuto, A. Marani, 2002. Salt Marsh Vegetation Radiometry: Data Analysis and Scaling, *Remote Sensing of Environment*, 80: 473-482.

5 - Zibordi G., Hooker S.B., Berthon J.F., D'Alimonte D., 2002. Autonomous Above-Water Radiance Measurements from an Offshore Platform: A Field Assessment Experiment. *Journal of Atmospheric and Oceanic Technology*, 19(5): 808-819.

THE INFLUENCE OF LIGHT INTENSITY ON GROWTH OF THE MARINE PLANKTONIC ALGA *CHLORELLA* SP. UNDER LABORATORY CONDITIONS

Igor Brautovic
Institute of Oceanography and fisheries, Dubrovnik, Croatia - igor@labdu.izor.hr

Abstract

Chlorella sp. cultures were exposed to the light intensities of 900, 2000, 4000, 6000, and 12000 lux until the steady phase of growth was achieved. Optimal growth at 6000 lux was established. The shortest period of log phase was recorded for the algae exposed at 6000 and 12000 lux, and the longest at 2000 lux. Algae at 900 lux were exposed to 12000 lux on the 23rd day of the experiment with successful growth.

Keywords: Chlorella, light intensity, growth rate

Introduction

The green phytoplankton alga *Chlorella sp.* is normally used in mariculture for human food, and for culturing zooplanktons in marine fish hatchery. In a microalgal culture under illuminated conditions, the production rate of cells depends on the distribution of light intensity and growth rate of cells (1). The aim of the research was to establish optimal light intensity in order to access maximal abundance of *Chlorella sp.* in the shortest time.

Material and methods

Chlorella sp. was isolated from the coastal waters of Kaštela bay, Central Adriatic Sea, and persistence in laboratory in a liquid medium. For each experiment 20 l of filtrated and sterilized (by UV lamp) sea water, 500 ml *Chlorella sp.* culture abundance $1.3x10^7$ cell ml^{-1}, 20.5 ml of nutrition medium "Walne" (2), and 0.25 ml of thiamine were added in three bags. In each experiment three different bags with algae culture were exposed to the certain light intensity estimated by the luxmeter: 900, 2000, 4000, 6000 and 12000 lux. The bags at 900 lux were exposed at 12000 lux on the 23rd day of the experiment. Light source for the intensities 900 – 600 lux were fluorescent tubes 40 W (220-240 V), and for the highest light intensity of 12000 lux VTFE lamp was used. Photoperiod 15 h light / 9 h dark was set by the timer mechanism. Cultures were continuously mixed by air pumps. Indoor and the temperature of the medium, as well as the salinity (psu) were controlled. The algae cells were counted daily at 9 am by the Bürcker-Türck counter.

Results and discussion

The initial abundance of algae was $3.3x10^5$ cell ml^{-1}. The seawater salinity was 37.5 psu at the beginning and at the end of the experiment it was between 42.0 psu (at 900 lux) and 43.3 psu (at 12000 lux). The temperature was between 23.9°C and 25.8°C. Photo bioreactors with diurnal cycles will save energy and improve organic carbon sources removal (3). (4) were tested the use of submarine lamps (1.20 m fluorescent tube, 90 W, 220-240 V) in large volume tanks (0.8 m^3) for the development of *Chlorella sp.* with the bloom technology. 10-16 x 10^6 cell ml^{-1} were obtained after a week. In our experiment maximal growth was at 6000 lux. After 7 days the abundance of *Chlorella sp.* was 19.1 x 10^6 cell ml^{-1}, and the maximal abundance was 85.9 x 10^6 cell ml^{-1} on the 15th day of the experiment (Fig. 1). Algae previously exposed at 900 lux, were in a steady phase on 23rd day, and then they were exposed at a significantly higher light intensity of 12000 lux that caused the growth after 48 hours, and a new steady phase was established after 7 days (Fig. 2). It seems that in the first part of the experiment the nutrition did not become depleted, so in the second phase the higher light intensity was stimulating the growth until the second steady phase was achieved.

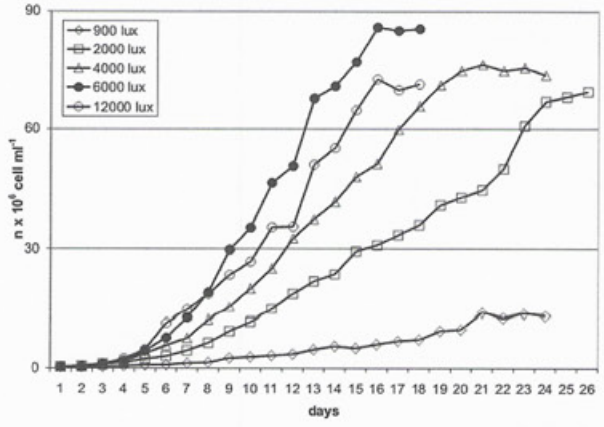


Fig. 1. The growth of *Chlorella sp.* under the different light intensities.

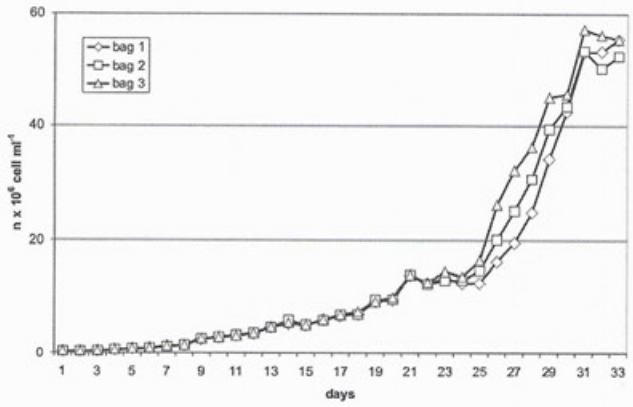


Fig. 2. A new growth of *Chlorella sp.* after changing the light intensity.

References

1 - Hirata S., Taya M., and Tone S., 1996. Characterization of *Chlorella* cell cultures in batch and continuous operations under a photoautotrophic condition. *Journ. Chem. Eng. Jap.*, 29: 953-959.

2 - Walne P.R., 1970. Studies on the food value of nineteen genera of algae to juvenile bivalves of the genera *Ostrea*, *Crassostrea*, *Mercenaria* and *Mytilus*. Minist. Agric., Fish. and Food (London). *Fish. Invest.*, 25: 62 pp.

3 - Lee K., and Lee C-G., 2001. Effects of light/dark cycles on wastewater treatments by microalgae. *Biotechnol. Bioprocess Eng.*, 6: 194-199.

4 - Sanmartin M., Bengoa-Ruigomez M.V., Hatziathanasiou A., Divanach P., and Kentouri M., 1995. On the use of submarine light tubes in large volume intensive *Chlorella sp.* culture: definition of the optimum number of lamps per unit of volume. Actas del V Cong. Nac. de Acuicul. Sant Carles de la Rapita, 10-13 de Mayo 1995. F Castello i Orvay and A. Calderer i Reig (eds.), Univ. de Barcelona Publ., 1000 p.

EVALUATION OF HUMAN PRESSURE ON THE ICHTHYOFAUNA OF CATALONIAN COASTAL WATERS

Jorge Brenner * and José A. Jiménez

Departament d'Enginyeria Hidràulica, Marítima i Ambiental, ETSECCPB, Universitat Politècnica de Catalunya, Barcelona, Spain - * jorge.brenner@upc.es

Abstract

In the past decades the Catalonian coastal zone has been subjected to intense human pressure due to high concentration of activities and settlements. Although some of the impacts are evident, others are not, or have not been studied in detail. In this study, we consider the environmental quality of coastal waters through the ichthyofauna diversity and distribution. We attempt to assess the potential influence of such activities on the ichthyofauna. This is done by selecting a number of indicators of pressure and relating them with biodiversity. Special interest has been given to rare and special concern species. Finally, we identify some areas of importance for conservation of the icthyofauna, and make recommendations on the evaluation of environmental impact on this group.

Keywords: coast, ichthyofauna, pressure, indicator, GIS

Introduction

Along its 848 km the Catalonian Coast house 490 out of the 655 fish species of the Mediterranean [1]. In Catalonia, the ichthyofauna is the best know marine group. Several of those species are rare and deserve special conservation attention. The majority of these species have been extensibly studied by taxonomists, ecologists and fisheries biologist in separate efforts. Moreover, the Catalonian coast also houses the two most important pressures on the Spanish littoral system, the tourist industry, the urbanization, and their associated impacts [2]. In order to alleviate the pressure on coastal environments and on their biodiversity, the European Community has recently recommended a new strategic and harmonized framework for regional and local implementation (COM/00/547). This new instrument recommends to study in an integral manner all the driving forces that generate pressure on the coastal system. In this study, we propose a methodology to identify the relationship between the forces of pressure that drive species diversity and distribution. Some of the impacts are evident and have been studied in larger detail as fisheries and some kinds of pollution but, in this case, we analyze the effect of inland-coastline generated pressures on this group.

Methodology

The approach involves the definition of threat categories based on diversity and distribution criteria, and the identification of component sources of pressure that can be mapped. These "stressors" include simple population and infrastructure features such as cities, ports, and discharge pipelines as well as more complex modelled layers of riverine inputs. Coast stressors have been previously identified by the Catalonian Port Plan [3]. Once these components have been selected, model rules are developed for translating them into measures of threat. The model produces map-based indicators of human pressure along the coast using a Geographic Information System (GIS) data model and application [4]. The index is designed to highlight areas where, either high diversity or high pressure occur. Other indexes will be developed using the database in order to attempt to assess the potential influence of such activities on the ichthyofauna. The combined index provides a regionally consistent indicator of human pressure on this group that could serve as a proxy guide to fish conditions across the Catalonian coast. We hope this will constitute a new form to observe and understand the effect of human activities on the coastal zone.

References

[1] - Allué, C., D. Lloris, S. Meseguer, 2000. Colecciones biológicas de referencia (1982-1999) del Instituto de Ciencias del Mar (CSIC): Catálogo de Peces. Instituto de Ciencias del Mar, Barcelona, 200 p.

[2] - Sardá, R., 2001. Shoreline development on the Spanish Coast. Pp. 149-163. In: von Bodungen, B., and R.K. Turner (eds.), Science and Integrated Coastal Management. Dahlem University Press, Berlin.

[3] - Generalitat de Catalunya, 2001. Pla de Ports de Catalunya. Departament de Política Territorial i Obres Publiques. Barcelona.

[4] - Vallega, A., 2003. From Rio to Johannesburg: The role of coastal GIS. Presented at CoastGIS'03, October 16-18th, Genova, Italy.

ASSESSMENT OF *CALANUS HELGOLANDICUS* EMBRYO AND NAUPLIAR MORTALITY USING FLUORESCENT PROBES

Isabella Buttino [1] *, Giovanna Romano [1], Maristela do Espirito Santo [1, 2], Adrianna Ianora [1] and Antonio Miralto [1]

[1] Stazione Zoologica "Anton Dohrn", Napoli, Italy - * buttino@szn.it

[2] CRIAcq Centro di Ricerca Interdipartimentale per l'acquacoltura, Portici, Napoli, Italy

Abstract

A diatom diet of *Thalassiosira rotula* and *Skeletonema costatum* induced egg mortality and abnormal development of hatched copepod *Calanus helgolandicus* nauplii, depending on the number of ingested cells and the duration of feeding. Here we use fluorescent techniques to evaluate copepod embryo mortality following spawning, using the vital probe SYTOX Green, and to assess apoptosis in abnormal nauplii using the TUNEL enzymatic assay.

Key-words: Copepod; vital fluorescent probes; apoptosis

In recent years it has been shown that several species of diatoms produce α–β unsaturated aldehydes that block embryonic divisions in various species of invertebrates, including copepods (1-3). The cellular target of these molecules is still unknown but previous studies have demonstrated that decadienal, one of the main unsaturated aldehydes isolated from diatoms, depolymerises microtubules and actin filaments in sea urchin and tunicate embryos (1;4) and induces apoptosis in copepod and sea urchin embryos (5). When copepods feed a diatom diet, egg viability is reduced in a time and concentration dependent manner (5;6). At lower diatom concentrations, some embryos develop to hatching but the embryos thus generated are strongly malformed(6). Here we apply two different fluorescent techniques to study the effect of diatom diets on the reproductive physiology of the copepod *Calanus helgolandicus*: a protocol to rapidly calculate embryo mortality soon after spawning, using the vital fluorescent probe SYTOX Green (Molecular probes), and an enzymatic *in-situ* labeled nucleotide assay (dUTP nick-end labelling, TUNEL) to evaluate the induction of apoptosis in abnormal nauplii.

SYTOX Green is a non-permeant nucleic acid stain that enters only into cells with damaged plasma membranes such as in dead cells that then appear with green fluorescent nuclei. *Calanus helgolandicus* embryos, produced by females fed the diatom *Thalassiosira rotula,* were incubated in chitinase solution (1U/ml for 50 min at 20°C) to permeabilize the chitinous wall soon after egg spawning. Embryos were then incubated in SYTOX Green 20 µM for 50 min, and observed with the epifluorescent or confocal laser scanning microscope. Egg mortality was determined as the number of fluorescent as opposed to non-fluorescent embryos. DNA fragmentation due to apoptosis was detected with the TUNEL kit (Boheringher GmbH) on abnormal *C. helgolandicus* nauplii produced by females fed the diatom *Skeletonema costatum*.

Eight days after feeding, percentage egg mortality increased to 75% when embryos were allowed to develop naturally to hatching (Fig. 1 control). SYTOX Green-treated embryos gave similar results for embryo mortality (Fig. 1 Sytox + and insert). Figure 2 shows a deformed nauplius positively stained with TUNEL (arrow) indicating activation of apoptotic processes in abnormal tissues. Such nauplii die soon after hatching.

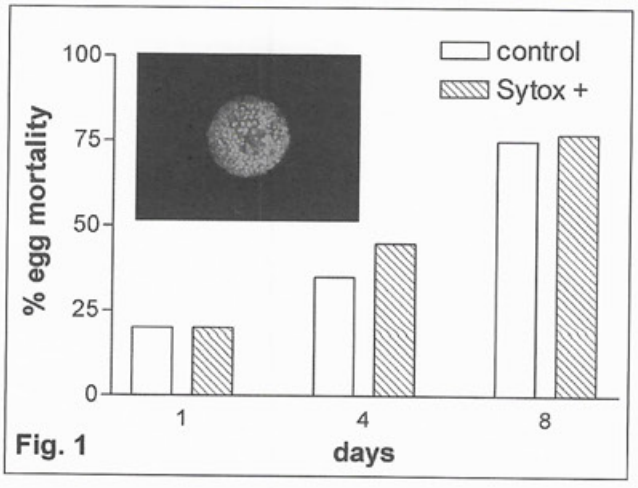


Fig. 1

The possibility of applying immuno-fluorescence techniques to stain embryos and nauplii opens new perspectives in studies on the reproductive physiology of copepods and zooplankton, allowing for the rapid assessment (2h) of hatching success and abnormal embryonic and post-embryonic development compared to other conventional techniques.

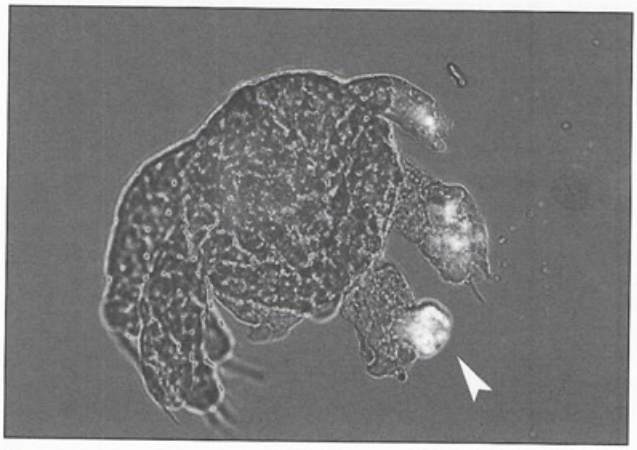


Fig. 2.

References

1 - Buttino I., Miralto A., Ianora A., Romano G., Poulet S.A., 1999. Water soluble extracts of the diatom *Thalassiosira rotula* induce aberrations in embryonic tubulin organisation of the sea urchin *Paracentrotus lividus*. *Mar. Biol.,* 134: 147-154.

2 - Miralto A., Barone G., Romano G., Poulet S.A., Ianora A., Russo G.L., Buttino I., Mazzarella G., Laabir M., Cabrini M., Giacobbe M.G., 1999. The insidious effect of diatoms on copepod reproduction. *Nature* 402: 173-176.

3 - Pohnert G., 2000. Wound-activated chemical defense in unicellular planktonic algae. *Angew Chem Int Ed.*, 39:4352- 4354.

4 - Tosti E., Romano G., Buttino I., Cuomo A., Ianora A., and Miralto A, 2003. Bioactive aldehydes from diatoms block fertilisation currents in ascidian oocytes. *Mol. Reprod. Dev.* 66: 72-80.

5 - Romano G., Russo G.L., Buttino I., Ianora A., Miralto A., 2003. A marine diatom-derived aldehyde induces apoptosis in copepod and sea urchin embryos. *J. Exp. Biol.* 206: 3487-3494.

6 - Poulet S., Laabir M., Ianora A., Miralto A., 1995. Reproductive response of *Calanus helgolandicus*. I. Abnormal embryonic and naupliar development. *Mar. Ecol. Prog. Ser.* 129: 85-95.

A NOVEL METHOD TO DETECT EMBRYO VIABILITY IN THE EGG-CARRYING COPEPOD *CLAUSOCALANUS FURCATUS*

Isabella Buttino *, Àurea Peralba and Maria Grazia Mazzocchi
Stazione Zoologica "Anton Dohrn", Napoli (I), Italy

Abstract
Copepods of the genus *Clausocalanus* are among the most abundant calanoids in Mediterranean zooplankton communities. However, the biology of this genus has been scarcely studied due to difficulties in species identification and rearing. Moreover, most *Clausocalanus* species carry the eggs, hindering an estimate of their egg production and viability. In fact, when the sac is separated from the female, eggs are unable to hatch. In this study we apply a novel method to *C. furcatus* to detect egg viability using vital fluorescent probe Fluorescein diacetate (FDA).

Key-words: vital fluorescent probe; confocal microscopy, fluorescein diacetate

Measurements of hatching success and naupliar viability in planktonic copepods provide important data for understanding recruitment rates and secondary production at sea (1). These parameters have also been used to test diet quality and toxic effects of marine natural products (2). In broadcast spawner copepods, hatching success can be easily calculated by allowing eggs to develop undisturbed to hatching (1). In egg-carrying copepods, however, this protocol is difficult to apply because embryos are not able to hatch once isolated from females, and total egg production rates can not be accurately defined.

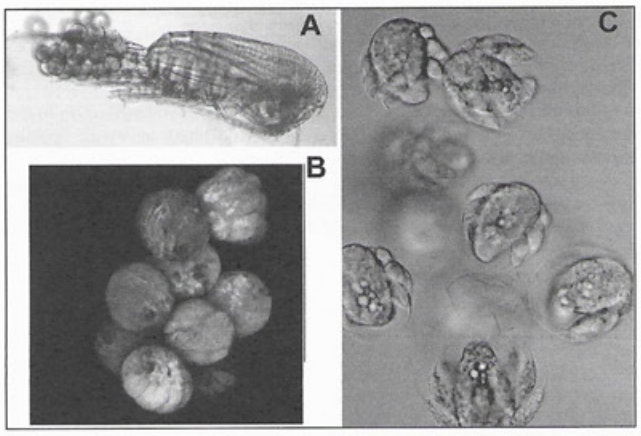
In plankton communities over a wide latitudinal range, very abundant copepods such as *Pseudocalanus* in the Atlantic Ocean, *Clausocalanus* in the Mediterranean Sea, *Oithona* and *Oncaea* in tropical environments, carry their embryos in sacs or egg masses.

In this study we analysed the egg viability of an egg-carrying calanoid copepod using a vital fluorescent probe Fluorescein diacetate (FDA) (Sigma-Aldrich). This dye penetrates in viable cells where esterases produce free fluorescent fluorescein and cells appear fluorescent in green.

Our target species was *Clausocalanus furcatus* (Brady, 1883), which is dominant in the epipelagic zone above the thermocline during summer in the Mediterranean Sea (3). *Clausocalanus furcatus* carry their eggs on the abdomen in a cylindrical mass that is discharged when the female is disturbed (4). Our method allowed analysing egg viability without disturbing females, and provided accurate measurement of egg production.

Clausocalanus furcatus females were sorted from zooplankton samples collected in the surface water of the Gulf of Naples (Southern Italy). They were incubated at 23°C in 2 l jars filled with natural particle assemblage collected at the sampling site with Niskin bottles. After 24h, the egg-carrying females were separated in two groups. One group were incubated in 7.5 µM FDA. After 15 min embryos were carefully separated from females and observed with the epifluorescent or confocal microscopy. The percentage of fluorescent embryos is a measure of their viability. Another group of females were incubated in 300 ml flask, left undisturbed until nauplii hatching and fixed in 4% paraformaldehyde. After settling, nauplii and eggs were counted under a stereomicroscope, as control.

Figure 1A shows a *C. furcatus* female carrying the egg mass. After FDA staining, viable embryos appeared fluorescent in green (Fig. 1B).



The same embryos hatched soon after observation confirming that they were viable (Fig. 1C). Some nauplii hatched after the embryos were removed from females probably because they were separated at the end of the embryonic development. The percentage of fluorescent embryos was 99± 1.5 sd similar to the controls. In free-spawning copepods this technique required previous permeabilisation of the chitinouse wall (5) while in egg-carrying copepods this treatment was not necessary, indicating that eggs lack hard chitin protection in egg-carrying species.

This simple and precise method allows to rapidly detect egg viability in egg-carrying copepods and could also be used to investigate other physiological aspects of egg production, such as remating frequency, or how long embryos must be carried for a successful hatching.

References

1 - Ianora A., 1998 Copepod life history traits in subtemperate regions. *J. Marine Syst.,* 15: 337-349.
2 - Miralto A., Guglielmo L., Zagami G., Buttino I., Granata A., Ianora A., 2003 Inhibition of population growth in the copepods *Acartia clausi* and *Calanus helgolandicus* during diatom blooms. *Mar. Ecol. Prog. Ser.,* 254: 253-268.
3 - Mazzocchi M.G. and Ribera d'Alcalà M. 1995 Recurrent patterns in zooplankton structure and succession in a variable coastal environment. *ICES Journal Marine Science,* 52: 679-691.
4 - Mazzocchi M.G. and Paffenhöffer G.A., 1998 First observations on the biology of Clausocalanus *furcatus* (Copepoda, Calanoida). *J. Plankton Res.,* 20: 331-342.
5 - Buttino I., Ianora A., Carotenuto Y., Zupo V. and Miralto A., 2003 Use of the Confocal Laser Scanning Microscope in studies on the developmental biology of marine invertebrates. *Microsc. Res. Tech.,* 60: 458-464.

UNVEILING THE SECRETS OF A SUCCESSFUL INVADER: PRELIMINARY DATA ON THE BIOLOGY AND THE ECOLOGY OF THE CRAB *PERCNON GIBBESI* (H. MILNE EDWARDS, 1853)

Stefano Cannicci [1] *, Fabio Badalamenti [2], Marco Milazzo [3], Marina Gomei [1], Alba Baccarella [2] & Marco Vannini [1]

[1] Dipartimento di Biologia Animale e Genetica "Leo Pardi", Università degli Studi Firenze, Italy - * cannicci@dbag.unifi.it, gomei@unifi.it ; vannini_m@dbag.unifi.it

[2] CNR-IAMC Laboratorio di Biologia Marina, Castellammare del Golfo (Tp), italy - fbadala@tin.it

[3] Dipartimento di Biologia Animale, Università di Palermo, Palermo, Italy - marmilazzo@iol.it

Abstract

The great increase of human activities in the sea has contributed to the transformation of the natural geographical ranges of species. In the Mediterranean Sea the invasion of alien species has increased enormously in the last years and one of the most successful invaders is the decapod crustacean *Percnon gibbesi*, presumably arriving from the Atlantic Ocean. This work offers a preliminary account on structure, bathymetric distribution, microhabitat preference and diet of a population newly recorded in northwestern Sicily. Our data, although preliminary, demonstrate that the studied population is now perfectly adapted to the colonized shores.

Keywords: alien, Percnon gibbesi, diet, habitat

Updated distribution in the Mediterranean Sea

One of the most successful marine invaders in the Mediterranean Sea is the decapod *Percnon gibbesi*, presumably arriving from the Atlantic Ocean, through vectors still to be identified. *Percnon gibbesi* is a subtropical species, distributed along the American Pacific coast, and both sides of the Atlantic Ocean (1, 2). Its presence in the Mediterranean Sea was first recorded in the summer of 1999: contemporaneously reported from the Balear Islands, Spain, (3, 4), southeastern Sicily, (5) and the Straits of Sicily (6). In 2000, the crab was recorded at Pantelleria and Ustica islands, along northwestern and eastern Sicily (7, 2). The most recent records come from northern Sicily, Tyrrhenian coast of Calabria (2), Malta (2), Ionic coast of Sicily, Ischia and Ponza Islands and Southern Sardinia.

The present contribution aims at (1) showing the results of preliminary field and lab work on the spatial and feeding preferences of individuals of *P. gibbesi* belonging to a newly recorded population (northwestern Sicily); (2) insights fpr the success of this alien species in the Mediterranean Sea.

Microhabitat preferences and natural diet

Methods. In order to assess habitat preferences, underwater surveys were carried out during the summer of 2003 in the MPA of Capo Gallo – Isola delle Femmine (northwestern Sicily). Individual specimens belonging to different size classes were randomly chosen and their occurrence within the different microhabitats and behavioural patterns were recorded. A total of 44 specimens were collected from two sites of the MPA for stomach contents analysis (8).

Results. *Percnon gibbesi* colonised the shallow subtidal, between 0.5 and 3 m depth. Our data show a strong preference for large submerged boulders, bare or with a limited macroalgal cover. Both small and large crabs prefer these microhabitats, while medium-size individuals are common in all microhabitats. Individuals of all size classes are more active at dusk, daytime activity is minimal (Fig. 1).

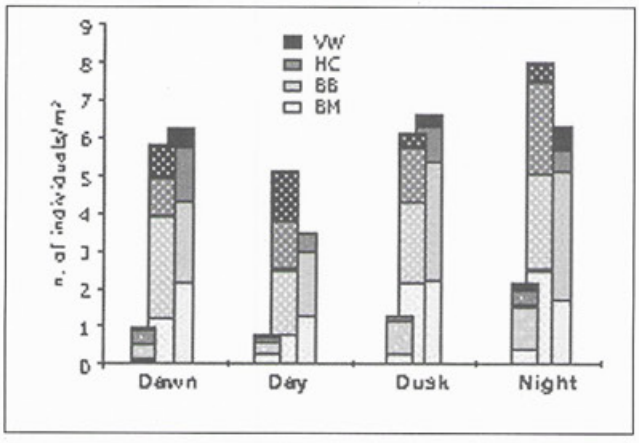


Fig. 1. Average density of *P. gibbesi* at different stages of the day in the four microhabitats considered: vertical walls (VW), holes and crevices (HC), bare boulders (BB), boulders with macroalgae (BM). The three size classes are reported: large (sparse dotted bars), medium (dense dotted) and small individuals (plain). Standard errors ranged from 0.04 to 0.8.

All crabs showed a high fidelity to individual areas. Active small- and medium-size crabs forage for about 50% of the time, while large males were also patrolling their activity areas. Interspecific interactions were rarely spotted and were directed at the ornate wrasse *Thalassoma pavo* and the rainbow wrasse *Coris julis*.

Percnon gibbesi is an omnivor (animal matter = 43.2% ± 7.47). A total of 27 taxa were identified from stomach contents, accounting for a generalistic, broad range, diet composition. The multivariate analyses showed no difference in diet composition related to sex and size. However, differences occurred between the diet of the two sub-populations sampled (ANOSIM test, 2-way crossed; factor size: R= 0.118, p=0.833; factor sub-population R=0.151, p=0.03). The preferred food items of the two sub-populations were gastropods and *Gelidium* sp. (Rhodophyta) and crustaceans and *Cladophora* sp. (Chlorophyta), respectively.

Conclusions

This Atlantic invader is still fast spreading along the rocky subtidal habitat of the Italian waters and our preliminary results allow some hypotheses on its success. *Percnon gibbesi* colonises bathymetric zone and microhabitat previously free from autoctonous large-size benthic algal browsers, and its plastic feeding habits provide it with a powerful tool to colonise new habitats.

References

1 - d'Udekem d'Acoz C., 1999. Inventaire et distribution des crustacés décapodes de l'Atlantique nord-oriental, de la Méditerranée et des eaux continentales adjacentes au nord de 25°N. *Publ. scient. M.N.H.N.*, 40: 383.

2 - Galil B., Froglia C., and Noel P., 2002. CIESM Atlas of exotic species in the Mediterranean. Vol. 2. Crustaceans: decapods and stomatopods. CIESM, Monaco. 192 p.

3 - Garcia L., and Reviriego B., 2000. Presència del cranc subtropical *Percnon gibbesi* (H. Milne Edwards, 1853) (Crustacea, Decapoda, Grapsidae) a les Illes Balears. Primera cita a la Mediterrania occidental. *Boll. Soc. Hist. Nat. Balears*, 43: 81-89.

4 - Müller C., 2001. Erstnachweis der Flachkrabbe *Percnon gibbesi* (Crustacea: Decapoda: Grapsidae) für die Balearischen Inseln. *Senckenb. marit.*, 31(1): 83-89.

5 - Mori M., and Vacchi M., 2002. On a new occurrence of the alien flat crab, *Percnon gibbesi* (H. Milne Edwards), in the southern Sicily (central Mediterranean sea) (Crustacea, Brachyura, Grapsidae). *Ann. Mus. Civ. St. Nat. "G. Doria"*, 94: 295-301.

6 - Relini M., Orsi L., Puccio V., and Azzurro E., 2000. The exotic crab *Percnon gibbesi* (H. Milne Edwards, 1853) (Decapoda, Grapsidae) in the Central Mediterranean. *Sci. Mar.*, 64(3): 337-340.

7 - Pipitone C., Badalamenti F., and Sparrow A., 2001. Contribution to the knowledge of *Percnon gibbesi* (Decapoda, Grapsidae), an exotic species spreading rapidly in Sicilian waters. *Crustaceana*, 74(10): 1009-1017.

8 - Cannicci S., Gomei M., Boddi B., and Vannini M., 2002. Feeding habits and natural diet of the intertidal crab *Pachygrapsus marmoratus*: Opportunistic browser or selective feeder? *Estuar Coast Shelf Sci*, 54 (6): 983-1001.

DO MEDITERRANEAN IMMATURE LOGGERHEAD TURTLES MIGRATE SEASONALLY ? CONTRASTING EVIDENCE FROM STRANDED SPECIMENS, FISHERMEN AND SATELLITE TRACKING

Cardona L. [1], Revelles M. [1], Carreras C. [1] *, San Felix M. [2], Fernández G. [3], Aguilar A. [1]

[1] Department of Animal Biology, Faculty of Biology, University of Barcelona, Spain
[2] Department of Zoology, Faculty of Biology, University of Valencia, Burjasot, Spain
[3] Fundación Marineland, Costa d'en Blanes-Calvià, Spain

Abstract

We studied the existence of a northward spring migration of immature loggerhead turtles in the Balearic archipelago. Fishermen claimed that loggerhead turtles are more often observed in summer, when the annual peak for stranded turtles was also recorded. However, none of the five turtles tracked by satellite from April 2003 to July 2003 migrated northwards. This suggested that turtles do not migrate northwards in spring. Reported seasonal patterns of sightings and strandings might reflect an increase in mortality rate due to the incidental catches produced by fishing.

Keywords: Caretta caretta, migration, telemetry

Immature loggerhead turtles (*Caretta caretta*) inhabiting cool-temperate areas usually migrate seasonally (1) to avoid cold-stunning at temperatures lower than 12 °C (2). Around the Balearic Islands, immature loggerhead turtles occur year round (3), but in the northern islands they have been claimed to migrate southward in winter.

We investigated the existence of a latitudinal migration using three methods: (i) recording the seasonal number of carcasses stranded in the archipelago from 1998 to 2002; (ii) conducting in 2002 (May-August) a questionnaire-based survey that included questions about monthly variation in sightings; and (iii) deploying in early April 2003 Telonics ST-18 satellite transmitters (4) on five immature loggerhead turtles (average Straight Carapace Length: 41.36 cm; range 37.1-48.7cm) collected off Formentera island. Position data were received and processed by the Argos Service (5). Turtles were tracked till late July. The Rayleigh test (6) was used for testing the existence of a preferred direction.

Fishermen stated that loggerhead turtles were more often observed during summer, when the annual peak for stranded individuals also occurred (Fig. 1). However, none of the five tracked turtles exhibited a consistent northward migration (Fig. 2) and the Rayleigh test did not identify any preferred direction for any of the animals (turtle A, $z=1.8$ $p>0.05$; turtle B, $z=2.4$ $p>0.05$; turtle C, $z=2.2$ $p>0.05$; turtle D, $z:1.2$ $p>0.05$; turtle E, $z: 2.8$ $p>0.05$).

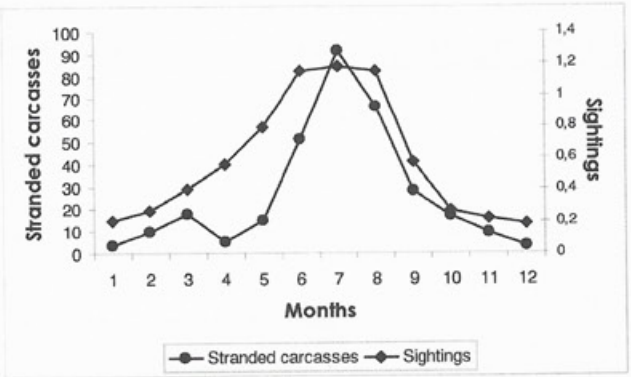


Fig. 1. Seasonal variation in sightings made by professional fishermen (left) and occurrence of stranded turtles (right).

These results suggest that immature loggerhead turtles did not migrate northward in spring. The reported summer increase in sightings and strandings is likely to be the result of the seasonal increase in mortality caused by fishing gears used only during the summer (3, 7). A further element affecting fishermen perception towards turtle abundance is likely to be the fact that these latter fishing gears are set and hauled during light hours, whereas those used in autumn and winter are set and hauled at night, when turtle sightings are unlikely. It is thus concluded that both information from fishermen and seasonal variation in number of stranded animals cannot be used to infer turtle migration or abundance.

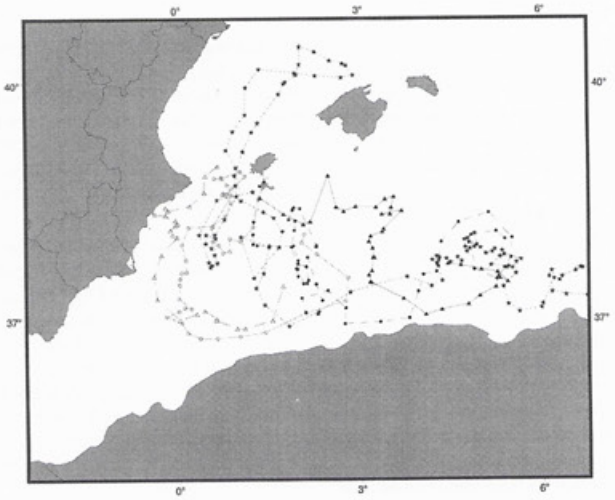


Fig. 2. Tracks followed by the five tagged turtles (early April to late July, 2003) within the Algerian basin.

References

1 - Musick J.A., Limpus C., 1997. Habitat utilization and migration in juvenile sea turtles. Pp. 137-163. *In:* Lutz P.L. and Musick J.A (eds.), The biology of sea turtles. CRC, Boca Raton.

2 - Lutz P.L., Bergey A., Bergey M., 1989. Effects of temperature on gas exchange and acid-base balance in the sea turtle *Caretta caretta* at rest and during routine activity. *J. Exp. Biol.*, 144: 155-169.

3 - Camiñas J.A., de la Serna J.M., 1995. The Loggerhead distribution in the Western Mediterranean Sea as deduced from captures by the Spanish Long Line Fishery. Pp. 316-323. *In:* Llorente G., Montori A., Santos X., and Carretero M. (eds.), Scientia Herpetologica. Asociación Herpetológica Española, Barcelona.

4 - Balazs G., Miya R., Beavers, S., 1996. Procedures to attach a satellite transmitter to the carapace of an adult green turtle, *Chelonia mydas*. Pp. 21-26. *In:* Keinath J., Barnard D., Musick J., and Bell B. (eds.). Proceedings of the 15th Annual Symposium on Sea Turtle Biology and Conservation. 1995. National Atmospheric and Oceanic Administration Tech. Memo. NMFS-SEFSC-367.

5 - Argos, 2000. User's manual. CLS, Ramonville.

6 - Zar J.H., 1984. Biostatistical Análisis. Prentice-Hall, Englewood Cliffs.

7 - Carreras C., Cardona L., and Aguilar A., In press. Incidental catch of the loggerhead turtle *Caretta caretta* off the Balearic Islands (western Mediterranean). *Biol. Conserv.*

ORIGIN AND MIGRATION PATTERN OF THE LOGGERHEAD TURTLE IN THE WESTERN MEDITERRANEAN

Carreras C. [1] *, Pascual M. [2], Cardona L. [1], Fernández G. [3], San Félix M. [4], Aguilar A. [1]

[1] Department of Animal Biology, Faculty of Biology, University of Barcelona, Spain - * carreras@ub.edu
[2] Department of Genetics, Faculty of Biology, University of Barcelona, Spain
[3] Fundación Marineland, Costa d'en Blanes, Calvià, Spain
[4] Department of Zoology, Faculty of Biology, University of Valencia, Burjasot (Valencia), Spain

Abstract

Genetic composition of loggerhead sea turtles occurring off Balearic Islands was assessed using a mitochondrial DNA marker. The haplotype composition indicated a contribution from Atlantic nesting sites, while evidence for contribution from the eastern Mediterranean was weaker. Genetic separation was found between Formentera population and the Majorca and Minorca group, suggesting different migration inputs. Majorca and Minorca populations were not different from the Azores or Madeira ones, supporting its Atlantic origin. Formentera population was not different from the Lampedusa one, suggesting a mixed origin. It is proposed that such differences reflect migratory patterns associated to prevailing currents in western Mediterranean.

Keywords: loggerhead, migration, mitochondrial DNA

Previous genetic studies have shown that loggerhead turtles present in the western Mediterranean come from nesting beaches located both in the western Atlantic and eastern Mediterranean (1), although basin heterogeneity was not considered. On the other hand, a fisheries based study (2), identified several migratory routes within the western Mediterranean, suggesting a heterogeneous contribution of Atlantic and eastern Mediterranean nesting beaches to different areas. The aim of this paper was to test the latter hypothesis.

Blood and tissue samples were collected from turtles in three islands of the Balearic archipelago: Majorca, Minorca and Formentera. A 391 bp of the control region of the D-loop of the mitochondrial DNA was sequenced using the BigDye® technology. A chi-square test was performed in order to test whether haplotype frequencies of the three islands were homogenous. Furthermore, they were compared to those reported for other immature populations found between the above mentioned putative nesting sites. Genetic distance ($Gamma_{ST}$) was estimated for each pair of populations using the programme DnaSP v3.99. Chi-square tests were used to detect differences between populations.

58 samples were analysed and 9 haplotypes were found, one of them not previously described. No significant (chi-square; $p>0.5$) differences were observed between Majorca and Minorca haplotype frequencies. Hence the two populations were grouped. Formentera differed from this group (chi-square; $p<0.01$), suggesting a different contribution of Atlantic and Mediterranean nesting beaches to both turtle populations. $Gamma_{ST}$ values between pairs of populations (Table 1) cluster them in two groups, one formed by Azores, Madeira and Majorca and Minorca and the other one by Formentera and Lampedusa. Chi-square results supported such grouping (Table 1) suggesting that Majorca and Minorca populations, as reported from Azores and Madeira (3), have an extremely limited contribution of eastern Mediterranean nesting beaches. Finally, Formentera, as reported from Lampedusa (1), might have a higher contribution from the eastern Mediterranean.

Table 1. $Gamma_{ST}$ values (above) and p-values of the chi-square test (below) between pairs of locations. ns = not significant; * = p<0.05; ** = p<0.01; *** = p<0.001.

	Formentera	Majorca & Minorca	Azores	Madeira	Lampedusa
Formentera		0.0559	0.0189	0.0298	0.0046
Majorca & Minorca	**		0.0055	0.0034	0.0770
Azores	**	ns		0.0007	0.0462
Madeira	*	ns	ns		0.0586
Lampedusa	ns	***	***	***	

Immature turtles drift passively with prevailing currents (4). Hence Atlantic juveniles enter the Mediterranean through the Gibraltar strait following the Atlantic current (Fig 1) until they reach Balearic Islands. This would explain the high similarity between Gimnesies and the Atlantic Islands. On the other hand, juveniles from the eastern Mediterranean enter the western Mediterranean through the Messina strait (5) and drift counter-clockwise with prevailing currents (Fig. 1). As Formentera is closer to the Iberian Peninsula, it is more influenced by these currents than the northern and more distant Majorca and Minorca (6). Lampedusa, as Formentera, is also influenced by both currents. This would explain the similarity and the higher contribution of Mediterranean turtles to both populations.

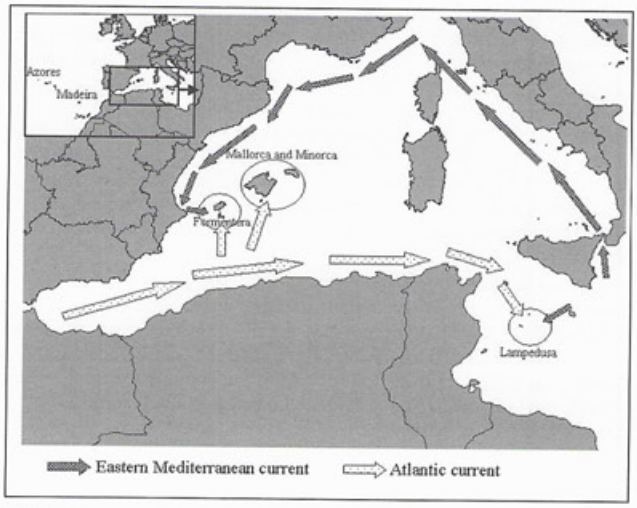


Fig 1. Map showing the major currents of the western Mediterranean and the proposed migration routes.

References

1 - Casale P., Laurent L., Gerosa G. and Argano R., 2002. Molecular evidence of male-biased dispersal in loggerhead turtle juveniles. *J. Exp. Mar. Biol. Ecol.*, 267: 139-145.

2 - Camiñas J.A. and de la Serna J.M., 1995. The Loggerhead distribution in the Western Mediterranean Sea as deduced from captures by the Spanish Long Line Fishery. Pp. 316-323. *In*: Llorente, G., Montori, A., Santos, X. and Carretero, M.A. (eds), Scientia Herpetologica. Asociación Herpetológica Española, Barcelona.

3 - Bolten A.B., Bjorndall A.A., Martins, H.R., Dellinger, T., Biscoito, M.J. Encalada, S.E. and Bowen, B.W., 1998. Transatlantic developmental migrations of loggerhead sea turtles demonstrated by mtDNA sequence analysis. *Ecol. Appl.*, 8(1): 1-7.

4 - Davenport J. and Clough W., 1986. Swimming and diving in young loggerhead sea turtles (*Caretta caretta* L.). *Copeia*, 53-57.

5 - Bentivegna F. Intra-Mediterranean migrations of loggerhead sea turtles (*Caretta caretta*) monitored by satellite telemetry. *Mar. Biol.*, 141 (4).

6 - López-Jurado J.L., 1990. Masas de agua alrededor de las Islas Baleares. *Boletín del Instituto Español de Oceanografía* 6(2): 3-20.

APOPTOSIS AND CELL LYSIS RATES DURING A DIATOM BLOOM IN THE NORTH ADRIATIC SEA

Casotti R. [1] *, Brunet C. [1], Bastianini M. [2], D'Ortenzio F. [1], Mazza S. [1], Ianora A. [1], Miralto A. [1]
[1] Stazione Zoologica "A. Dohrn" di Napoli, Italy - * raffa@szn.it
[2] Istituto di Scienze Marine, CNR, Venezia, Italy

Abstract
During the late winter diatom bloom in the Northern Adriatic Sea in 2002, the proportion of apoptotic cells were estimated using the TUNEL assay, and cell lysis rates using the FDA method. Apoptotic cells were more abundant (up to 85%) at the peak phase of the bloom, when also cell lysis rates increased (up to 0.8 d^{-1}), indicating that phytoplankton was experiencing physiological stress conditions. The occurrence of apoptotic cells may indicate an endogenous control of diatom abundances when nutrients are close to depletion, possibly triggered by chemical signaling within the population.

Keywords: diatoms, bloom, apoptosis, fronts, Adriatic

In February-March 2002, six stations were sampled on a weekly basis to estimate phytoplankton cell concentrations along a coast-to-offshore transect in correspondence to the Po river delta. Phytoplankton concentrations were estimated using flow cytometry, microscopy, HPLC-pigment analysis, and remote sensing (SeaWifs). Percentages of apoptotic cells were estimated using the TUNEL assay, while cell lysis rates were estimated using the FDA method.

Pigment indicators (Dt/Dt+Dd) suggested a light-induced stress on phytoplankton trapped within the front separating Po river freshwater from offshore marine waters.

The evolution of total phytoplankton concentrations was evident only at the three most offshore stations, situated on the external side of an haline front, caused by the freshwater river outflow. Cell concentrations ranged from 500 cell ml^{-1} before the bloom to 10^5 cell ml^{-1} at its peak (20 March). The phytoplankton bloomwas mainly composed of diatoms (up to 90% of total counts), with *Skeletonema costatum* dominating the diatoms at the peak phase of the bloom.

At the frontal area (station 4) high percentages of Diatoxanthin and Diadinoxanthin were observed, indicating the occurrence of light-induced stress within the phytoplankton population trapped within the haline front.

Within the *S. costatum* population, apoptotic cells ranged from 30 to 85% of total cells at all stations, and at station 4 their evolution strongly correlated with *S. costatum* cell numbers (Fig. 1). The peak in apoptotic cells corresponded to a peak in cell lysis rates (from 0.1 to 0.8 d^{-1}).

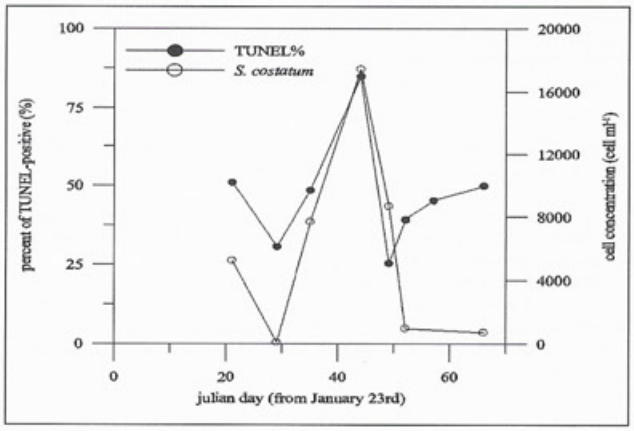


Fig. 1. *S. costatum* cell concentrations (cell ml^{-1}, closed symbols) and percentages of TUNEL-positive cells (open symbols) in the northern Adriatic Sea in February-March 2002.

The high percentage of apoptotic cells may indicate an endogenously-controlled process of initiation of lysis of phytoplankton cells.

Apoptosis is the phenotype of Programmed Cell Death, an active mechanism of cell disruption activated by cells as a response to stress or changes in environmental factors.

The presence of apoptosis in unicellular organisms may represent an evolutionary relic, but also support the hypothesis that it is a widespread and crucial feature of the eukaryote world, best suited for adaptation to different environments, and, as in our case, as a reaction to unfavorable conditions.

The late winter diatom bloom is a recurrent feature in the North Adriatic Sea, starting in February and persisting in a large area for more than two months. With respect to other coastal areas, this bloom is characterized by the dominance of *Skeletonema costatum*, which is later on replaced by *Chaetoceros* species, during the following spring bloom. No detailed information is available on the dynamics of this bloom, which is peculiar for its duration and almost monospecificity. Miralto *et al.* (1) have shown that the North Adriatic late winter diatom bloom has a strong effect on copepod reproduction and therefore recruitment, strongly impacting the whole food web. This effect has been attributed to the production of unsaturated aldehydes by diatom species. These molecules appear to be involved in a defence mechanism activated after cell membrane disruption, as during grazing (2). It is reasonable to expect that aldehydes are also released in the seawater following cell lysis, a common process at sea, controlled by exogenous (bacteria, viral attack, nutrient limitation), or endogenous (senescence, automortality) factors (3; 4). Algal aldehydes have been shown to be toxic to other phytoplankton and to induce apoptosis in Copepods and sea urchin embryos (5). Possibly, the realease of such compounds via natural lysis of cells during the bloom may have determined apoptosis of cells during the late winter bloom of 2002. Apoptosis may therefore be regarded as a general mechanism acting at sea to control population growth, in order to optimize resources utilization at the end of the bloom.

References

1 - Miralto A., Barone G., Romano G., Poulet S.A., Ianora A., Russo G.L., Buttino I., Mazzarella G., Laabir M., Cabrini M., Giacobbe M.G., 1999. The insidious effect of diatoms on copepod reproduction. *Nature*, 402: 173-176.
2 - Pohnert G., 2000. Wound-activated chemical defense in unicellular planktonic algae. Angew. *Chem. Int. Ed Engl.*, 39: 4352-4354.
3 - Agustí S., Satta M.P., Mura M.P., Benavent E., 1998. Dissolved esterase activity as a tracer of phytoplankton lysis: Evidence of high phytoplankton lysis rates in the northwestern Mediterranean. *Limnol. Oceanogr.*, 43(8): 1836-1849.
4 - Veldhuis M.J.W., Kraay G.W., Timmermans K.R., 2001. Cell death in phytoplankton: correlation between changes in membrane permeability, photosynthetic activity, pigmentation and growth. *Eur. J. Phycol.*, 36: 167-177.
5 - Romano G., Russo G.L., Buttino I., Ianora A., Miralto A., 2003. A marine diatom-derived aldehyde induces apoptosis in copepod and sea urchin embryos. *J. Exp. Biol.*, 206: 3487-3494.

SEASONAL DIFFERENCES IN THE GROWTH OF PILCHARD *SARDINA PILCHARDUS* LARVAE IN THE CATALAN SEA (NW MEDITERRANEAN).

I.A. Catalán, M.P. Olivar *, I. Palomera, E. Berdalet, C. Roldán and B. Aguilera
Institut de Ciències del Mar, Barcelona, Spain - * polivar@icm.csic.es

Abstract

The long- and short-term growth of 3.5 to 16 mm standard length *Sardina pilchardus* larvae was compared between two cruises conducted in autumn and winter in the Catalan Sea (NW Mediterranean). Growth was significantly higher in November than February, as assessed by muscle fibre recruitment and RNA/DNA ratios. Otolith age-length relationships suggested a similar trend. Sea temperature is regarded as a plausible explanatory factor for the differences in growth.

Keywords: Sardina pilchardus, larvae, growth, NW Mediterranean, temperature

Peak spawning of *Sardina pilchardus* in NW Mediterranean occurs in the unstable autumn-winter season (1). Although variations in environmental factors are known to affect both distribution and abundance of pilchard larvae in this area (2, 3), there is little information on the possible effects of environmental conditions on larval biological parameters and their possible relationship to survival.

The objective of the present study was to test the hypothesis that long- or short-term growth does not differ between two seasons (autumn and winter) characterised by marked differences in mean water temperature and comparable mean concentrations of potential food items.

Two cruises were conducted, in the Catalan Sea in November 1998 and February 1999. Long-term growth was estimated by (a) age-length relationships, and (b) the variation of fast muscle fibre numbers. The rationale for the latter method, seldom used in field studies, is that small differences in environmental variables (particularly temperature) during egg and early larval stages are known to alter muscle hyperplasia and/or hypertrophy, thus modifying larval growth (4, 5). Short-term growth was assessed through RNA/DNA ratios, based on the method described by Deniel (6).

Mean sea surface temperature in November 1998 (Mean=19.2ºC, SE=0.007) was about 6°C higher than in February (Mean=12.9°C, SE=0.07)). The analysed larvae were collected from areas where the median values of copepod nauplii were between 4.4 nauplii l^{-1} (November) and 6.3 nauplii l^{-1} (February). The vertical profiles of mean temperature in the depth-range inhabited by pilchard larvae (2) showed a strong thermocline in November. It is believed that relative temperature differences between cruises were maintained during all developmental history of the larvae (based on AVHRR data: 7).

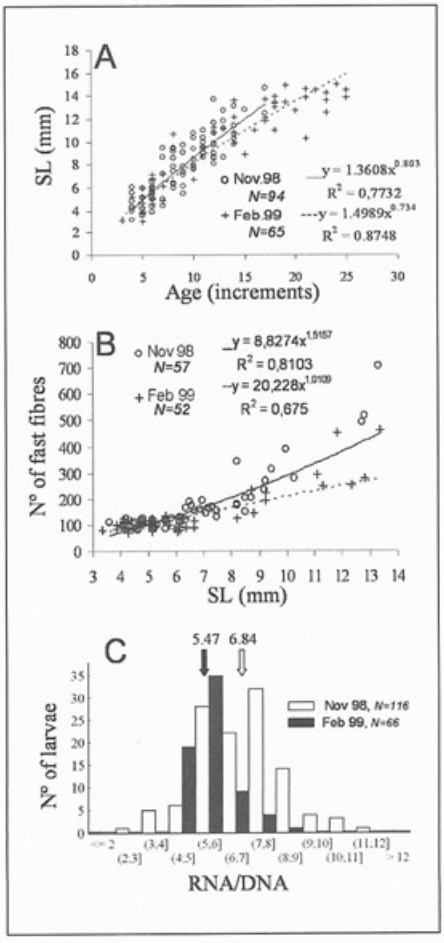


Fig. 1. Comparison of long and short-term growth of *Sardina pilchardus* larvae in November 1998 and February 1999. (A) Relationship between estimated age and standard length. (B) Relationship between standard length and total number of fast fibres, per transverse section of myotomal muscle. (C) Frequency distributions of RNA/DNA ratio values. Arrows indicate medians.

Long-term measures of growth indicated that pilchard larvae exhibited higher growth rates in November than in February. For both otolith and muscle-derived data, the slopes of the regression lines were compared between periods by testing the significance of the interaction term in a crossed two-way ANOVA with covariates (age or length) performed on appropriatedly standardised variables for GLM analysis. Although no significant difference in the slopes could be established between cruises for the age-length data at an α=0.05, the qualitative observation of the data (Fig 1A) suggest that November larvae tended to be younger (faster-growing) for a given length (Fig. 1 A). This hypothesis is strengthened by the significantly higher recruitment of fast muscle fibres in November respect to February (Fig. 1B), as shown by the significant interaction term in the ANOVA (interaction term: "year x total length" length used as a covariate, $F_{1,106}$=13.43, p<0.001).

The median RNA/DNA ratio in November was also significantly (Mann-Whitney W=4174, p<0.0001) higher than in February, which reinforces the results of the long-term growth analyses (Fig. 1C).

It is concluded that the 6ºC difference in temperature between the two periods could account for the observed higher growth estimates in November than in February. However, the effect of changes in species composition of potential prey in February, related to the long persistence of a mesoscale eddy near the study area (7), cannot be ruled out. The slower growth of winter-spawned larvae could have negative consequences for survival to juvenile stages. Individuals would remain longer in the planktonic phase, which as noted elswhere (8) could increase the predator-induced accumulated mortality.

References

1 - Palomera I., Olivar MP., 1996. Nearshore ichthyoplankton off the Costa Brava (Northwest Mediterranean). *Bol. Inst. Esp. Oceanogr.*, 22: 71-76.

2 - Olivar MP., Salat J., Palomera I., 2001. Comparative study of spatial distribution patterns of the early stages of anchovy and pilchard in the NW Mediterranean Sea. *Mar. Ecol. Prog. Ser.*, 217: 111-120.

3 - Olivar MP., Catalán IA., Emelianov M., and Fernández de Puelles ML., 2003. Early stages of *Sardina pilchardus* and environmental anomalies in the NW Mediterranean. *Est. Coast. Shelf Sci.*, 56: 609-619.

4 - Stoiber W., Haslett JR., Sänger A.M., 1999. Myogenic patterns in teleosts: what does the present evidence really suggest? *J. Fish Biol.*, 55: 84-99.

5 - Johnston IA., Temple GK., Vieira VLA., 2001. Impact of temperature on the growth and differentiation of muscle in herring larvae. Pp. 99-120. *In*: Thorndyke D.A.M.. (ed), Environment and Animal Development: Genes, Life Histories and Plasticity. BIOS Scientific Publishers Ltd., Oxford.

6 - Berdalet E., 2002. Quantization of nucleic acids in marine microplankton samples Pp. 271-289. *In*: Pelagic Ecology Methodology. Subba Rao D.V. (ed). A.A. Balkema publishers.

7 - Pascual A., *et al.*, 2000. Detection by altimetry and AVHRR images of fan intense anticyclonic eddy in the Balearic Sea. *Proc. Int. Soc. Opt. Eng.*, 4172: 31-36.

9 - Hunter, J.R., 1981. Feeding ecology and predation of marine larvae. Pp. 34-77. *In*: Lasker, R. (ed), Marine fish larvae: morphology, ecology and relation to fisheries, Univ. of Washington Press, Seattle.

RELATIONS BIOMETRIQUES CHEZ LE MULET DORÉ *LIZA AURATA* DE LA LAGUNE MELLAH (ALGERIE NORD-EST)

Chaoui L. [1] *, Kara M.H. [1] et Quignard J.P. [2]

[1] Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie - * chaouilamya@hotmail.com
[2] Laboratoire d'Ichtyologie Méditerranéenne, Castelnau-Le-Lez, France

Résumé

La morphologie du mulet doré *Liza aurata* de la lagune du Mellah est décrite par 15 caractères morphologiques. L'expression mathématique de la relation taille-poids indique une croissance allométrique minorante. Les variations mensuelles du coefficient d'allométrie permettent de déceler la période de reproduction.

Mots-clés: mulet doré, lagune, MED, morphologie, croissance

Introduction

Le concept de la structuration géographique chez les poissons est important pour l'étude de la dynamique des populations et pour la gestion des pêcheries. Dans ce contexte, la quantification des caractères morphologiques d'un groupe d'individus peut démontrer le degré de spéciation induit, aussi bien par des facteur biotiques qu'abiotiques, contribuant ainsi à l'identification des stocks différents. L'expression mathématique de la relation taille-poids permet, pour sa part, de connaître l'embonpoint des poissons et constitue une donnée nécessaire pour l'estimation des biomasses. En outre, ses variations mensuelles peuvent nous renseigner sur la période de reproduction.

Nous décrivons dans cette note la morphologie du mulet doré *Liza aurata* de la lagune du Mellah et l'évolution mensuelle de sa croissance relative.

Matériel et méthodes

L'étude biométrique porte sur quinze caractères métriques mesurés chez 167 individus des deux sexes, de longueur totale comprise entre 23,2 et 44,7 cm. Les différentes dimensions sont exprimées en fonction de la longueur totale ou de la longueur de la tête par une relation allométrique de la forme $y = ax^b$ (a: constante, b: coefficient d'allométrie). La comparaison statistique du coefficient d'allométrie avec la valeur 1 est réalisée par le test t de Student (1) au seuil de signification $\alpha = 0,001$.

La relation entre la longueur totale et le poids total est déterminée mensuellement à l'aide du programme Fishparm 3.0 (2). Son expression globale à l'échelle de l'année est également donnée pour un total de 300 individus d'une longueur totale comprise entre 20 cm (71 g) et 49,5 cm (1004 g).

Résultats et interprétations

Le Tab. 1 montre que tous les paramètres mesurés sont significativement corrélés à la longueur totale ou à la longueur céphalique ($P \leq 0,01$). La corrélation la moins forte est celle qui relie le diamètre de l'œil à la longueur de la tête ($r = 0,442$). L'isométrie de croissance concerne cinq des caractères examinés (longueur standard, longueur à la fourche caudale, diamètre de l'œil, longueur pré-dorsale, longueur post-pectorale). Les autres dimensions croissent de manière allométrique majorante par rapport à la longueur totale ou à celle de la tête. Seuls 3, 4 et 5 se sont intéressés à la morphologie de *L. aurata*, mais uniquement les rapports longueur standard/ longueur totale ou longueur à la fourche/ longueur totale ont été considérés.

Tab. 1. Corrélations et relations d'allométrie entre les différents caractères mesurés et la longueur totale ou céphalique de *Liza aurata* de la lagune Mellah.

Fonction	Corrélation	Relation d'allométrie	Valeurs extrêmes (mm)
Ls = f (Lt)	0,980	*Ls = 0,680 $Lt^{1,027}$	207 ≤ Ls ≤ 402
Lf = f (Lt)	0,985	*Lf = 0,993 $Lt^{0,981}$	183 ≤ Lf ≤ 363
Lc = f (Lt)	0,891	**Lc = 0,025 $Lt^{1,344}$	38 ≤ Lc ≤ 89
Do = f (Lc)	0,442	*Do = 0,224 $Lc^{0,929}$	8 ≤ Do ≤ 14
Po = f (Lc)	0,659	**Po = 0,060 $Lc^{1,304}$	8 ≤ Po ≤ 20
po = f (Lc)	0,798	**po = 0,115 $Lc^{1,402}$	14 ≤ po ≤ 68
Hc = f (Lt)	0,694	**Hc = 34.10^{-5} $Lt^{2,034}$	25 ≤ Hc ≤ 72
Hpc = f (Lt)	0,797	**Hpc = 88.10^{-4} $Lt^{1,369}$	16 ≤ Hp ≤ 35
Pd = f (Lt)	0,953	*Pd = 0,299 $Lt^{1,042}$	87 ≤ Pd ≤ 175
Pp = f (Lt)	0,888	**Pp = 0,006 $Lt^{1,582}$	40 ≤ Pp ≤ 87
pp = f (Lt)	0,900	*pp = 0,297 $Lt^{1,026}$	76 ≤ pp ≤ 145
Pa = f (Lt)	0,895	**Pa = 0,200 $Lt^{1,175}$	118 ≤ Pa ≤ 253
Lmax = f (Lc)	0,512	**Lmax = 0,003 $Lc^{1,857}$	4 ≤ Lmax ≤ 13
Lid = f (Lt)	0,678	**Lid = 18.10^{-4} $Lt^{2,109}$	22 ≤ Lid ≤ 71
Eio = f (Lc)	0,847	**Eio = 0,001 $Lc^{1,039}$	16 ≤ Eio ≤ 39

Lt: longueur totale; Ls: longueur standard; Lf: longueur à la fourche caudale; Lc: longueur céphalique; Do: diamètre de l'œil; Po: longueur pré-orbitaire; po: longueur post-orbitaire; Hc: hauteur du corps; Hpc: hauteur du pédoncule caudal; Pd: longueur pré-dorsale; Pp: longueur pré-pectorale; pp: longueur post-pectorale; Pa: longueur pré-anale; Lmax: longueur du maxillaire supérieur; Lid: longueur inter-dorsales; Eio: espace inter-orbitaire; *: isométrie; **: allométrie.

Globalement, le poids de *Liza aurata* de la lagune du Mellah croît moins vite que sa longueur ($P = 1,9 . 10^{-2} L^{2,776}$; $r^2 = 0,875$). Cette situation est décrite également dans l'étang de Berre et de Port de Bouc (6). Les variations mensuelles du coefficient d'allométrie (Fig. 1) montrent que les valeurs les plus élevées, indiquant une allométrie majorante, sont enregistrées à la fin de l'automne et au début de l'hiver. Cette période coïncide avec la saison de reproduction de l'espèce. En effet, le développement des gonades entraîne un gain pondéral somatique important.

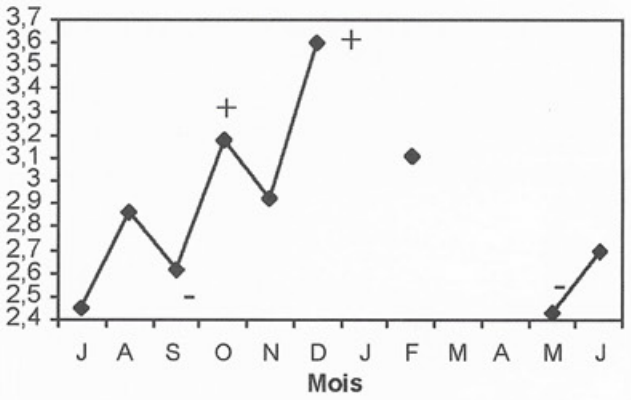


Fig. 1. Variations mensuelles du coefficient d'allométrie de *Liza aurata* dans la lagune Mellah (+: allométrie majorante; -: allométrie minorante).

Références

1 - Dagnélie P., 1975. Théorie et méthodes statistiques. 2: les méthodes de l'inférence statistique. Les presses agronomiques de Gembloux. 451 p.

2 - Saila S. B., Recksiek C. R., Prager M. H., 1988. Basic fishery science programs. A compenction microcomputer programs and manual of operation. Elsevier, *Dev. Aquacult. Fish. Sci.*, 18: 231 p.

3 - Ezzat A., 1964. Contribution à l'étude de la biologie des mugilidés de la région de l'étang de Berre et de Port de Bouc. *Rec. Trav. Stn. Mar. Endoume*, 47(31): 187-202.

4 - Sancho J. M., 1975. Estudio comparativo del crecimiento del Albur, *Mugil auratus*, en tres esteros de la provincia de Cadiz y parametros mas importantes obtenidos. *Publ. Tec. Junta Est. Pesca*, 11: 231-43.

5 - Farrugio H., 1975. Les muges de Tunisie. Répartition et pêche. Contribution à leur étude systématique et biologique. Thèse, Université des Sciences et Techniques du Languedoc, Montpellier.

6 - Ezzat A., 1965. Contribution à l'étude de la biologie de quelques mugilidés de la région de l'étang de Berre et de Port de Bouc. Thèse, Marseille.

DIET COMPARISON OF THE BATHYAL SHRIMPS *ARISTEOMORPHA FOLIACEA* (RISSO, 1827) AND *ARISTEUS ANTENNATUS* (RISSO, 1816) (DECAPODA: ARISTEIDAE) IN THE EASTERN MEDITERRANEAN.

Chartosia N. [1] *, Kitsos M.-S. [1], Karani I. [1], Tzomos Th. [1], Tselepides A. [2], Koukouras A. [1]

[1] Department of Zoology, School of Biology, Aristoteleio University of Thessaloniki, Greece - * akoukour@bio.auth.gr
[2] Institute of Marine Biology of Crete, Iraklio, Crete, Greece

Abstract

Stomach contents analysis of the bathyal shrimps *Aristeomorpha foliacea* and *Aristeus antennatus*, collected by otter trawl in the Cretan Sea, at depths of 623-627 m, revealed the presence of a wide variety of prey categories. Crustacea was the most abundant and frequent prey category in both species. The diets of *A. foliacea* and *A. antennatus* do not differ significantly.

Key words: Diet, Aristeus antennatus, Aristeomorpha foliacea

Introduction

The information concerning the diet of *Aristeomorpha foliacea* (Risso, 1827) and *Aristeus antennatus* (Risso, 1816) in the Mediterranean is limited to studies carried out in the northwestern or central Mediterranean (1-5).

The aim of this study is to document and compare the diet of these species in the Eastern Mediterranean.

Material and methods

The material was collected with an otter trawl in the Cretan Sea in February 2000, at depths 623-627 m. Analysis of the stomach contents followed previously described methods (6).

Results and discussion

The stomach content analysis of 200 individuals of *A. foliacea* showed that 37% were empty. The most abundant prey category was Crustacea (50.23% of the prey items) followed by Chordata (20.54%).

The analysis of 192 stomachs of *A. antennatus* showed that 39% of them were empty. The most abundant prey category was Crustacea (41.80%) followed by Echinodermata (18.88%).

The percentage frequency of occurrence (F %) for the two species is given in Figure 1. The most frequent prey category was Crustacea, both for *A. foliacea* (Fig.1A) and for *A. antennatus* (Fig.1B).

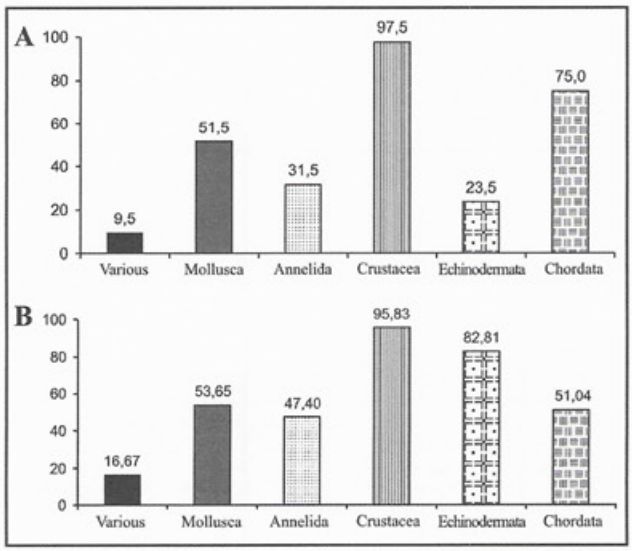


Fig. 1. The percentage frequency of occurrence (F %) of A. *Aristeomorpha foliacea*, B. *Aristeus antennatus*.

Concerning *A. foliacea*, our results agree with Bello au Pipitone (5), while those of *A. antennatus* agree with those of Cartes (3).

The diet comparison of these two species does not show significant differences between them.

References

1 - Lagardère, J.-P., 1971. Research on the nutrition of shrimps from the Moroccan continental shelf. *Tethys*, 3(3): 655-675.

2 - Cartes, J.E., F. Sardà, 1989. Feeding ecology of the deep-water aristeid crustacean *Aristeus antennatus*. *Mar. Ecol. (Prog. Ser.)*, 54(3): 229-238.

3 - Cartes, J.E., 1994. Influence of depth and season on the diet of the deep water aristeid *Aristeus antennatus* along the continental slope (400 to 2300 m) in the Catalan Sea (western Mediterranean). *Mar. Biol.*, Berlin, Heidelberg, 120(4): 639-648.

4 - Cartes, J.E., 1995. Diets of, and trophic resources exploited by bathyal penaeoidean shrimps from the western Mediterranean. *Mar. Freshwat. Res.*, 46(6): 889-996.

5 - Bello, G., C. Pipitone, 2002. Predation on cephalopods by the giant red shrimp *Aristaeomorpha foliacea*. *J. Mar. Biol. Assoc. U.K.*, 82(2): 213-218.

6 - Deniel, C., 1975. Régimes alimentaires d'*Arnoglossus thori* Kyle et d'*Arnoglossus imperialis* Rafinesque (Téléostéens-Bothidae) en la baie de Douarnenez. *Rev. Trav. Inst. Sci. Pêches marit.*, 39(1): 105-106.

ANALYSIS OF BOAT SEINE CATCHES OF *MULLUS BARBATUS, M. SURMULETUS, PAGELLUS ERYTHRINUS AND TRACHURUS MEDITERRANEUS* IN GREEK WATERS

Anna Chilari * and George Petrakis

National Centre for Marine Research, Aghios Kosmas, Hellinikon, 16610, Athens, Greece - * annachil@ncmr.gr

Abstract

A scientific observer programme was used to study boat seine catches taken in three areas of Greece: Ionian Sea, Cyclades Islands, Pagassitikos Gulf, between October 2000 and May 2001 Discarding practices concerning four species, red mullet (*Mullus barbatus*), striped red mullet (*M. surmuletus*), common red pandora (*Pagellus erythrinus*) and mediterranean horse mackerel (*Trachurus mediterraneus*), for which minimum landing size (MLS) restrictions are currently enforced, were analysed in order to quantify the capture of undersized individuals of the target species and to assess the possible negative impact of the fishery on the stocks.

Keywords: boat seine, catches, minimum landing size, Greece

Introduction

Fishing activities result in the capture of non-target species and undersized individuals of target species (1). Although boat seine is considered to have a negative impact on the stocks due to the capture of large numbers of juveniles or under-sized individuals of many commercial species, related studies are very scarce.

The boat seine fishery in Greek waters is managed by technical measures including spatial and temporal closures, gear restrictions including minimum mesh sizes, distance from the coast and minimum landing size restrictions (2). In this study, the catches and the length frequency distributions of four of the most important target species (red mullet, striped red mullet, common pandora and mediterranean horse mackerel), for which MLS restrictions are currently enforced, caught by boat seining in three different areas of Greece, were analysed in order to quantify the capture of undersized individuals and to evaluate the impact of the gear on the resources.

Materials and methods

Scientific observers accompanied commercial boat-seine crews on 17 fishing trips (94 hauls) between October 2000 and May 2001 in three different regions of Greece: Ionian Sea, Aegean Sea-Cyclades Islands and Pagassitikos Gulf. The mesh size used was 16 mm and fishing took place in depths 15-47 m. For each haul, the total catch was sorted into the retained and discarded components by the commercial fishers. The total weights and numbers of each individual species (retained and discarded) were recorded, as were the lengths (to the nearest cm) of all the species.

Results and discussion

Data on the catch composition of the boat seine and the mean total numbers of retained and discarded individuals are presented elsewhere (3). Retained catch rates of horse mackerel were estimated to be greater than 100 individuals per haul in Pagassitikos Gulf (Table 1). Red mullet and common pandora had estimated retained catch rates greater than 10 individuals per haul in the Ionian Sea and Pagassitikos Gulf, while striped red mullet in Aegean and Ionian Sea. Red mullet and striped red mullet and horse mackerel (except in Pagassitikos Gulf) had estimated discarded rates of less than 1 individual per haul. Common pandora had greater discard rates (>3 individuals per hauls) with more than 100 individuals discarded per haul in Pagassitikos Gulf.

Table 1. Mean numbers of retained and discarded individuals of the four main target species caught in the boat seine fishery in each of the sampling areas for the period between October 2000 and May 2001.

	Species	Cyclades	Ionian Sea	Pagassitikos Gulf
Retained	*Mullus barbatus*	1.04	29.34	28.59
	Mullus surmuletus	18.86	25.38	0.43
	Pagellus erythrinus	4.64	19.55	39.16
	Trachurus mediterraneus	0.04	1.17	274.51
Discarded	*Mullus barbatus*	0.04	0.34	
	Mullus surmuletus		0.31	
	Pagellus erythrinus	3.00	14.48	117.19
	Trachurus mediterraneus	0.11	0.90	17.24

Analysis of the sizes of retained and discarded individuals of the four species is presented in Table 2. None or very few individuals of red mullet and striped red mullet were discarded in the three areas. In the Ionian Sea 33% of the retained individuals of both species were undersized (<11 cm), as were 97% of the retained individuals of red mullet and 14% of striped red mullet in Cyclades Islands. Almost 99% of the discarded individuals of common pandora in the three areas were below the MLS (<12 cm), while 4.8% and 12.6% of undersized individuals were retained in Ionian Sea and Pagassitikos Gulf. Almost 14% of the retained horse mackerel in Pagassitikos Gulf were undersized (<12 cm), while on the other hand 18% and 53.8% of the discarded individuals were above the MLS in the same area and in Ionian Sea, respectively.

Table 2. Total, retained and discarded numbers in relation with MLS for the four species, in the boat seine fishery in Greek waters between October 2000 and May 2001.

	Species	Total		Retained		Discards	
		Number	%< MLS	Number	%< MLS	Number	%< MLS
Cyclades	*M. barbatus*	30	96.7	29	96.6	1	100.0
	M. surmuletus	528	13.8	528	13.8	-	
	P. erythrinus	214	38.8	130	0.0	84	98.8
	T. mediterraneus	4	75.0	1	0.0	3	100.0
Ionian Sea	*M. barbatus*	861	34.4	851	33.6	10	100.0
	M. surmuletus	745	34.2	736	33.2	9	100.0
	P. erythrinus	987	44.6	567	4.8	420	98.3
	T. mediterraneus	60	20.0	34	0.0	26	46.2
Pag.Gulf	*M. barbatus*	1058	2.3	1058	2.3	-	
	M. surmuletus	16	6.3	16	6.3	-	
	P. erythrinus	5785	78.0	1449	12.6	4336	99.8
	T. mediterraneus	10795	17.8	10157	13.8	638	82.0

The retention of undersized specimens of individuals of *Mullus* spp. is explained by their high commercial value. In contrast, individuals larger than the MLS of the low commercial value horse mackerel were also returned to the sea. In conclusion, except for common pandora in Pagassitikos Gulf, the operation of the gear showed no significant impact on the juveniles of these species.

References

1 - Jennings S., and Kaiser M. J., 1998. The Effects of Fishing on Marine Ecosystems. *Adv. Mar. Biol.*, 34: 201-352.

2 - Stergiou K. I., Christou E. D., Georgopoulos D., Zenetos A., and Souvermezoglou C., 1997. The Hellenic Seas: Physics, Chemistry, Biology and Fisheries. *Oceanogr. Mar. Biol.* (Annual Review), 35: 415–538.

3 - Petrakis G., Chilari A., and Kavadas S., 2003. Retained and discarded catches from commercial boat seine in Greek waters (this volume).

APPLYING THE MASS-BALANCE APPROACH TO STUDY THE EXPLOITED MARINE ECOSYSTEMS IN NW MEDITERRANEAN SEA

Marta Coll [1] *, Isabel Palomera [1], Sergi Tudela [2], Francesc Sardà [1]

[1] Institut de Ciències del Mar (CMIMA – CSIC), Barcelona, Spain - * mcoll@icm.csic.es
[2] WWF Mediterranean Program Office, Barcelona, Spain

Abstract

The mass-balance approach was applied to study the structure and function of the exploited ecosystem associated with the Delta of Ebro River, NW Mediterranean Sea. An ecological model composed of 45 functional groups related with pelagic, demersal and benthic domains was constructed and important ecosystem attributes and interactions within species and fisheries were underlined.

Keywords: Mass-balance model, Ecopath, NW Mediterranean

Introduction

There are few examples of the mass-balance approach applied to Mediterranean marine ecosystems (1-3). Yet it provides important knowledge on ecosystem-based management of fisheries within the Mediterranean context. This attempt aims to study the trophic structure and functioning of an exploited marine ecosystem, to analyze the ecosystem attributes related with the state of health and maturity theoretical frameworks (4) and to set the baseline to conduct dynamic simulations and fisheries policy analysis accounting for ecosystem trophic interactions (5, 6). The study area is important, related with fishing activity within the Spanish Mediterranean context and also especially relevant for conservation of seabird populations (7).

Methodology

The application was developed in the shelf and upper slope exploited area associated with the Delta of Ebro River (from 50-400 m depth), excluding the coastal region where the artisanal fleet operates. Semi-industrial fleets (i.e., bottom trawlers, purse seiners and longliners) are the most important in terms of catches. The troll bait fleet was also considered in the study.

The mass-balance model was constructed using the latest version of Ecopath (5, 6). The Automatic Mass Balance Procedure (8) (AMBP) was used to assess mass-balance, while the Pedigree routine was applied to describe the origin and quality of inputs and to assign confidence intervals to data to apply then while using AMBP. Biomass, P/B ratio, Q/B ratio, trophic information, assimilation rate and fisheries' data were recompiled for 1994 to 2000 from trawling and acoustic surveys and bibliographic sources mainly (9). Discards and estimation of catches from IUU fishing activities (illegal, unreported or unregulated catches) were also included to modify official catch data. Inputs were expressed on an annual basis per unit surface area and wet weight terms (T/km^2,$T/km^2/y$). Functional groups were defined from over 190 species of invertebrates, fish and other vertebrates considering ecological and biological features, trophic information and importance in fishery (9).

Results and discussion

45 functional groups were defined: 11 related with invertebrates, 20 of benthic, benthopelagic and pelagic fishes, 5 of non-fish vertebrates, 3 related with primary production, detritus and import biomass and 6 related with fisheries in terms of fleets and discards. The model was comprised between four trophic levels, the highest value belonging to anglerfish (4.53), followed by coastal dolphins and squids. Most functional groups occurred at trophic levels 2.80 to 3.83.

Flows ($T/km^2/year$) per trophic level underlined the importance of phytoplankton–zooplankton compartments in the ecosystem (with 47.2% of the absolute flows), of detritus (28.1%), of polychaete-other benthic invertebrate groups (12.2%), and to a lesser extent of small pelagic fishes (4.6%). These results could underline bottom-up and wasp-waist control situations, as well as competition between groups of similar trophic levels. The same conclusion arises when analyzing the mixed trophic impact routine that enables the qualitative exploration of impacts that a theoretical increase of the biomass of a functional group would have on the other biomasses (5, 6). Anchovy and sardine were also shown to have wide impacts on numerous functional groups of higher and lower trophic levels. Transfer efficiency (5, 6) (12.7%) was within the common values described in the literature (10).

The primary production required to support the fisheries was 49% of the primary production of the ecosystem, highlighting an intensive fishing pressure on marine resources. This value was high compared with other models and even higher than a preliminary estimate for the Catalan coast (11). The analysis of the relative consumption of target fish groups production by different predators showed that squids had the higher impact on consumption of benthic and demersal fish production (47%), followed by the fishery (27%). The first consumer of small and medium sized pelagic fish production was the fishery (39%), followed by adult hake (32%) and squids (17%). The analysis of catch per trophic level showed that the third trophic level provided the highest caught biomass (72.9%), followed by the second (15.2%). Therefore, the mean trophic level of the catch was 3.03, underlying that catches were mostly composed of organisms feeding on zooplankton, e.g. small pelagics. Comparing the trophic levels of the fleets with the trophic levels of the functional groups it was seen that fisheries functioned as top predators.

The trawling fleet had the widest impact on the different functional groups of the ecosystem and also the deepest impact on some of the target and non-target functional groups of the ecosystem. The longline fleet had some deep negative impact on biomass of marine turtles, sea birds and dolphins and slightly positive impacts, mainly on small pelagics and mackerel. The purse seine fleet and troll bait fleet had lower impacts on the diversity of groups; however important negative impacts were recorded on their main target species.

References

1 - Örek H., 2000. An application of Mass Balance Ecopath Model to the trophic structure in the Black sea "after anchovy collapse". Ms. In Marine Science. Middle East Technical University. 119 p.

2 - Pinnegar J.K., 2000. Planktivorous fishes: links between the Mediterranean littoral and pelagic. PhD Thesis, University of Newcastle upon Tyne, UK. 213 p.

3 - Pranovi F., Libralato S., Raicevich S., Granzotto A., Pastres R. and Giovanardi O., 2003. Mechanical clam dredging in Venice lagoon: ecosystem effects evaluated with trophic mass-balance model. *Mar. Biol.*, 143: 393-403.

4 - Christensen V., 1995. Ecosystem maturity – towards quantification. *Ecol. Model.*, 77: 3-32.

5 - Christensen V., Walters C. and Pauly D., 2000. Ecopath with Ecosim: a User's guide. Fisheries Centre of University of British Columbia, Canada / International Center for Living Aquatic Resources Management, Malaysia. 130 p.

6 - Pauly D., Christensen V. and Walters C., 2000. Ecopath, Ecosim and Ecospace as tools for evaluating ecosystem impact of fisheries. *ICES J. Mar. Sci.*, 57: 697-706.

7 - Abelló P., Arcos J.M and Gil De Sola L., 2003. Geographical patterns of seabird attendance to a research trawler along the Iberian Mediterranean coast. *Sci. Mar.*, 67 (Suppl.2): 69-75.

8 - Kavanagh P., 2002. Automatic Mass Balance Procedure for Ecopath Ecosystem Models User's Guide. Fisheries Center. University of British Columbia. 28 p.

9 - Coll M., 2002. Construcción de un modelo de equilibrio de masas Ecopath en el ecosistema marino explotado asociado al Delta del Ebro, Mediterráneo noroccidental. Recogida y análisis de los datos básicos. M.Sc. thesis. Autonomous University of Barcelona, Spain. 241 p.

10 - Odum E. P., 1971. Fundamentals of Ecology. Saunders Publ., Philadelphia. 574 p.

11 - Tudela S., 2000. Assessment of the ecological footprint of fishing in the Catalan central coast (NE Spain). *In*: Briand F. (ed.). Fishing down the Mediterranean Food Webs? *CIESM Workshop Series*, 12: 79-81.

PRELIMINARY RESULTS OF MODELING FISHING EFFECTS ON EXPLOITED MARINE ECOSYSTEMS IN NW MEDITERRANEAN SEA

Marta Coll [1] *, Sergi Tudela [2], Francesc Sardà [1], Isabel Palomera [1],
[1] Institut de Ciències del Mar (CMIMA – CSIC), Barcelona, Spain - * mcoll@icm.csic.es
[2] WWF Mediterranean Program Office, Barcelona, Spain

Abstract
A mass-balance model of the NW Mediterranean Sea was used as a baseline to explore ecosystem effects of fishing under different combinations of bottom-up and top-down control situations and under different changes in fishing effort. Preliminary results of main ecosystem effects are explored.

Keywords: Effects of fishing, Ecosim, NW Mediterranean

Introduction

The dynamic simulation tool Ecosim (1, 2) has extended Ecopath initial capabilities by providing a temporal dimension and spread out its applications for exploring ecosystem effects of changes in fishing efforts and fishing policies (3, 4). Preliminary results of an attempt to apply Ecosim to a case study from the NW Mediterranean Sea (5) are presented and ecosystem effects of fishing accounting for ecosystem trophic interactions under different combinations of bottom-up and top-down control situations and under different theoretical fisheries regimes are explored.

Methodology

The Ecopath model constructed for the exploited ecosystem associated with the Delta of Ebro River, NW Mediterranean (5), settled the baseline to apply Ecosim (1, 2). All simulations assumed default values from the model, with the exception of flow controls in the ecosystem determining the type of control between functional groups. An initial period of five years without changing fishing scenario was established to reach stability of the ecosystem prior to perturbation and simulations were settled for an additional 45 years.

Three scenarios of flow control were explored by changing the vulnerability values of groups: (1) bottom-up control, prey control of zooplanktivorous fishes by zooplankton preys; (2) wasp-waist control, top-down control of zooplankton by small pelagic fishes and bottom-up control of pelagic predators by small pelagic fishes; and (3) mixed control, neither bottom-up nor top-down control. Three different fishing scenarios were also considered related with all functional groups of the ecosystem and with sardine (*Sardina pilchardus*), anchovy (*Engraulis encrasicolus*) and adult and juvenile hake groups (*Merluccius merluccius*), all important groups in terms of biomass and catches. Scenarios were related with (a) the definitive closure of fishing activities; (b) a quick and permanent increased of fishing activity (4 times higher that its original level); and (c) a temporary increase in fishing activity for a period of 5 years (4 times higher), after which fishing activity was restored to its original level.

Results and discussion

Globally, fishing effects on the ecosystem were deeply dependent on the configuration of interactions of the groups in the ecosystem. All simulations showed that under wasp-waist control fishing effects were wider and major perturbations propagated thought the system. Mixed control situation showed intermediate results, while under bottom-up control fishing impacts were narrow and frequently had shorter propagated effects. Similar results had been previously achieved from the upwelling ecosystem of Southern Benguela (4).

Important **effects of closing the fishing activities** were related with a decrease of jellyfish biomass under bottom-up and wasp-waist control and the collapse of seabirds under all control situations, probably due to their dependence on discards. On the contrary, bonito, tuna and swordfish showed deep increases, mainly related with an increase of prey availability and a decrease of fishing mortality. **The closure of** the **sardine-anchovy** fishery had positive impacts on most of the pelagic and demersal top predators, as well as on themselves. However adult hake, blue whiting and fin whale were strongly depleted. **The closure of** the **adult hake fishery** had positive impact on itself under bottom-up and mixed control, while an initial increase turning to a notable decrease of biomass was observed under wasp-waist control. Juveniles were permanently depleted under all control situations, possibly due to adults' predation on juveniles and resource competition. **The closure of juvenile hake fishery** had some important negative impacts on target species were seen under wasp-waist control.

The permanent increased of fishing resulted in a collapse of octopus, various demersal fishes and small and large pelagics under all situations. Notable decreases on adult hake under wasp-waist and mixed control and on juvenile hake under bottom-up and mixed control were also shown. Seabirds increased under bottom-up and wasp-waist control, while demersal sharks increased under all situations and dolphins and turtles were notably depleted. Total catch showed a stable increase of 50% under bottom-up control, but were depleted around 60% from its initial value under wasp-waist and mixed control. **The permanent increase of sardine-anchovy catches** had a higher depletion on total catches (≈ 75%) under wasp-waist and mixed control and jellyfish significantly increased, while numerous target and not target groups were negatively impacted. Sardine and anchovy collapsed under wasp-waist and mixed control. **The increase of adult hake catches** had slightly higher impact on total catches (≈ 10%) under all control situations and important decreases were shown by juvenile hake and sardine. Adult hake collapsed under all situations and significant increases were shown by pelagic top predators. An **increase of juvenile hake** catches had little positive impacts on total catch (≈ 5%), important increases on pelagic top predators and decreases on hake and small pelagic fishes.

Temporary increase of total fishing had a negative impact on total catches when fishing effort was reestablished after intensive activity. The lowest ecosystem recovery was under wasp-waist control and total catches took ≈ 35 years to achieve initial values after reestablishing initial fishing effort. The highest ecosystem recovery was under bottom-up control. Under mixed control 10 years were necessary to achieve initial catches. **The temporary increase of sardine-anchovy** showed similar patterns of ecosystem and catches recovery. However, under wasp-waist control catches were not recovered after 40 years, intense changes on the ecosystem were shown and sardine-anchovy collapsed. **The temporary fishing increase on juvenile and adult hake** had non significant impacts on total catches, with highest positive impact under wasp-waist control of ≈ 10%, but intense changes on ecosystem functional groups were shown under wasp-waist control.

Therefore, the results underline differences under different settled control situations for different fishing scenarios. This stresses the importance of understanding internal controls between ecosystem components to correctly predict ecosystem effects of fishing while applying dynamic modeling techniques. This agrees with the results from the Southern Benguela upwelling ecosystem (4).

References

1 - Pauly D., Christensen V. and Walters C., 2000. Ecopath, Ecosim and Ecospace as tools for evaluating ecosystem impact of fisheries. *ICES J. Mar. Sci.*, 57: 697-706.
2 - Walters C., Christensen V. and Pauly D., 1997. Structuring dynamic models of exploited ecosystems from trophic mass-balance assessments. *Reviews in Fish Biology and Fisheries*, 7: 139-172.
3 - Pauly D., 1998. Use of Ecopath with Ecosim to evaluate strategies for sustainable exploitation of multi-species resources. *Fisheries Centre Research Reports*, 6(2), 49 p.
4 - Shannon L.J., Cury P.M. and Jarre A., 2000. Modelling effects of fishing in the Southern Benguela ecosystem. *ICES J. Mar. Sci.*, 57: 720-722.
5 - Coll M., Tudela S., Palomera I. and Sarda F., 2003. Applying mass-balance approach to study the exploited marine ecosystems in the North-western Mediterranean Sea, (this volume).

INTEGRATING BIOCHEMICAL MARKERS AND TARGET POLLUTANT CONCENTRATIONS IN EUROPEAN EEL *ANGUILLA ANGUILLA* FOR ECOSYSTEM HEALTH ASSESSMENT OF A COASTAL LAGOON

Corsi I., Mariottini M., Badesso A., Bianchini A., Bonacci S., Borghesi N., Iacocca A., Lancini L., Focardi S. *
Dipartimento di Scienze Ambientali "G. Sarfatti", Università di Siena, Siena, Italy

Abstract
Many lagoons are impacted by human activities, which lead to progressive ecosystem degradation. In order to assess the ecological risk of the Orbetello lagoon (Tuscany, Italy), several biomarkers as EROD, B(a)PMO, reductases NADH cytochrome c, NADH ferrycianide, AChE and levels of polychlorinated biphenyl (PCB) were measured in European eel (*Anguilla anguilla* L.) collected in seven sites of the lagoon. Results suggested that the lagoon is mainly impacted by agricultural run-off and nutrient-rich effluents rather than by industrial activities.

Keywords: biomarkers, lagoon, European eel, pollution

Introduction

Lagoon ecosystems, like most brackish environments, are biotopes of great ecological value which could be at risk without appropriate management and risk assessment (1). In order to assess the ecological risk in a brackish environment, specimens of European eel (*Anguilla anguilla* L.) were collected from a moderately polluted brackish environment, the Orbetello Lagoon (Southern Tuscany, Italy) known for its complex seasonal physico-chemical fluctuations (1). The aim of this work was to investigate the site-specific variability of several biomarkers in eel and its sensitivity as bioindicator. Liver 7-ethoxyresorufin-O-deethylase (EROD), benzo(a)pyrene monooxygenase (B(a)PMO), NADH cytochrome c (NADH cyt c red) and NADH ferrycianide (NADH ferry red) reductases and muscle Acetylcholinesterase (AChE) were investigated and integrated with levels of polychlorinated biphenyl (PCBs) in muscle tissue to provide an idea of the overall fish and ecosystem resistance/susceptibility to chemical disturbance in the lagoon.

Materials and methods

Sampling was conducted in June 2002 in the Orbetello Lagoon, a 2600-hectare area on the southern coast of Tuscany (Lat. 42° 30'N; Long. 11° 10'E), bordered by two sandbars. Seventy eels were collected from seven sites (Fig. 1) and their liver microsomal fraction as previously described (4) was used to determine EROD, B(a)PMO and NADH cyt c and NADH ferryred activities based on (5), (6) and (7) respectively. AChE activity was measured in crude muscle preparations according to (8). Total protein was measured based on (9). PCBs were extracted from pooled muscle tissues according to (10) and expressed as Aroclor 1260, calculated on wet weight basis (w.w.). Log-transformed data were analysed using analysis of variance (ANOVA). Post-hoc Tukey compromise tests were used to determine statistical differences in means among sites.

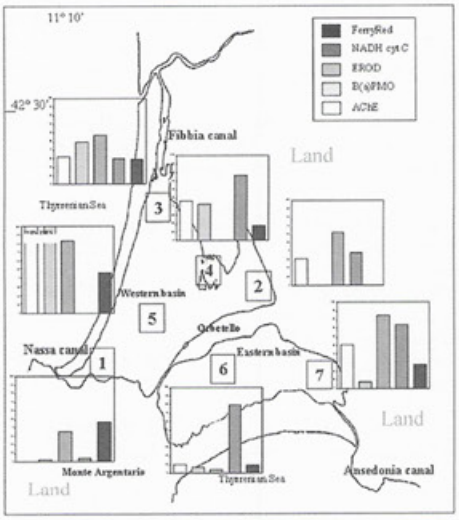


Fig. 1. Biochemical markers in European eels from seven sites: enzyme activities are shown as percentage of variation with respect to the lowest activity recorded among seven sites.

Results and discussion

All the enzymes analysed in eels from the seven sites varied significantly (Fig. 1). EROD, NADH ferry red and NADH cyt c red were significantly higher at site 5 ($p<0.05$) in the middle of the western basin compared to values in other sites while B(a)PMO activities were highest at site 6 in the middle of eastern basin. The most congruent and lowest enzyme activities were found in organisms from site 1 located in the Nassa canal. AChE activities also differed among sites, although no significant differences were observed except for sites 1, 3 and 5 (located near Nassa canal, Albegna river mouth and the middle of western basin, respectively). Considering the average AChE activities recorded in eels from all sampling sites, the differences were below 50%, suggesting that there is no neurotoxic risk for this species. The highest PCB levels (Table 1) were found in eels collected from site 5 while the lowest ones were recorded in specimens from site 2, near the fertilizer plant. On the basis of the results obtained, European eel seems to be a suitable bioindicator of environmental quality for the Orbetello lagoon.

Site	n	l.w. (%)	PCBs
1	3	3	9.72
2	3	2	4.98
3	3	5	17.80
4	5	2	8.48
5	3	10	23.73
6	2	10	16.43
7	6	7	16.61

Table 1. PCB levels expressed as ng g^{-1} wet weight in liver of European eels collected from seven sites of Orbetello lagoon (n = number of samples; l.w. lipid weight in liver tissue).

References

1 - Cognetti G. and Maltagliati F., 2000. Biodiversity and adaptive mechanisms in brackish water fauna. *Mar. Pollut. Bull.*, 40: 7-14.
4 - Corsi I., Mariottini M., Sensini C., Lancini L., Focardi S. 2003. Cytochrome P450. Acetylcholinesterase and gonadal histology for evaluating contaminant exposure levels in fishes from a highly eutrophic brackish ecosystem: the Orbetello Lagoon, Italy. *Mar. Poll. Bull.*, 46: 203-212.
5 - Burke M.D., Mayer R.T., 1974. Ethoxyresorufin: direct fluorimetric assay of a microsomal-*O*-dealkylation which is preferentially inducible by 3-methylcholantrene. *Drug Metab. Dispos.*, 2: 583-588.
6 - Kurelec B., Brivtic S., Rijaved M., Muller W.E.G., Zahn R.K., 1977. Benzo(a)pyrene monooxygenase induction in marine fish. Molecular response to oil pollution. *Mar. Biol.*, 44: 211-216.
7 - Livingstone D.R. and Farrar S.V. 1984. Tissue and subcellular distribution of enzyme activities of mixed-function oxygenase and benzo(a)pyrene metabolism in the common mussel *Mytilus edulis* L.. *Sci. Total Environ.*, 39: 209-235.
8 - Ellmann G. L., Courtney K.D., Andreas V. Jr., Featherstone R.M., 1961. A new and rapid colorimetric determination of Acetylcholinesterase activity. *Biochem. Pharmacol.*, 7: 82-88.
9 - Bradford M.M., 1976. A rapid and sensitive method for the quantification of microgram quantities of protein utilising the principle of protein-dye-binding. *Anal. Biochem.*, 72: 248-254.
10 - Kannan K., Hilscherova K., Yamashita N., Williams L.L. and Giesy J.P., 2001. Polychlorinated naphtalenes, -biphenyls, -dibenzo-*p*-dioxins, and dibenzofurans in double-crested cormorans and herring gulls from Michigan waters of Great Lakes. *Environ. Sci. Technol.*, 35: 441-447.
11 - Bressa G., Bronzi P., Romano P., Sisti E. 1995. Chlorinated pesticides and PCBs in wild and farmed eels (*Anguilla anguilla* L.): influence of water temperature and diet. *Agrofood Ind. Hi. Tec.*, 1: 46-48.

FIRST DATA ON THE NUTRITIONAL CONDITION OF THE MEDITERRANEAN BULLET TUNA LARVAE, *AUXIS ROCHEI,* FROM THE BALEARIC ARCHIPELAGO

D. Cortés *, A. García and T. Ramírez

Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Fuengirola, Málaga, Spain - * lcortes@ma.ieo.es

Abstract

Nutritional condition of bullet tuna post-flexion larvae was analysed by the quantification of nucleic acids and protein content from samples collected off the Balearic archipelago. Highest RNA/DNA and protein/DNA ratios were observed in a cold water mass south of Mallorca.

Introduction

The waters off the Balearic archipelago constitute an optimum spawning habitat for several tuna species, among which the bullet tuna *Auxis rochei* is the most abundant, as shown by the results of the TUNIBAL surveys (1), conducted during the spawning season of this species, from June to September (2).

During the last decade some research has been done on morphological, physiological and nutritional aspects of this species with laboratory-reared specimens. Nutritional condition of wild-caught bullet tuna larvae from the Panama Bight estimated by histological techniques was examined by Margulies (3).

The present paper provides data on the nutritional status of individual bullet tuna post-flexion larvae from the Balearic spawning grounds.

Material and methods

The methodological protocols used to determine the content of RNA, DNA and protein is described in (4). Larvae were collected by means of 1-m Bongo net (1mm mesh size) towed at the surface during the TUNIBAL 06/01 survey.

Results and discussion

A total of 118 bullet tuna post-flexion larvae were analysed for RNA, DNA and protein content. The samples were obtained at different sites off the Balearic islands each characterized by particular hydrographic conditions (Fig. 1). The average size of the sampled population was 7.3mm standard length (SL) (sd=1.24) and 1.12 mg dry weight (DW) (sd=0.86). The biochemical parameters showed a significant exponential increase with length and weight ($p<0.05$).

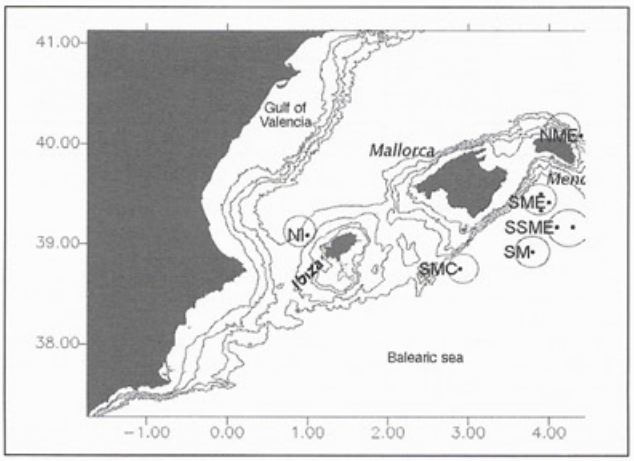


Fig. 1. Sampled sites of the bullet tuna larvae.

The survey area is characterized by the encounter of two water masses: Mediterranean waters from the north meeting waters of Atlantic origin, which cause important frontal systems and an intense ageostrophic circulation. (5). The sampled population belong to sites with different hydrographic characteristics (1). The north Ibiza (NI) and Mallorca channel (SMC) sites were located within intense frontal structures. Mean surface temperature (at 5 m) in these sites was 24ºC. Another larval sample was collected south of Mallorca (SM) within a colder water mass (22ºC). South off Menorca (SME), larvae were sampled within an anticyclonic gyre. South of this anticyclonic gyre, at SSME, another larval sample was collected. In the latter two areas, the mean surface temperature was 24-25ºC. Another larval sample was collected at a site north of Menorca (NME) with a surface temperature of 24ºC. The average size of the sampled population and biochemical parameters by site are given in Table 1.

Table 1. Average values of the sampled population and the biochemical parameters by site (NI, North Ibiza; SMC, South Mallorca Channel; SM, South Mallorca; SME; South Menorca; SSME, Southermost Menorca; NME, North Menorca; SL, standard length; DW, dry weight.

Site	SL	DW	DNA/larva	RNA/larva	protein/larva	RNA/DNA	protein./DNA
NI	8.2	1.46	22.31	98.91	493.06	3.9	21.0
SMC	6.8	0.64	8.07	29.64	169.87	3.8	21.9
SM	6.5	0.51	3.64	22.78	236.04	6.3	65.1
SME	7.6	1.35	12.87	60.98	331.75	4.9	27.0
SSME	8.1	1.82	13.83	61.18	315.74	4.3	27.1
NME	5.9	0.45	4.25	16.48	129.95	4.2	33.4

The RNA/DNA and protein/DNA ratios were significantly higher (ANOVA-Tukey post hoc comparison; $p<0.05$) in the samples originating from the cold water site (SM). The remaining areas, that had similar temperature regimes, did not show any significant differences in biochemical ratios, with the exception of the slightly higher values in the site SME. The higher values observed at SM do not necessarily imply a better nutritional status for bullet tuna larvae. The RNA/DNA dependence on temperature might cause variability in the ratios (6). Larvae located at SME showed better condition with respect to larvae sampled at other sites with similar temperature regimes. In general, the nutritional condition of the sampled population can be considered adequate, in agreement with (3) who did not find signs of malnourishment of bullet tuna post-flexion larvae from the Panama Bight.

References

1 - García A., Alemany F., Vélez-Belchí P., López Jurado J.L., de la Serna J.M., González Pola C., Rodríguez J.M. and Jansá J., 2002. Bluefin tuna and associated species spawning grounds in the oceanographic scenario of the Balearic archipelago during June 2001. ICCAT, SCRS/02/41.

2 - Sabates A., and Recasens L., 2001. Seasonal distribution and spawning of small tunas (*Auxis rochei* and *Sarda sarda*) in the northwestern Mediterranean. *Sci. Mar.* 65(2): 95-100.

3 - Margulies D., 1993. Assessment of the nutritional condition of larva and early juvenile tuna and Spanish mackerel (Pisces: Scombridae) in the Panama Bight. *Marine Biology*, 115: 317-330.

4 - Moksness E., Belchier M., Clemmesen C., Cortés D., Doan A., Folkvord A., García A., Geffen A.J., Høie H., Johannessen A., Pontual H., Ramírez T., Schnack D., and Sveinsbø B., 2000. Manual of Tools for Recruitment Studies (PARS).Final Report UE FAIR CT 96-137.1997-1999.

5 - Vélez-Belchí P., and Tintoré J., 2001. Vertical velocities at an ocean front. *Sci. Mar.*, 65: 301-304.

6 - Goolish E.M., Barron, M,G., and Adelman, I.R., 1984. Thermoacclimatory and response of nucleic acid and protein content of carp muscle tissue: influence of growth rate and relationship to glycine uptake by scales. *Can. J. Zool.*, 62: 2164-2170.

EFFECTS OF UVC RADIATION ON SURVIVAL OF *ARTEMIA* CYSTS AND NAUPLII (CRUSTACEA, BRANCHIOPODA)

Marija Crnčević [1] *, Melita Peharda [2], Jakša Bolotin [3], Slaven Dobrović [4], Adam Benović [3], Ana Bratoš [1], Valter Kožul [3], Nikša Glavić [3], Pero Tutman [2], Josip Lovrić [1], Nikola Ružinski [4]

[1] Collegium Ragusinum, Dubrovnik, Croatia - * marijica1@netscape.net
[2] Institute of Oceanography and Fisheries, Split, Croatia
[3] Institute of Oceanography and Fisheries, Dubrovnik, Croatia
[4] Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Croatia

Abstract

The objective of this research was to examine the potential of UVC radiation (254 nm) to kill organisms in ballast water, using brine shrimp *Artemia* nauplii and their resistant resting cysts as model organisms. Brine shrimp nauplii could be killed using UV radiation, while cysts were found to be more resistant.

Key words: Artemia, ballast water, UV radiation

Introduction

The movement of ship's ballast water is currently the most important source of marine species transfers throughout the world, posing a serious threat to biodiversity, economy and human health (1, 2, 3). Land-locked Adriatic Sea can be influenced by such introductions (4). Authorities of some Croatian ports are looking into possibilities of expanding their current activities and there are indications that a vast quantities of ballast waters will be discharged in the North Adriatic Sea in a very near future.

The most effective solution for reducing transfer of alien species is treatment of ballast water (5). Ultraviolet radiation (UV) is an environmentally benign approach (6) that produces no significant residual toxicants. It is already present at many re-circulating water aquaculture operations as a means of improving water quality (7). This study was designed to evaluate the potential of UV to kill cysts and nauplii of brine shrimp *Artemia*.

Material and methods

The experimental assembly, consisted of batch type UV disinfection units with centrally placed source of UV light, protected from water with quartz tube. The light source of every unit was single low-pressure mercury lamp at 254 nm. UV intensity was kept constant (40 μW/cm^2) and the UV dose was calculated as the product of intensity (μW/cm^2) and exposure time (s). Absorbance at 254 nm was A=0.06 and was measured in spectrophotometer HP 8453 using 1 cm quartz cuvette. Exposure columns were made of 50 cm tall glass cylinders (8.8 cm inner diameter). In the experiment, simultaneously run in triplicate, nauplii (6 ind/cm^3) were exposed to different UV dose levels: 2.4, 7.2, 12, and 19.2 mWsec/cm^2. Control nauplii received air, at the same flow rate and exposure times, as the treatment nauplii. Survival rates were estimated from manual counts of nauplii in six replicate 1 cm^3 samples, collected from each exposure column 0, 60, 120 and 1440 min after UV exposure, to look at long–term survival.

In experiments with cysts, *Artemia* cysts (2g/dm^3) were placed in each of two 2 dm^3 exposure columns (one treatment and one control). Cysts were exposed to different UV dosages: 24, 72, 144, 432, 720, and 1008 mWsec/cm^2. After exposure, cysts were cultured at 27°C and 15 psu for 24 h. Cyst survival rates were estimated from manual counts of hatched nauplii in 10 replicate 1 cm^3 samples collected from each exposure column.

Difference in survival among different treatments was tested using Kruskal Wallis nonparametric analysis of variance.

Results and discussion

All experiments were performed at 23.5 - 24°C, 37.4 psu, and pH 8.15 - 8.18. Cyst viability ranged between 72.02% for UV dose 24 mWs/cm^2 and 11.78% for UV dose 1008 mWs/cm^2. Statistically significant differences were found for survival of cysts exposed to different doses of UV radiation ($p < 0.001$, $n = 60$).

During preliminary experiments, 100 % brine shrimp nauplii mortality was achieved by 24 mWs/cm^2 UV dose. Survival of nauplii after UV exposure decreased significantly with increasing time after exposure. The mean percent survival for an exposure time of 1min (UV dose 2.4 mWs/cm^2) was 73.3%; immediately after exposure; while after 24 hours of exposure it was only 21.1% (Table 1). There was a statistically significant difference ($p<0.001$) in the long-term survival of nauplii exposed to different UV dose levels.

Significant differences ($p<0.001$) in survival of nauplii were found among treatments for different exposure time immediately after treatment, 1 hour after treatment and 2 hours after treatment. There was no significant difference in survival among treatments for different exposure times 24 hours after ($p = 0.157$). The effectiveness of UV in inactivating *Artemia* depends on the life stage of the organism. It has been shown that UV has a potential to kill nauplii while cysts of *Artemia* are much more resistant.

This research could be applied in future investigation of methods for inactivation of different target organisms and their resting stages in the ship's ballast water. Investigation of UV treatment in real ballast tank would be necessary because there may be mechanisms that can change the possibility of UV species inactivation.

Table 1. Long – term survival * (mean ± SE) of brine shrimp nauplii exposed to UV radiation

UV dose mWsec/cm^2	Time after UV exposure (min)			
	0	60	120	1440
2.4	73.3 ± 6.63	67.5 ± 7.10	73.3 ± 12.48	21.1 ± 6.44
7.2	64.2 ± 7.36	82.5 ± 12.44	90.8 ± 17.09	6.8 ± 3.03
12	53.3 ± 7.60	5.0 ± 2.10	5.0 ± 1.72	9.0 ± 4.52
19.2	2.5 ± 1.36	3.3 ± 1.94	0.8 ± 0.83	4.5 ± 2.86

* Percent survival = mean of 100 X percent survival of each replicate/mean of treatment control percent survival

References

1 - Carlton J.T., 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanogr. Mar. Biol. Ann. Rev.*, 23: 313-371.

2 - Golani D., Orsi-Relini L., Massuti E., and Quignard J.-P., 2002. CIESM Atlas of Exotic species in the Mediterranean. Vol.1. Fishes. (F. Briand, ed.). CIESM Publ., Monaco, 256 p.

3 - Hallegraeff G.M., Bolch C.J., Bryan J. and Koerbin B., 1990. Microalgal spores in ships' ballast water: a danger to aquaculture. Pp. 475-480. *In:* Graneli E. *et al.* (ed.), Toxic Marine Phytoplankton. Elsevier, New York.

4 - Benović A., Lovrić J. and Ružinski N. 1995. Ballast waters: problems and perspectives. Proceedings of the VII Congress of the International Maritime Association of Mediterranean, pp. 440-446.

5 - Oemcke D., 1999. The treatment of ships' ballast water. Ecoports Monograph Series No. 18 (Ports Corporation of Queensland, Brisbane), 102 p.

6 - Sutherland T.F., Levings C.D., Elliott C.C. and Hesse W.W., 2001. Effect of a ballast water treatment system on survivorship of natural populations of marine plankton. *Mar. Ecol. Prog. Ser.*, 210: 139-148.

7 - Liltved H., Hektoen H., and Efraimsen H., 1995. Inactivation of bacterial and viral fish pathogens by ozonation or UV irradiation in water of different salinity. *Aquacult. Eng.*, 14: 107-122.

DISTRIBUTION VERTICALE DU PLANCTON GÉLATINEUX DANS LE GOLFE DE TUNIS (AUTOMNE, 1995)

Mohamed Néjib Daly Yahia [1] *, Ons Daly Yahia-Kéfi [2] et Sami Souissi [3]

[1] Groupe de Recherche en Hydrologie et Planctologie. Laboratoire de Bio-Surveillance de l'Environnement. Faculté des Sciences de Bizerte, Tunisie

[2] Groupe de Recherche en Hydrologie et en Planctologie. Unité Ecosystèmes et Ressources Aquatiques Institut National Agronomique de Tunisie

[3] Ecosystem Complexity Research Group. Université des Sciences et Technologies de Lille, CNRS-UMR 8013 ELICO, Station Marine, Wimereux, France

Résumé

Une campagne de prélèvements du plancton gélatineux réalisée en novembre 1995 dans le golfe de Tunis sur une radiale de 6 stations nous a permis d'effectuer une analyse taxonomique et d'étudier la distribution quantitative verticale de ce maillon clé des écosystèmes pélagiques. Sur les 32 taxons identifiés la richesse spécifique du plancton gélatineux herbivore atteint 10 espèces tandis que les organismes gélatineux carnivores sont plus diversifiés avec 22 espèces. La cartographie verticale des abondances montre des structures en essaim avec des densités maximales de l'ordre de 410 individus m^{-3}.

Mots clés: plancton gélatineux, Méditerranée sud occidentale

Introduction

Dans le cadre d'un programme d'étude de la distribution taxonomique et quantitative spatio-temporelle du plancton du Golfe de Tunis, la distribution verticale des organismes gélatineux est envisagée à l'échelle automnale.

Le plancton gélatineux de la baie de Tunis se compose d'herbivores comme les Salpes (2 espèces), les Dolioles (3 espèces) et les Appendiculaires (4 espèces). Les carnivores sont représentés par les Siphonophores (11 espèces) et les Hydroméduses (11 espèces).

La position trophique du plancton gélatineux herbivore en tant que consommateur du bactérioplancton, du phytoplancton et du microzooplancton en fait un compartiment clé dans le réseau trophique marin. Il participe activement à la boucle microbienne et se voit utilisé d'une part par les carnivores gélatineux et, d'autre part, par de nombreux organismes nectoniques [1].

Matériel et méthodes

Des prélèvements verticaux au filet Hensen-egg (300µm) ont été réalisés dans le Golfe de Tunis dans les tranches d'eaux 0-20m, 20-40m, 40-60m, 60-80m et 80-100m au niveau d'une radiale côte-large de 6 stations. La première station GT1 est de coordonnées (36°51'00' ; 10°32'00") et la dernière station GT6 a les coordonnées (37°04'30' ; 10°37'30").

Résultats et discussion

L'analyse taxonomique révèle l'existence de 32 taxons répartis comme suit :

- 11 Hydroméduses : *Clytia* spp ; *Ectopleura dumortieri* ; *Eucodonium brownei* ; *Liriope tetraphylla* ; *Lizzia blondina* ; *Obelia* spp; *Aglaura hemistoma* ; *Podocoryne carnea* ; *Rhopalonema velatum* ; *Sminthea eurygaster* ; *Solmundella bitentacula*
- 11 Siphonophores : *Abylopsis eschscholtzi* ; *Abylopsis tetragona* ; *Bassia bassensis* ; *Chelophyes appendiculata* ; *Crystallophyes amygdalina* ; *Eudoxoides spiralis* ; *Lensia conoidea* ; *Lensia meteori* ; *Lensia multicristata* ; *Lensia subtilis* ; *Muggiaea kochi*
- 5 Appendiculaires : *Fritillaria megachile* ; *Fritillaria pellucida* ; *Oikopleura albicans* ; *Oikopleura dioica* ; *Oikopleura longicauda*
- 3 Dolioles : *Doliolum (dolioletta) gegenbauri* ; *Doliolum (dolioletta) nationalis* ; *Doliolum (dolioletta) denticulum*
- 2 Salpes : *Salpa maxima* ; *Thalia democratica*

La distribution verticale des herbivores montre une structure en essaim dans la tranche 0-20m au niveau de la station GT_4 et dans la tranche 20-40m au niveau de la station GT_5 (Fig.1) avec des densités maximales respectives de 360 et 200 ind. m^{-3}. Cette distribution est étroitement corrélée avec la distribution des carnivores gélatineux dans la colonne d'eau (Fig. 2) avec un « patch » plus large indiquant une bonne efficience écologique de ce compartiment zooplanctonique. Les densités des carnivores restent cependant plus faibles avec des maximales de près de 80 ind. m^{-3} dans la tranche d'eau 20-40 à la station GT_5.

La dynamique du plancton gélatineux dans le Golfe de Tunis caractérisé par une forte production biologique au niveau des stations GT_3 à GT_5 sur l'ensemble de la colonne d'eau laisse supposer l'existence d'une structure frontale dont les investigations futures devront confirmer ou infirmer l'hypothèse.

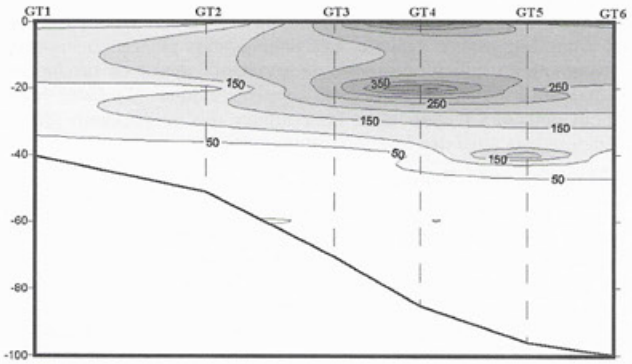


Fig. 1. Distribution du plancton gélatineux herbivore dans le golfe de Tunis (ind. par m^3).

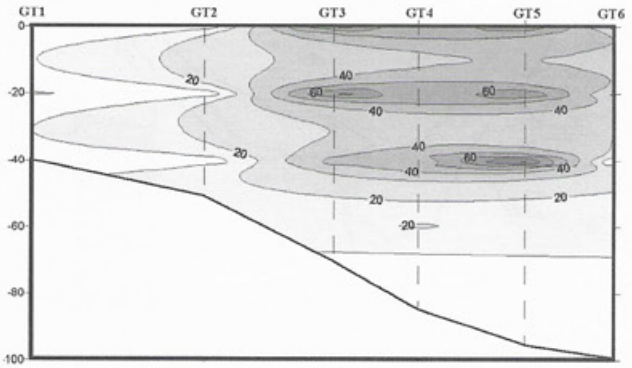


Fig. 2. Distribution du plancton gélatineux carnivore dans le golfe de Tunis (ind. par m^3).

Remerciements. Nous tenons à remercier les Docteurs Jacqueline Goy du Muséum d'Histoire Naturelle de Paris et Claude Carré de la Station Zoologique de Ville-Franche sur Mer pour leur aide dans la détermination taxonomique des espèces de plancton gélatineux.

Références

1 - C.I.E.S.M., 2001. Gelatinous zooplankton outbreaks: theory and practice. CIESM Workshop Series 14, 110 p.

STRUCTURATION VERTICALE DU PHYTOPLANCTON DANS LE GOLFE DE TUNIS (AUTOMNE 1995)

Ons Daly Yahia- Kefi [1] *, Mohamed Néjib Daly Yahia [2] Et Sami Souissi [3]

[1] Institut National Agronomique de Tunisie. Département R.A.H.A. Unité Ecosystèmes et Ressources Aquatiques. Groupe de Recherche en Hydrologie et en Planctonologie, Tunis. Tunisie - * dalyyahya.ons@inat.agrinet.tn

[2] Faculté des Sciences de Bizerte. Laboratoire de Bio-surveillance de l'Environnement Groupe de Recherche en Hydrologie et en Planctonologie, Zarzouna, Tunisie

[3] Ecosystem Complexity Research Group. Université des Sciences et Technologies de Lille, CNRS-UMR 8013 ELICO, Station Marine, Wimereux, France

Résumé

La prospection des eaux du golfe de Tunis a été réalisée suivant une radiale de six stations au cours de la saison automnale (Novembre 1995). Cette étude nous a permis d'identifier 156 taxa et de montrer la dominance relative des diatomées par rapport aux autres classes phytoplanctoniques. La répartition verticale du phytoplancton a mis en évidence des densités maximales proche du fond pour les stations peu profondes alors que pour celles plus au large le maximum a été enregistré à 15m de profondeur.

Mots clés : Phytoplancton, Méditerranée Sud-Occidentale

Introduction

Le golfe de Tunis a une grande importance sur le plan socio-économique (pêche, tourisme,…) et sur le plan écologique et la compréhension de son écosystème planctonique, base de la chaîne alimentaire, est d'une importance capitale. Les peuplements phytoplanctoniques constituent, en milieu océanique, la principale source de production primaire utilisée par les herbivores zooplanctoniques [1]. Cette étude a pour objectif l'identification taxinomique des peuplements phytoplanctoniques ainsi que leur répartition verticale.

Matériels et Méthodes

Une radiale de six stations d'étude ont été prospectées durant le mois de novembre 1995 au niveau du golfe de Tunis (Fig.1). Des prélèvements hydrologiques ont été réalisés, au niveau de chaque station et à différentes profondeurs (0; 5; 10; 15; 20; 30; 50; 75 et 100m), à l'aide d'une bouteille Ruttner. Les échantillons destinés à l'étude du phytoplancton ont été traités suivant la méthode décrite par Throndsen [2].

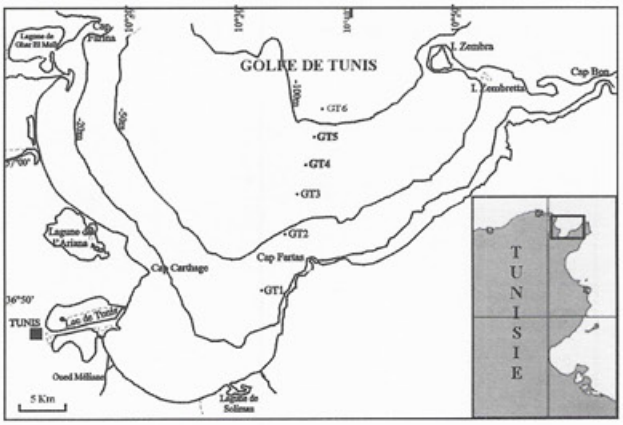


Fig. 1. Situation géographique et emplacement des stations d'étude

L'inventaire spécifique du peuplement phytoplanctonique nous a permis d'identifier 156 taxa dont 92 dinoflagellés, 61 diatomées, 2 prymnésiophycées (coccolithophorales) et 1 silicoflagellé.

La figure 2 laisse apparaître une nette dominance des diatomées qui régissent le plus souvent la structuration verticale du peuplement. Au niveau des stations GT1, GT2, et GT3 les densités cellulaires maximales (respectivement 1872 ; 2780 et 3584 cellules l^{-1}) ont été accusées près du fond, c'est à dire à 30, 40 et 70m de profondeur, et sont l'œuvre des diatomées. Une telle abondance phytoplanctonique au niveau des couches profondes a été citée par Gomez et Gorsky [3]. Les taxa dominants formant ce bloom sont *Pseudo-nitzschia* spp et *Asterionellopsis glacialis*. La station GT4 a été caractérisée par une nette diminution de la densité cellulaire au niveau de toute la colonne d'eau associée à une dominance relative des dinoflagellés, représentés par *Prorocentrum* spp et *Gymnodinium* spp, par rapport aux diatomées essentiellement à 20m de profondeur. Cette structuration verticale est modifiée au niveau des stations situées plus au large (GT5 et GT6) avec une abondance maximale à 15m (1630 et 4084 cellules l^{-1}) commandée par *Skeletonema costatum* qui a constitué plus de 70% de la flore diatomique.

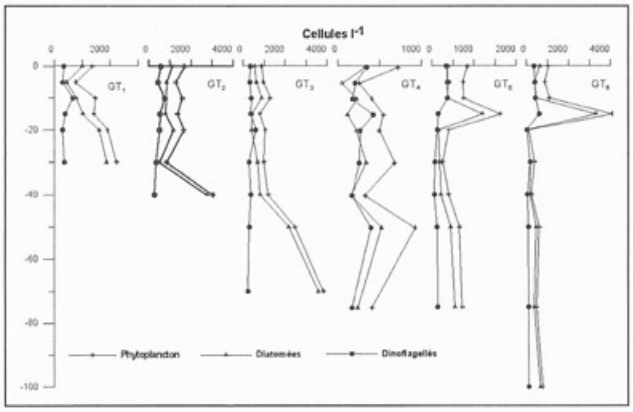


Fig. 2. Distribution verticale du phytoplancton au niveau du golfe de Tunis

Cette différence dans la structure des peuplements phytoplanctoniques et, en particulier diatomique, semble résulter de l'hétérogénéité de la distribution verticale et horizontale des éléments nutritifs particulièrement les phosphates et les nitrites.

Une autre hypothèse consiste à considérer l'impact qualitatif des herbivores du zooplancton sur les peuplements en place. En effet, seules les espèces coloniales sont susceptibles de proliférer échappant ainsi aux filtreurs et aux brouteurs.

Références

1 - Levinton J.S., 2001. Marine Biology : Function, Biodiversity, Ecology. Oxford University Press, Oxford.

2 - Throndsen, J., 1995. Estimating cell numbers. In : Hallegraeff, G. m., Anderson, D. M., Cembella, A. D. (Eds), Manual on harmful marine microalguae. IOC. Manuals and guides N°33, UNESCO, Paris, pp. 63-80.

3 - Gomez F., and Gorsky G., 2003. Microplankton annual cycles in the bay of Villefranche, Ligurian Sea (northwest Mediterranean Sea). *J. Plankton Res.*, 25 (4): 323-339.

MACRO AND MICROALGAL COMMUNITIES AS INDICATOR OF TROPHIC LEVELS IN A SHELLFISH FARMING LAGOON

De Casabianca M.L. *, Facca C. and Rabotin M.
CNRS, CEFE. UPR 9056, Sète, France - * mlc@univ-montp2.fr

Abstract

This study measures marine macrophyte and phytoplankton communities composition and specific diversity in a French Mediterranean lagoon (Thau lagoon) subject to intensive shellfish farming activity. We define in three sites, different dominant macrophytes and microphytes communities characterised by increasing eutrophication (increase of siltation and shell fragments in sediments to the detriment of sand).

Keywords: Mediterranean lagoon, eutrophication, macrophytes, microphytes

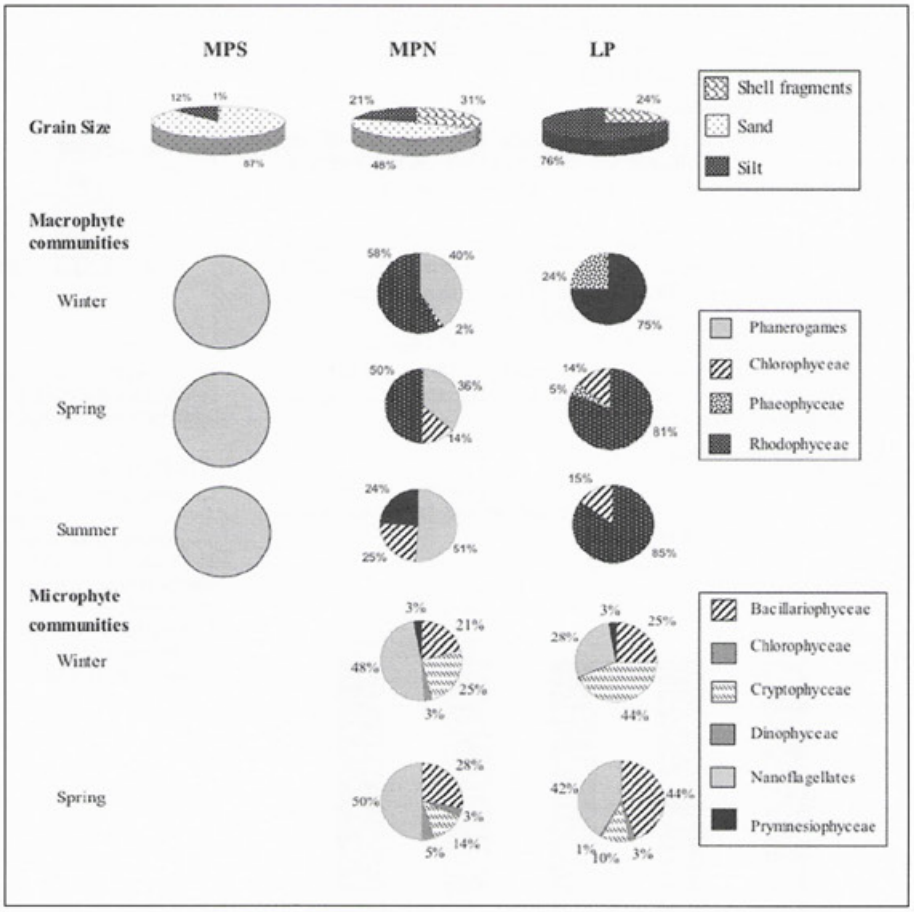
Results – Discussion

The study was conducted seasonally at 1.5 m water depth.

Along the increasing eutrophication gradient, the dominant macrophyte communities were:

(i) pure eelgrass (*Zostera marina* L. and *Z. noltii* Hornem.);(ii) eelgrass invaded by seaweed (Rhodophyceae and Chlorophyceae); and (iii) a red seaweed community dominated by three *Gracilaria* species. In the first site, the eelgrass predominated on the sand. The macroalgal diversity was maximal in the second site, because the shell debris in the sediments increased the surface available for the settlement of algae. In the third site the shells were smothered by mud, the sea-grass disappeared and the red algae were dominant as the turbidity increased with increased silting.

The phytoplankton communities, in the two last sites, in spite of the seasonal changes, always differed. Both sites were dominated by nanoflagellates. The most oligotrophic site was characterised, above all, by diatoms which are usually planktonic and pelagic (i.e. *Chaetoceros affinis* and *Pseudonitzschia heimii*). At the eutrophicated site, epiphytic (i.e. *Cocconeis molesta*, *C. scutellum* and *Licmophora debilis*) and benthic (i.e. *Amphora veneta* and *Pleurosigma formosum*) diatoms were abundant.



Conclusion

The increasing eutrophication gradient demonstrates the stages of eelgrass degradation in a longterm evolution. The phytoplanktonic species confirm these results, which are important for the management of marine areas impacted by shellfish farming.

REPRODUCTIVE ASPECTS OF RED MULLET *(MULLUS BARBATUS)* IN THE ALBORAN SEA (WESTERN MEDITERRANEAN)

Del Árbol J., J. Rey and L. Gil de Sola *
Instituto Español de Oceanografía. Muelle Pesquero s/n. Málaga, Spain

Abstract
The spawning period, length at first maturity and reproductive biomass of red mullet (*Mullus barbatus*) in the Alboran sea (western Mediterranean) were studied from data collected during five seasonal trawl surveys between 2001 and 2002.

Keywords: Red mullet, reproduction, spawning, Alboran Sea, Mediterranean

Introduction

Red mullet (*Mullus barbatus L.*) is a target species in the Alboran Sea (western Mediterranean) where it is mainly captured with trawlers, between 50 and 150 m, and gillnets in shallow waters. In the present study, some aspects of the reproductive biology of red mullet in the Alboran Sea were investigated.

Material and methods

Data were collected from five seasonal trawl surveys off the Spanish littoral in the Alboran Sea carried out with R/V *Cornide de Saavedra* and *Fco. de Paula Navarro* between Spring of 2001 and 2002.

A total of 190 hauls were conducted between 40 and 796 m, using a GOC73 gear with mesh size of 40 mm and based on stratified random sampling (1). Total length (TL) at first maturity was calculated using the least square method.

The sample sizes were: 107 (Spring 2001), 137 (Summer 2001), 457 (Autumn 2001), 169 (Winter 2002) and 213 (Spring 2002). The average reproductive stock biomass was calculated by season following Bertrand *et al.* (1)

Results and discussion

Most females (Fig. 1) and all males were premature or mature in all sampling seasons, except the recruitment season (autumn), where immature individuals predominated.

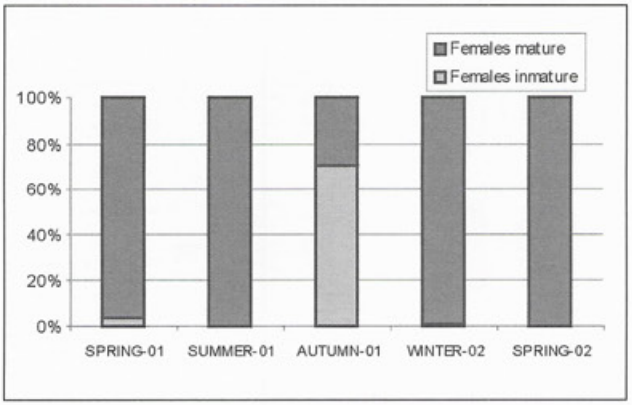


Fig. 1. Proportion of mature *Mullus barbatus* females in the Alboran Sea between spring 2001 and 2002.

Among females, however, spawning individuals were only found in spring (April-June). Males also presented a spawning peak in spring, though a low proportion of ripping males were also found during the rest of the year (Fig. 2). The total length (TL) at first maturity was 11.65 cm for males and 12.23 cm for females, both indicating an age of 1 yr (2).

The average reproductive stock biomass calculated by season (Spring 01, Summer 01, Autumn 01, Winter 02 and Spring 02) and sex were: 12.053 (SE: 7.71), 14.685 (SE: 7.79), 18.347 (SE: 7.78), 4.62 (SE: 2.07) and 11.07 kg/h (SE: 4.99) for males and 14.095 (SE: 9.01), 8.819 (SE: 4.67), 23.876 (SE: 10.12), 4.85 (SE: 2.18) and 14.996 kg/h (SE: 6.77) for females (Fig. 2).

These seasonal changes could be due to the migration pattern of the species (3). The decline in the biomass of mature females could be explained by migration either to shallow waters (<50m), where trawling is not allowed, or to inaccessible rocky bottoms.

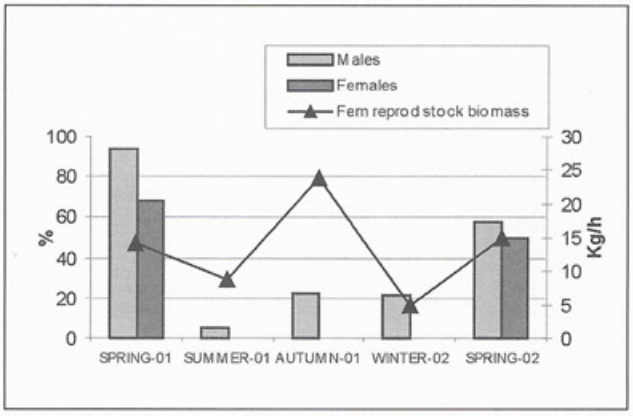


Fig. 2. Proportion of spawning *Mullus barbatus* in the Alboran Sea between spring 2001 and 2002. Average female reproductive stock biomass (>12 cm of length) is also shown.

References

1 - Bertrand A., Gil de Sola C., Papacontantinou G. and Souplet A., 1998. AN international bottom trawl survey in the Mediterranean: the MEDITS programme. IFREMER Actes de colloques, 26: 76-93.
2 - Livadas R. J. 1982. A study of the growth and maturity of striped Mullet *(Mullus barbatus L.)* in waters of Cyprus. *FAO Fish Report.*, Vol 412: 44-51.
3 - Suau P., Vives F. (1957) Contribución al estudio del salmonete de fango *(Mullus barbatus L.)* del Mediterráneo Occidental. *Investigación Pesquera*, 9: 97-118.

PRELIMINARY ASSESSMENT OF TNT-EXPOSURE IN FISH IN THE TREMITI ISLAND MARINE PROTECTED AREA

Della Torre C. [1] *, Alcaro L. [1], Bonacci S. [2], Corsi I. [2], Farchi C. [1], Giordano P. [1], Penna M. [1], Amato E. [1], Focardi S [2]

[1] Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare (ICRAM), Roma, Italy - * camilla.dellatorre@tiscali.it

[2] Dipartimento di Scienze Ambientali "G. Sarfatti", Università degli Studi di Siena, Siena, Italy

Abstract

This study was performed to preliminarily assess the ecological risk due to the presence of 2,4,6-trinitrotoluene and its degradation products in the marine environment. A multimarkers approach (EROD, AChE) was applied in specimens of *Conger conger* (Linnaeus, 1758) collected in the waters of Pianosa Island (TNT site) and in a reference site, S. Domino Island, in the same archipelago, the Tremiti Islands Marine Protected Area (Adriatic Sea, Italy). Levels of TNT in fish tissues were also measured.

Keywords: biomarkers, TNT, Tremiti Islands, biomonitoring

Introduction

Disposal at sea of ordnance containing the explosive 2,4,6-trinitrotoluene (TNT) represents a serious hazard to marine ecosystems (1). The objectives of the present study were to obtain preliminary data regarding the health of demersal fish species resident in a TNT-impacted site and to test the possibility of using the sentinel fish species *Conger conger* (Linnaeus, 1758) as a suitable bioindicator to monitor the biological effect of TNT-exposure in aquatic organisms.

Within the current research, Pianosa Island (Tremiti Islands Marine Protected Area, Adriatic Sea, Italy) was chosen as the study area because the seabed around the island has served as a dumping ground for bombs since the Second World War.

Both a chemical approach, to detect traces of these products in fish tissues, and a biomonitoring approach, aimed at detecting enzymatic alterations by means of specific biomarkers, were applied.

Two well-established enzymatic responses currently used in pollution monitoring and assessment were chosen: the 7-ethoxyresorufin-O-deethylase (EROD) and Acetylcholinesterase (AChE).

Materials and methods

Specimens of *C. conger* were collected in June 2001 and 2002 both in Pianosa Island and in a reference site in the same archipelago near S. Domino Island (Tremiti Islands Marine Protected Area, Adriatic Sea, Italy). The Fish tissues were examined for presence of TNT, 4ADNT and 2ADNT traces by means of a chromatographic assay (2), as well as liver microsomal EROD activity (3), and Acetylcholinesterase (AChE) activity in brain tissues (4). Total protein contents were measured (5). Statistical analyses were carried out using STATISTICA® *Stat Soft* 5.0 software. Significant differences between enzymatic values were assessed using the non parametric Mann-Whitney test and results were considered as statistically significant at $p<0,05$.

Results

No detectable levels of TNT or its degradation products were observed in *C. conger* tissues by means of the chromatographic assay. AChE activities assayed in the brain were significantly lower in specimens collected from the TNT-impacted site in both 2001 and 2002 compared to those measured in specimens collected in the reference site. Significantly higher EROD activities were observed in samples from the impacted area compared to those collected from the reference site (Fig. 1).

The results of this preliminary study reveal a situation of instability of the fish enzymatic systems. The lower AChE activities in specimens from the TNT-impacted site suggest the presence of neurotoxic compounds, like TNT (6), able to affect nerve impulse transmission.

Moreover, the higher EROD activities observed in specimens from the impacted site suggest potential biotransformation pathways for TNT involving P-450 enzymes, as already suggested in previous studies (7-9).

The metabolic alterations registered within the specimens collected from Pianosa Island should be considered as a sign of exposure to toxic compounds. However, the lack of data concerning the presence of TNT or its degradation products within the tissues of the same specimens, stresses the need of further information to verify the responsibility of these products in altering enzymatic activities.

The current research presents preliminary data concerning biomarkers of exposure and effect in *C. conger*, potentially very useful for future ecotoxicological studies in the marine environment.

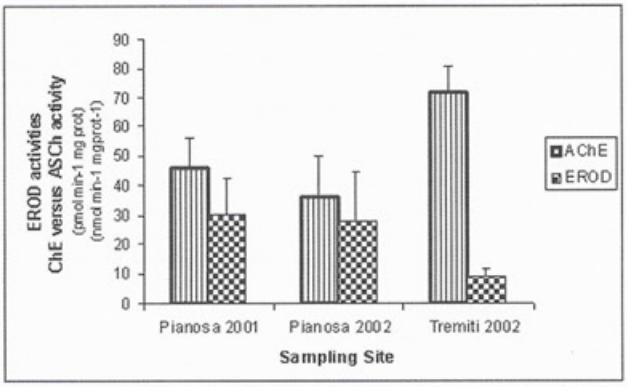


Fig. 1. EROD activities (pmol min-1 mg prot-1) in liver and ChE activity *versus* ASCh (nmol min-1 mg prot-1) in brain of *C. conger* collected in the Tremiti Islands Marine Protected Area (Adriatic Sea, Italy). Values are expressed as mean ± standard deviation (6<n<10).

Conclusions

The absence of detectable traces of TNT and its degradation products in fish tissues confirms their low biodisponibility and bioconcentration potential. The results of the multimarkers approach however, taking into account the absence of local xenobiotics sources in the uninhabited and protected island, reveal the existence of a stressing condition that could be linked to the presence of these molecules in the impacted site.

References

(1) - Lotufo G.R., Farrar D.J., Inouye L.S., Bridges T.S., Ringelberg D.B., 2001. Toxicity of sediment-associated nitroaromatic and cyclonitramine compounds to benthic invertebrates. *Env. Toxl. Chem.*, 20 (8): 1762-1771.

(2) - Lang P.Z., Wang Y., Chen D.B., Wang N., Zhao X.M., Ding Y.Z., 1997. Bioconcentration, elimination and metabolism of 2,4-dinitrotoluene in carps (*Cyprinus carpio* L.). *Chemosphere*, 35: 1799.

(3) - Burke M.D. and Mayer R.T., 1974. Ethoxyresorufin: direct fluorimetric assay of a microsomal-O-dealkylation which is preferentially inducible by 3-methylcholantrene. *Drug Met Disp*, 2: 583-588.

(4) - Ellman G.L., Courtney K.D., Andreas V.J.R., Featherstone R.M., 1961. A new and rapid colorimetric determination of Acetylcholinesterase activity. *Biochem. Pharm.*, 7: 82-88.

(5) - Bradford M.M., 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein-dye-binding. *Anal. Biochem.*, 72, 248-254.

(6) - Smock L.A., Stonuburner D.L., Clark J.R., 1976. The toxic effects of trinitrotoluene (TNT) and its primary degradation products on two species of algae and the fathead minnow. *Water Research*, 10: 537-543.

(7) - Zitting A., Szumanska G., Nickels J., Savolainen H., 1982. Acute toxic effects of trinitrotoluene on rat brain, liver and kidney: role of radical production. *Arch. Toxicol.*, 51: 53-64.

(8) - Leung K.H., Yao M., Stearns R., Chiu S.-H.L., 1995. Mechanism of bioactivation and covalent binding of 2,4,6-trinitrotoluene. *Chem. Biol. Inter.*, 97: 37-51.

(9) - Johnson M.S., Vodela J.K., Reddy G., Holladay S.D., 2000. Fate and the biochemical effects of 2,4,6-trinitrotoluene exposure to tiger salamanders (*Ambistoma tigrinum*). *Ecotox. Env. Saf.*, 46: 186-191.

ALIMENTATION DE LA BADÈCHE *EPINEPHELUS COSTAE* (STEINDACHNER, 1878) DES CÔTES DE L'EST ALGÉRIEN

Derbal F. * and Kara M.H

Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie

Résumé

Le régime alimentaire d'*Epinepheus costae* est étudié sur les côtes Est algériennes durant les années 2001 et 2002. Un total de 74 individus de longueur totale comprise entre 18,9 cm (83 g) et 90 cm (7500 g) sont examinés. Le coefficient de vacuité digestive moyen est de 21,62%. Malgré la fréquence des proies ichtyologiques et la prépondérance numérique et pondérale des ascidies, aucune proie n'est considérée comme préférentielle ni même principale.

Mots-clés: alimentation, Epinephelus costae, MED, Algérie

Introduction

Sur les côtes Est de l'Algérie, la fréquence d'*E. costae* est estimée à 36,5% contre 38,2% pour *E. marginatus*. Le reste est partagé entre *E. caninus* (17,65%) et *E. aeneus* (7,65%). En plus de leur importance en pêche, les mérous présentent un intérêt aquacole certain. Des études récentes ont montré les possibilités d'élevage du genre *Epinephelus* (1). Chez *E. costae*, des essais de reproduction artificielle et l'élevage larvaire sont menés (2).

En Méditerranée sud occidentale, les principaux travaux sur *E. costae* sont réalisés sur les côtes tunisiennes (3, 4) et égyptiennes (5, 6, 7). L'absence de données sur les côtes algériennes nous a conduit à étudier l'écobiologie de cette espèce dont les données présentées ici font partie.

Matériel et méthodes

Un total de 74 individus mesurant entre 18,9 et 90 cm de longueur totale et pesant entre 83 et 7500 g ont été examinés, entre juin 2001 et mai 2002. Ils sont pêchés aux filets maillants, à la palangre de fond et à l'arbalète, entre les villes d'El-Kala (36°15' Nord - 8°15' Est) et de Skikda (37°01' Nord - 07°14' Est), soit une bande côtière d'environ 170 km de long.

Les proies ingérées sont identifiées, dénombrées puis pesées par taxon. L'analyse quantitative consiste à calculer le coefficient de vacuité digestive saisonnier (C_v). Les différentes proies sont classées selon leur prépondérance (fréquence, nombre, poids) en utilisant l'indice d'aliment principal ou MFI (Main Food Index) (8).

Tab. 1. Composition de l'alimentation et classement des proies d'*E. costae* de l'Est algérien.

Ni: nombre de tubes digestifs contenant la proie i - ni: nombre d'individus de la proie i - pi: poids total de la proie i ou p_i - F (%): fréquence d'une proie - C_{ni} (%): pourcentage en nombre d'une proie - C_{pi} (%): pourcentage en poids d'une proie - MFI: Main food index

Taxons ingérés	N_i	n_i	P_i (g)	F (%)	C_n (%)	C_p (%)	MFI
POISSONS TÉLÉOSTÉENS	**44**	**61**	**137,90**	**75,86**	**1,15**	**25,40**	**31,27**
Clupeidae	2	4	3,85	3,45	0,08	0,71	1,12
- *Sardina pilchardus*	1	9	5,97	1,72	0,17	1,10	1,02
- *Sardinella aurita*	3	9	24,20	5,17	0,17	4,46	3,45
Sparidae nd.	1	1	1,75	1,72	0,02	0,32	0,53
Téléostéens nd.	37	38	103,08	63,79	0,72	18,99	24,75
CRUSTACÉS EUMALACOSTRACÉS	**13**	**2265**	**33,16**	**22,41**	**42,66**	**6,11**	**14,10**
Eucarides	-	-	-	-	-	-	-
Décapodes reptantia	-	-	-	-	-	-	-
- *Iriphia* sp.	1	1	0,02	1,72	0,02	0,00	0,06
Portunidae nd.	2	2	3,03	3,45	0,04	0,56	0,09
Brachyoures nd.	5	7	1,19	8,62	0,13	0,22	0,98
Décapodes natantia	-	-	-	-	-	-	-
- *Plesionika edwardsii*	1	12	25,90	1,72	0,23	4,77	2,16
Crustacés nd.	1	11	0,39	1,72	0,02	0,07	0,25
Péracarides	-	-	-	-	-	-	-
Isopodes	-	-	-	-	-	-	-
- *Idotea* sp.	4	5	0,08	6,90	0,09	0,01	0,23
Amphipodes	1	11	0,03	1,72	0,21	0,01	0,07
Mysidacae	2	2226	2,52	3,45	41,92	0,46	3,25
ASCIDIES	**8**	**2542**	**283,75**	**13,79**	**47,87**	**52,27**	**40,14**
MOLLUSQUES	**3**	**3**	**0,18**	**5,17**	**0,06**	**0,03**	**0,29**
Bivalves	2	2	0,11	3,45	0,04	0,02	0,19
Gastéropodes	1	1	0,07	1,72	0,02	0,01	0,11
CŒLENTÉRÉS ANTHOZOA	**4**	**404**	**10,75**	**6,90**	**7,61**	**1,98**	**3,79**
MACROPHYTES	**7**	**8**	**34,03**	**12,07**	**0,15**	**6,27**	**6,19**
Thallophytes	5	5	33,64	8,62	0,09	6,20	5,20
Cormophytes	3	3	0,39	5,17	0,06	0,07	0,43
ÉLÉMENTS NON IDENTIFIÉS	**27**	**27**	**43,10**	**46,55**	**0,51**	**7,94**	**13,67**
TOTAL		**5310**	**542,87**				

Résultats et discussion

La badèche des côtes de l'Est algérien s'alimente au cours de toute l'année. Les valeurs moyennes saisonnières du coefficient de vacuité digestive sont inférieures ou égales à 26%. Elles mettent en évidence la continuité et l'intensité de l'activité trophique de cette espèce.

Seules cinq espèces proies ont pu être identifiées. Il s'agit de deux poissons clupéidés (*Sardina pilchardus* et *Sardinella aurita*) et de trois crustacés eumalacostracés (Tab. 1). Ces derniers sont représentés par 2 eucarides (*Plesionika edwardsii* et *Iriphia* sp.) et un péracaride (*Idotea* sp.). La badèche semble se focaliser sur les proies invertébrées macrozoobenthiques, telles que les tuniciers (ascidies) et les crustacés qui dominent numériquement (C_n = 47,87 et 42,66%, respectivement). Les cœlentérés anthozoa et les poissons sont plus nombreux (C_n = 7,61 et 1,15%, respectivement) que les mollusques dont la présence dans les tubes digestifs est très faible (C_n = 0,06%). Les taxons ingérés massivement sont les ascidies (C_p = 52,27%) et les poissons (C_p = 25,40%). Aucune proie n'est considérée comme préférentielle ni même principale. Les poissons et les ascidies apparaissent comme des aliments secondaires, tandis que les autres taxons sont ingérés accessoirement. Cependant, selon Tortonese (9), les badèches se différencient des autres *Epinephelus* par une ichtyophagie quasi-exclusive.

Bibliographie

1 - Gracia V., 1996. Estudio della biologia y posibilidades de cultivo de diversas especies del genero *Epinephelus*. PhD Thesis, Universitat de Barcelona, Barcelona. Espana.

2 - Glamuzina B., Glavic N., Tutman P., Kozul V., Skaramuca B., 2000. Notes on first attemp at artificial spawning and rearing of early stages with goldbloctch grouper, *Epinephelus costae* (Steindachner, 1875). *Aquac. Inter., Acad. Publ.*, 8: 551-555.

3 - Bouain A., Siau Y., 1983. Observations on the female reproductive cycle and fecundity of three species of groupers (*Epinephelus)* from the southeast Tunisian seashores. *Mar. Biol.*, 73(2): 211-220.

4 - Bouain A., 1986. Croissance linéaire des mérous du golfe de Gabès (Tunisie). *Cybium*, 10(3): 299-302.

5 - Ezzat A.A., Mikhail M.Y., Wadie W.F., Hashem M.T., 1982. Length-weight relationship and condition factor of *Epinephelus aeneus* and *Epinephelus alexandrinus* in the Egyptian Mediterranean waters. *Bull. Inst. Oceanogr. Fish.*, Cairo, 8(1): 173-186.

6 - Wadie W.F., Hashem M.T., Mikhail MY., Ezzat A.A., 1981. Age and growth of *Epinephelus alexandrinus* in the Egyptian Mediterranean waters. *Bull. Inst. Oceanogr. Fish.* Cairo, 7(3): 559-574.

7 - Wadie W.F., Ezzat A.A., Mikhail M.Y., 1985. Biometric studies on *Epinephelus aeneus* (G. Saint Hilaire) and *E. alexandrinus*. *Folia morph.* Prague, 33(4): 310-315.

8 - Zander C.D., 1982. Feeding ecology of littoral gobiid and blennioid fish of the Banyuls area (Mediterranean sea). I. Main food and trophic dimension of niche and ecotype. *Vie et Milieu*, 32(1): 1-10.

9 - Tortonese E. 1986, Serranidae. In: Whitehead P.J.P., Bauchot, M.L., Hureau J.C., Nielsen J. and Tortonese E. (eds). Fishes of the North-eastern Atlantic and the Mediterranean. Vol. II. 515-1007. U.N.E.S.C.O, Paris: 780-792.

CATCHES OF THE HOLOTHURIAN *STICHOPUS REGALIS* (CUVIER, 1817) DURING THE "PIPETA" EXPEDITION IN THE ADRIATIC SEA

Marija Despalatović *, Ivana Grubelić and Ante Šimunović
Institute of Oceanography and Fisheries, Šet. I. Meštrovića 63, 21000 Split, Croatia - mare@izor.hr

Abstract
We present data on the abundance of the holothurian *Stichopus regalis* (Cuvier, 1817) on the continental shelf of the Adriatic Sea during 11 cruises of the "Pipeta" Expedition (1985-1994). A total of 518 bottom trawl hauls were performed covering an area of approximately 59,000 km^2 of different substrata at different depths. The greatest catch rate (33.88 kg h^{-1}) of the species was recorded at 105 m and on "relict" sand sediment.

Keywords: Stichopus regalis, catch, Adriatic Sea

Introduction

Bottom trawl by-catch was recorded for the first time during the "Pipeta" Expedition in the Adriatic Sea. The holothurian *Stichopus regalis* (Cuvier, 1817) is a common species in trawl by-catches from the continental shelf in the Adriatic (1). It is an edible species but not consumed in the Adriatic region. Here, we present the species catch rates based on the "Pipeta" Expedition results.

Material and methods

Samples were collected during 11 cruises of the "Pipeta" Expedition (1985-1994) with standard Italian bottom trawl (2) during different periods of the year. Trawling was performed on 10 transects (A-L) (Fig. 1) over the Adriatic continental shelf, at depths 10-430 m, covering an area of about 59,000 km^2 of different substrata. Catch rates per station were expressed as mean kg h^{-1} of trawling.

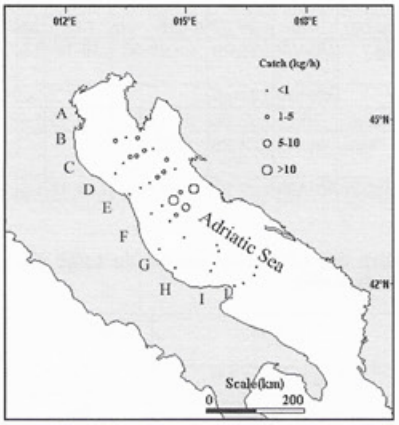


Fig. 1. Catch rates (kg h^{-1}) of the holothurian *Stichopus regalis* during the "Pipeta" Expedition (1985-1994) along 10 transects in the Adriatic Sea.

Results and discussion

A total of 518 bottom trawl hauls were performed during 1985-1994. To calculate mean catch values at different substrata, 356 hauls were used from the area of its distribution (i.e., stations where the species was caught at least once). The greatest mean catch rate of *Stichopus regalis* was recorded at depths 50-100 m, whereas it is normally distributed at depths 5-470 m (3). The highest mean catch rate (4.62 ±6.31 kg h^{-1}) was recorded at stations with "relict" sand (Table 1). On clay silt and silty clay sediments, its presence was negligible being in accordance with previous data (1). Generally, the mean catch rates at the stations of each sediment type differed significantly (ANOVA, $P<0.01$). Furthermore, the high standard deviation values of the means (Table 1) denote the uneven species distribution in the area. The species was not caught at stations on transects "A" and "B". The greatest catch (33.88 kg h^{-1}) was recorded on transect "F" (Fig. 1), in the area where Šimunović (1) recorded 940 specimens per hour, while very small catches along the "H", "I" and "L" transects. The mean catch rates of *S. regalis* during 11 cruises did not differ significantly (ANOVA, $P>0.1$) (Fig. 2). Finally, the mean catch rates did not differ with season (ANOVA, $P>0.1$) (Table 1).

Table 1. Mean (±SD), range (min-max) and number (n) of the holothurian *Stichopus regalis* trawl catches (kg h^{-1}) at different sediment types and seasons during the "Pipeta" Expedition (1985-1994).

SEDIMENT	MEAN DEPTH (m)	CATCH RATE (kg h^{-1})				
		n	min	max	$\bar{x}$	SD
"relict" sand	75	79	0	33.88	4.62	6.31
clayey silt and silty clay	91	151	0	0.43	0.03	0.08
clayey "relict" sand	105	126	0	1.30	1.32	2.38
SEASON						
autumn		123	0	16.94	1.14	2.41
winter		103	0	17.92	1.13	2.64
spring		69	0	26.68	2.13	5.15
summer		61	0	33.88	1.94	5.12

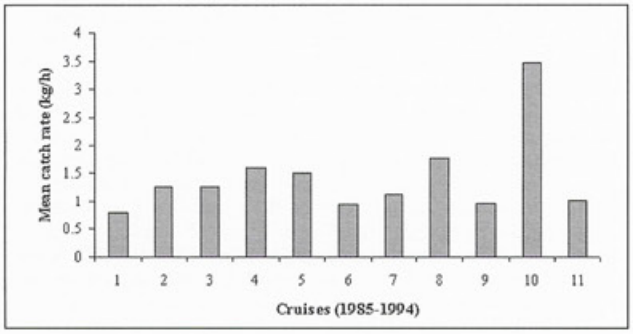


Fig. 2. Mean catch rates (kg h^{-1}) of the holothurian *Stichopus regalis* during 11 cruises of the "Pipeta" Expedition (1985-1994) in the Adriatic Sea.

References

1 - Šimunović A., 1997. Quantitative and qualitative investigations of benthic communities in the areas of mobile bottoms of the Adriatic Sea. *Acta Adriat.*, 38: 77-194.
2 - Piccinetti C., 1972. Catalogue of fishing gear designs. FAO, London, 42 p.
3 - Zavodnik D., and Šimunović A., 1997. Beskralješnjaci morskog dna Jadrana. Svjetlost, Sarajevo, 217 p.

CARACTERES MERISTIQUES ET METRIQUES DE *POMATOMUS SALTATRIX* (TELEOSTEI, POMATOMIDAE) DANS LE GOLFE DE GABES, TUNISIE

Khalifa Dhieb [1] *, Mohamed Ghorbel [1] et Abderrahmen Bouaïn [2]

[1] Institut National des Sciences et Technologies de la Mer, Centre de Sfax, Tunisie - * khalifadhieb@yahoo.fr
[2] Faculté des Sciences, Sfax, Tunisie

Résumé

L'étude des caractères méristiques et métriques de *Pomatomus saltatrix* du golfe de Gabès (Tunisie) montre que sa formule radiaire ne diffère guère de celle de la même espèce qui vit dans d'autres secteurs maritimes et que les différentes parties de son corps (hormis la hauteur) croissent suivant une isométrie franche avec la longueur totale.

Mots-clés: Pomatomidae, biométrie, Gulf of Gabès

Introduction

Le serre, *Pomatomus saltatrix*, est un téléostéen appartenant à la famille des Pomatomidae. C'est une espèce pélagique à large répartition géographique dont la taille pourrait dépasser 100 cm (1). Néanmoins, dans le golfe de Gabès, zone sud de la pêche maritime en Tunisie, le plus grand spécimen observé durant quatre ans d'échantillonnage (1998-2002) n'a mesuré que 445 mm. L'étude des principaux caractères morphométriques de cette espèce nous est donc paru utile. Les résultats que nous présentons dans cette note pourraient servir à une éventuelle comparaison.

Matériel et méthodes

Cette étude a été réalisée sur un échantillon de 663 individus de *Pomatomus saltatrix* de longueur totale (LT) comprise entre 109 et 445 mm provenant du golfe de Gabès. A l'œil nu, nous avons relevé le nombre de rayons, respectivement, aux deux nageoires dorsales (D1 et D2), à la nageoire pectorale droite (P), à la nageoire ventrale droite (V) et à la nageoire anale (A). Les branchiospines du premier arc branchial droit et les écailles de la ligne latérale ont été dénombrées sous une loupe binoculaire. Le nombre de vertèbres est compté, après cuisson de l'individu, de la première cervicale à l'urostyle. Concernant les caractères métriques, nous avons utilisé un ichtyomètre et un compas à deux pointes sèches pour mesurer en millimètres les longueurs, totale (LT), à la fourche (LF), standard (Lst), de la tête (T), des nageoires dorsales (LD1 et LD2), de l'intervalle entre les deux dorsales (ID) et des distances prédorsales (PD1 et PD2). A partir de ces mensurations, nous avons estimé la croissance relative des différentes parties du corps par une fonction de la forme $y = ax^b$, où y = longueur du caractère considéré, x = LT (longueur de référence); a et b sont des constantes. Ces dernières sont estimés par la méthode des moindres carrés.

Résultats et discussion

La première dorsale de cette espèce est soutenue par 7 ou 8 rayons durs dont le plus postérieur pourrait s'escamoter chez la plupart des individus âgés. Selon Kedidi (2), toute la population du serre vivant dans le golfe de Tunis possède 8 rayons, mais le huitième peut ne pas être apparent. La deuxième dorsale comporte un aiguillon dur suivi de rayons mous dont la hauteur décroît dans le sens antéro-postérieur. La nageoire anale, légèrement plus courte que la deuxième dorsale, commence par un aiguillon toujours précédé de deux courtes épines indépendantes. Les nageoires pectorales, elles, s'insèrent latéralement sur des bases verticales. Elles sont courtes et présentent, chacune, un aiguillon fortement collé contre le rayon mou qui le suit. Les nageoires ventrales sont soutenues par un rayon dur et cinq rayons mous chacune. Ainsi, la formule radiaire de *Pomatomus saltatrix* du golfe de Gabès ne diffère pratiquement pas de celles de la même espèce qui vit ailleurs (Tab. 1). La ligne latérale, presque rectiligne, comporte des écailles tubulées dont le nombre, relevé sur 116 spécimens, varie de 85 à 102. Tortonese (3) a dénombré de 95 à 106 écailles à la ligne latérale de *Pomatomus saltatrix* de l'Italie. Le nombre de branchiospines comptées sur le premier arc branchial droit de 208 individus varie de 10 à 21; il décroît avec la taille mais reste compris entre 10 et 15 à partir d'une longueur standard de 120 mm. Lund (4) a conclu qu'il existe une corrélation négative entre le nombre de branchiospines et la longueur du poisson. Pour les vertèbres, le nombre relevé chez une centaine d'individus est constant; il est de 26. Le nombre de vertèbres du serre de l'Italie étudié par Tortonese est de 24.

La tête représente à peu près le quart de la taille du poisson. Sa croissance est plus ou moins isométrique avec la longueur totale. La première hauteur, mesurée au niveau des nageoires pelviennes, et la deuxième hauteur, mesurée au niveau de l'origine de la nageoire anale, sont très comparables. Chacune représente à peu près le cinquième de la longueur totale et croît avec celle-ci suivant une allométrie minorante. Les longueurs des prédorsales PD1 et PD2 représentent respectivement 29,5 % et 46,1 % de la longueur totale du poisson quel que soit le nombre de rayons à sa première dorsale. Nous en déduisons que les positions des nageoires dorsales ne subissent pas de changement; c'est plutôt l'intervalle qui les sépare qui est affecté. Concernant les longueurs à la fourche et standard, elles croissent avec la longueur totale suivant une isométrie. Les équations de la croissance relative de ces différentes parties du corps sont consignées dans le Tab. 2.

Tableau 1. Formules radiaires de *Pomatomus saltarix* dans différentes régions.

	Région	D1	D2	A	P	V
Legall (1934)	Atl. Est (Maroc)	VIII	I.25-27	II.I.26- 28	I.16	I.5
Dieuzeide *et al.* (1959)	Méd. (Alg.)	VII-VIII	I.25-29	II.I.25-30	16-18	I.5
Tortonese (1975)	Italie	VII-VIII	I.25-28	-	-	-
Kedidi (1975)	Golfe de Tunis	VIII	I.23-27	II.I.24-28	I.14-15	I.5
Fischer *et al.* (1987)	Méd., Mer Noire	VII-VIII	I.23-28	II.23-27	-	-
Présent travail	Golfe de Gabès	VII-VIII	I.22-27	II.I.23-29	I.14-16	I.5

Tableau 2. Croissance relative des différentes parties du corps chez *Pomatomus saltatrix* du golfe de Gabès.

Nbre d'ind. examinés	$Y = ax^b$	Coef. R
639	$T = 0,35LT^{0,93}$	0,99
627	$H1 = 0,65LT^{0,79}$	0,98
628	$H2 = 0,51LT^{0,85}$	0,99
639	$Œ = 0,27T^{0,93}$	0,98
221 (8 r)	$PD1 = 0,28LT^{1,01}$	0,99
221 (8 r)	$PD2 = 0,52LT^{0,98}$	0,99
81 (7 r)	$PD1 = 0,32LT^{0,98}$	0,99
81 (7 r)	$PD2 = 0,45LT^{1,01}$	0,99
639	$Lst = 0,9LT^{0,98}$	0,99
639	$LF = 1,2LT^{0,95}$	0,99

Références

1 - Fischer W., Bauchot M. L., et Schneider M., 1987. Fiches F.A.O. d'identification des espèces pour les besoins de la pêche 'Révision' Méditerranée et mer Noire. Zone de pêche 37. Volume II. Vertébrés. Rome, F.A.O, (2): 761-1530.

2 - Kedidi M. S., 1975. Contribution à l'étude morphologique et biologique de *Pomatomus saltatrix* (Lin. 1758) poisson téléostéen du golfe de Tunis. D.E.A. Fac. Sci. Tunis, 60 p.

3 - Tortonese E., 1975. Fauna d'Italia: Osteichthyens, pesci ossei. Edit. Calderini, Bologna XI, 635 p.

4 - Lund W. A. Jr., 1961. A racial investigation of the Bluefish, *Pomatomus saltatrix* (Linn.) the Atlantic coast of North America. *Univ. Orien. (Cumana, Venezuela) Separata Bol.*, 1 (1): 73-129.

5 - Le Gall J., 1934. Le tassergal ou Bluefish, (*Pomatomus saltatrix* = *Temnodon saltator*) Résumé des connaissances acquises sur la biologie et l'utilisation de ces poissons. *Rev. Tra. Off. Pêch. Marit.*, 7 (1): 27-85.

6 - Dieuzeide R., Novella M., et Rolland J., 1959. Catalogue des poissons des côtes algériennes. Imp. Off. Déleg. Géner. Gouv. Algérie (II), pp. 259-261.

INTERACTIONS BETWEEN FISH CAGE FARMING AND THE MARINE ENVIRONMENT IN GERA BAY (AEGEAN SEA, EASTERN MEDITERRANEAN)

Dimitriadis Ch. *, Koutsoubas D and G. Tsirtsis
Dept. Marine Sciences, University of the Aegean, Mytilene, Hellas

Abstract
Interactions between aquaculture and the marine environment were investigated in an enclosed coastal area in the NE Aegean (Lesvos Island). Moderate disturbance of the marine environment was detected, restricted however to a small area in the vicinity of the fish cages.

Key Words: aquaculture, marine environment, coastal area

Introduction

During the last 20 years aquaculture activity has rapidly expanded in coastal marine areas, often resulting in increasing concern over its potential effects in the marine environment [1,2]. The high enrichment of nutrient load in the water column deriving from fish farms could potentially be related to eutrophication in the coastal zone [1,3] and consequently to increased organic load in the sediment that might have a strong impact on the structure of the macrobenthic communities [2]. The present study attempts to determine the interactions between aquaculture and the marine environment, on a spatio-temporal scale, in an enclosed coastal area in the Eastern Mediterranean, where comparable studies are generally lacking [2].

Materials and Methods

Samples were collected from four stations (Pal1 - 10m; Pal2 - 50m; Pal3 -100m; Palbl - 400m = Control site) in Gera Bay an enclosed coastal area in the NE Aegean (Fig.1). Water column and sediment samples were collected by means of a Van Dorn sampler and a Van Veen grab correspondingly, during July 2002, November 2002 and April 2003. Samples for macrofaunal analysis (3 replicates, total surface area of 0.30m^2) were sieved through a 0.5mm mesh and preserved in 5% neutralized formalin. In the laboratory, the macrofauna were sorted and identified to species level, counted and weighed. Organic content, Chl-a and nutrient concentrations were obtained according to standard procedures [4]. The PRIMER package developed at Plymouth Marine Laboratory was used for data analysis.

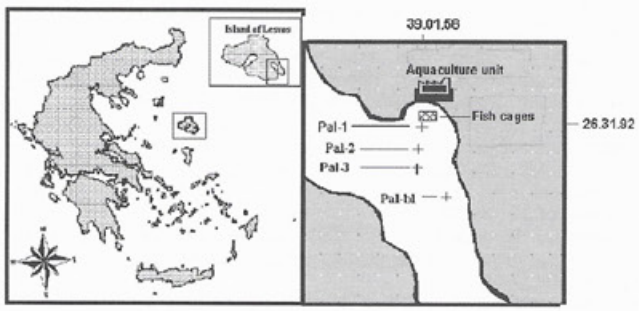


Fig. 1. Map of Gera Bay with indication of study area and sampling stations.

Results and Discussion

Concentrations of NH_4 -N fluctuated between 0.2 (control site) to 5.83 µg-at/l (100m), whereas NO_3-N values reached a peak of 6 µg-at/l near the cages. The NO_2-N, PO_4-P and SiO_2-Si seasonal concentrations (means: 0.4, 0.14, and 3.86 µg-at/l correspondingly) appeared to be similar to those recorded in Gera Bay [5]. Increased Chl-a concentrations were recorded in the proximity of cages (e.g. 1.12mg/l - 10m), but there was a gradual decrease with increasing distance from the cages (0.2µg/l – control site). The Redfield's ratio (N/P) revealed that the study area is a P-limited ecosystem in contrast with the N-limited character of Gera Bay as a whole [5]. The study area has a mesotrophic character even if eutrophication trends were detected close to the cages (10m). Organic material concentrations in the sediment were increased by a factor of 2 to 3 up to a distance of 100m in comparison with the control site (1.11-1.42% *vs* 0.8% correspondingly). Analysis of the molluscan fauna revealed a total of 38 species (17 Gastropods, 18 Bivalves and 2 Scaphopods). Molluscan diversity indices (s, d and H') values were low close to the fish-farm unit and increased along with distance from the cages. Multivariate analyses on the molluscan community revealed a clear difference between the area in the proximity of the cages and that of the rest study area (Fig. 2a). Disturbance techniques applied (ABC curves) indicated also a moderate disturbance effect on molluscan community up to a distance of 50m from the cages (Fig. 2b). As a preliminary result there appears to be a degree of impact of the aquaculture activity in the marine environment in the study area, which, however, is not acute and is detected only in the vicinity of the cages, similar to what has been reported in comparable studies in the Mediterranean [1,2].

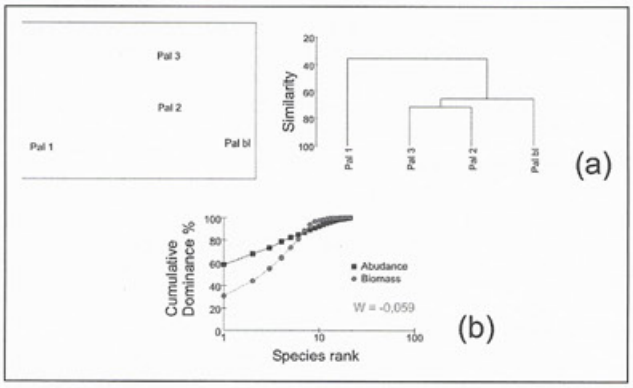


Fig. 2. (a) Similarity dendograms and MDS ordination plots of stations in the study area of Gera Bay based on molluscs species. (b) ABC curve along with W-statistic value for station of 50m in the study area.

References

1 - Pitta P., Karakassis I., Tsapakis M. and Zivanovic S., 1999. Natural *vs* mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. *Hydrobiol.*, 391:181-194.
2 - Karakassis I., Tsapakis M., Hatziyanni E., Papadopoulou K.N. and Plaiti, W., 2000. Impact of cage farming of fish on the seabead in three Mediterranean coastal areas. *ICES J. Mar. Sci.* 57: 1462-1471.
3 - Grall J. and Chauvaud L., 2002. Marine eutrophication and benthos: the need for new approaches and concepts. *Glob. Ch. Biol.*, 8: 813-830.
4 - Strickland J.D.H. and Parsons T.R., 1968. A manual of sea-water analysis. *Bull. Fish. Res. Bd. Can.*, 167: 1-311.
5 - Arhonditsis G., Tsirtsis G. and Karydis M., 2002. The effects of episodic rainfall events to the dynamics of coastal marine ecosystems: applications to a semi-enclosed gulf in the Mediterranean Sea. *J. Mar. Syst.*, 35: 183-205.

SOME NEW DATA ON THE OCCURRENCES OF *SCHEDOPHILUS OVALIS* (CUVIER, 1833) (PISCES: CENTROLOPHIIDAE) IN THE EASTERN ADRIATIC

J. Dulčić [1] *, V. Onofri [2], I. Jardas [1], A. Pallaoro [1] , A. Soldo [1], B. Glamuzina [3]

[1] Institute of Oceanography and Fisheries, Split, Croatia - * dulcic@izor.hr
[2] Institute of Oceanography and Fisheries, Dubrovnik, Croatia
[3] University in Dubrovnik, Department for Aquaculture, Dubrovnik, Croatia

Abstract

Two specimens of the imperial blackfish *Schedophilus ovalis* (in 1979-TL=25.2 cm; in 2003- TL=37.7 cm) were caught in the southern Adriatic. Periodically occurrences of this species could be explained by the "Adriatic ingressions", NAOi and warming of Adriatic waters.

Key-words: Schedophilus ovalis, occurrences, Eastern Adriatic

Introduction

The imperial blackfish *Schedophilus ovalis* (Cuvier, 1833) is present in the Eastern and Western Central Atlantic, Australia, and throughout most of the Mediterranean (1). *S. ovalis* lives both in surface waters (juvenile phase associated with floating wreckage and jellyfish) and on slope bottoms in habitats which have not yet been defined. Many aspects of its biology remain obscure (1), especially in the Mediterranean, where it has for a long time been supposed that that this species is rare (2). Jardas (3) noted that *S. ovalis* (Cuvier, 1833) is very rare species in the Adriatic Sea.

In this paper we present some new data on the occurrences of the imperial blackfish in the eastern Adriatic.

Material and methods

The specimens were identified according to Jardas (3). They are deposited in the Ichthyological Collection of the Institute of Oceanography and Fisheries in Split, Croatia. The specimens were measured to the nearest 0.1 cm (TL-total length), and weighed to the nearest 0.1 g.

Results and discussion

On 26 June 1979 one specimen of the imperial blackfish was caught with the deep bottom trawl in the open waters of the southern Adriatic, about 20 Nm SE from Dubrovnik at depth of about 1000 m depth. The total length of caught specimen was TL = 25.2 cm (no data on weight and sex undetermined). Another specimen of the imperial blackfish was caught on 28 July 2003 with «brankarela» (ripping hook mounted together on the iron or wooden stick) in the open waters of southern Adriatic, 35 Nm SE from Dubrovnik (southern Adriatic), at about 1200 m depth. The sea surface temperature was SST=26.5^{0}C. The total length was TL=37.7 cm, and weight W=820.2 g (sex undetermined). The growth of the imperial blakfish specimens to about 45 cm TL (4) corresponds to the first year of life. If we take this into consideration both caught specimens in the eastern Adriatic were juveniles (0+).

S. ovalis was firstly recorded in the Adriatic as *Centrophilus corcyrensis* (5) since it was caught in the vicinity of the Korčula Island (southern Adriatic). The second specimen (without measures) of this species was captured together with *S. medusophagus* in Pelješac channel (southern Adriatic) in 1982 (at depth 2 m, T=25^{0}C) and it was accompanied the occurrence of *Pelagia noctiluca* (6). We assume that those periodically occurrences could be explained by the Adriatic ingressions, NAOi (North Atlantic Oscillation Index) and warming of Adriatic waters (7). Observations on the Adriatic ichthyofauna (period 1973-1998) showed changes in the quantitaive and qualitative composition of the fish fauna. The number of thermophilic species has increased; several species, scarce or rare until now are more abundant, while others are new records (7). Dulčić *et al.* (7) considered that the presence of the imperial blackfish and cornich blackfish *S. medusophagus* in the Adriatic waters depends on water warming. The northward extension of *S. ovalis* to the Bay of Biscay (8) and recent occurrences of young *S. ovalis* along French Mediterranean coasts (9) could support this hypothesis. Francour and Javel (9) assume that the observations of small to medium sized *S. ovalis* they gathered in 2000-2001 in the Alpes-maritimes department (Cannes, Antibes, Beaulieu/Mer) could be also explained by the present warming of waters (10).

According to Morović (11), the rarity of certain fish species could be evaluated from the records in scientific literature. Same author pointed that if the species is recorded fewer than five times, it should be treated as a very rare species. According to this, we could still treated the imperial blackfish (4 records in scientific literature until now) as a very rare species in the eastern Adriatic. We must also be careful with tools (gears) for providing target species if we want to evaluate their rarity since it is hard to sample the imperial blackfish (during different life phases) using conventional methods. FADs (Fishing Attractive Devices) provide a useful tool for studying mentioned species (12), so it could be proposed for next studies on fish assemblages in the southern Adriatic. The results of Deudero *et al.* (12) confirm the rare observations on the imperial blackfish (13) in the Ligurian Sea. Moreover, in the Balearic Sea only 3 catches of this species have been reported (14).

References

1 - Haedrich R.L., 1986. Centrolophidae. Pp. 1177-1182. *In*: Whitehead P.J.P., Bauchot M.L.., Hureau J.C., Nielsen J., and Tortonese E. (eds.), Fishes of the North-Eastern Atlantic and the Mediterranean. UNESCO, Paris.

2 - Tortonese E., 1975. Osteichthyes. Parte Seconda. Fauna Italia II, Calderini, Bologna.

3. Jardas I., 1996. Jadranska ihtiofauna. Školska knjiga, Zagreb.

4 - Orsi-Relini L., Fida B., and Relini M., 1990. Notes about *Schedophilus ovalis* (Osteichthyes, Centrolophidae) in the Ligurian Sea. *Rapp. Comm. int. Mer Médit.*, 31, 1: 272.

5 - Kolombatović J., 1902. Contribuzioni alla Fauna dei vertebrati della Dalmazia. Glas. Naravoslov. Društva, 13: 22-37.

6 - Onofri I., 1986. The rare saw-cheeked fish (*Schedophilus medusophagus* Cocco, 1839) (Pisces, Centrolophidae) in central Adriatic. *Zbornik Matice srpske za prirodne nauke*, 70: 135-141. (in Serbian).

7 - Dulčić J., Grbec B., and Lipej L., 1999. Information on the Adriatic ichthyofauna – Effect of the water warming? *Acta Adriat.*, 40: 33-43.

8 - Quero J.C., Du Buit M.H., Laborde J.L., and Vayne J.J., 2000. Observations ichtyologiques effectuees en 1999. *Ann. Soc. Sci. nat. Charente-Marit.*, 8: 1039-1045.

9 - Francour P., and Javel F., 2003. Recent occurrences of young *Schedophilus ovalis* (Centrolophidae) along French Mediterranean coasts. *Cybium*, 27: 57-58.

10 - Francour P., Boudouresque C.F., Harmelin J.G., Harmelin-Vivien M., and Quignard J.P., 1994. Are the Mediterranean waters becoming warmer? Information from biological indicators. *Mar. Poll. Bull.*, 28: 523-526.

11 - Morović D., 1973. Rijetke ribe u Jadranu. *Pomorski zbornik*, 11: 367-383.

12 - Deudero S., Merella P., Morales-Nin B., Massutí E., and Alemany F., 1999. Fish communities associated with FADs. *Sci. Mar.*, 63: 199-207.

13 - Relini M.L., Relini L., and Relini G., 1994. An offshore buoy as a FAD in the Mediterranean. *Bull. Mar. Sci.*, 55: 1099-1105.

14 - Masuttí E., and Stefanescu C., 1994. Sobre la presència de dues espècies de peixos pelàgics associats a objectens flotants en el Mar Català. *Boll. Soc. Hist. Nat. Balears*, 37: 117-123.

THE SPREADING OF LESSEPSIAN FISH MIGRANTS INTO THE ADRIATIC SEA: A REVIEW

J. Dulčić [1] *, L. Lipej [2], A. Pallaoro [1], A. Soldo [1]
[1] Institute of Oceanography and Fisheries, Split, Croatia - * dulcic@izor.hr
[2] Marine Biology Station, Piran, Slovenia

Abstract

Eight Lessepsian fish migrants have reached the Adriatic Sea in the last 20 years (one in the 19th century). The Lessepsian migrants found along the eastern Adriatic coast are: *Pampus argenteus, Parexocoetus mento, Hemiramphus far, Saurida undosquamis, Sphyraena chrysotaenia, Epinephelus coioides, Leiognathus klunzingeri, Stephanolepis diaspros* and *Siganus rivulatus*. The Adriatic records constitute the northernmost occurrences of those species.

Key-words: fish, Lessepsian migrants, Adriatic Sea

Introduction

The term "Lessepsian migration" was first used to characterize a new phenomenon of unidirectional and successful biotic advance from the Red Sea to the Eastern Mediterranean (1). The term "Lessepsian migrant" for Red Sea species that have passed through the Suez Canal and settled in the Eastern Mediterranean was coined by Por (2).

Changes in the Adriatic ichthyofauna have been recorded and among that some Lessepsian fish species were recently recorded (3). The purpose of this paper is to examine the records, distribution and abundance of the fish Lessepsian immigrants in the Adriatic waters taking into account some new data on their presence.

Results and discussion

At least 8 Lessepsian fish migrants reached the Adriatic Sea in last 20 years (one in the 19 century). All records were along the eastern Adriatic coast: three species were found at the Albanian coast, one species at the Montenegro coast, four species at the Croatian coast and one species at the Italian coast. Lessepsian fish species may be characterized according to several traits, namely abundance, habitat, feeding habits and size (4). Characterization of Lessepsian fish species in the Adriatic is: *Pampus argenteus* (caught in 1896 near Rijeka; 5, 6) – abundance: VR – very rare, habitat: P – pelagic, feeding habits: PL – planktivores, size: M – medium; *Hemiraphus far* (caught at Albanian coast, 7) – abundance: unknown, habitat: IP – inshore pelagic; feeding habits: PL – planktivores, size: unknown; *Parexocoetus mento* (caught at Albanian coast, 8) – abundance: unknown, habitat: IP – inshore pelagic, feeding habits: PL – planktivores, size: unknown; *Saurida undosquamis* (caught at Albanian coast, 9) – abundance: VR – very rare, habitat: B – benthic, feeding habits: FI – feeders of fish and benthic invertebrates, size: M - medium; *Sphyraena chrysotaenia* (caught on 10 August 2000 in Molunat Bay, Croatian coast, 10) – abundance: VR – very rare, habitat: BP – bentho-pelagic, feeding habits: FI – feeders of fish and benthic invertebrates; size: M – medium; *E. coioides* (caught in the Trieste Bay, 16 May 1998, 11) – abundance: VR – very rare, habitat: B – benthic, feeding habits: FI – feeders of fish and benthic invertebrates, size: M – medium; *Leiognathus klunzingeri* (caught in Saplunara Bay, Island Mljet, 29 June 2000, 12) – abundance: VR – very rare, habitat: B – benthic, feeding habits: BI – benthic invertebrates, size: S – small; *Stephanolepis diaspros* (caught at Hrid Djeran, Montenegro coast, 23 August 2002, 13) – abundance: VR – very rare, habitat: R – rocky, feeding habits: BI – benthic invertebrates, size: S – small; *Siganus rivulatus* (caught near Cavtat, Croatian coast, 5 October 2002, 14) – abundance: VR – very rare, habitat: B – benthic, feeding habits: H – herbivores; size: M – medium.

Nine Lessepsian fish migrants brought up (together with previous mentioned species in 3) the number of species recorded for the Adriatic to 432 and 122 families. The record of *P. argenteus* dated from 1896 and represents the first Lessepsian migrant in the Mediterranean Sea. The occurrence of the orange-spotted grouper *E. coioides* in the Gulf of Trieste (11) is very interesting indeed, since it had been previously recorded only from the coast of Israel and considered a rare and recent invader (15). Other seven species were amongst the first Erythrean invaders of the Eastern Mediterranean more than thirty years ago, when recorded as common or very common fish species in the Aegean coast and off Anatolian coast (16).

It is not really known what is the impact of the Lessepsian migrants in the Adriatic environment and in this stage it is very hard to perform any direct study to assess possible impact.

The last decade has witnessed an upsurge of comprehensive studies on the phenomenon of Lessepsian fish migration. The Adriatic Sea is obviously becoming an area on the westward distribution path of Lessepsian migrants and has provided some important notes and studies of westward spreading of them. We are looking forward to the continuation of this scientific effort and hope for further cooperation among the ichthyologists of the Levant and Adriatic Sea in the study of Lessepsian migration.

References

1 - Por F. D. 1964. A study of the Levantine and Pontic Harpaticoidea (Crustacea, Copeoda). *Zool. Verh. Rijksmus Nat. Hist. Leiden*, 64, 128 pp.
2 - Por F. D. 1969. The Canalidae (Copepoda, Harpaticoidea) in the waters around the Sinai peninsula and the problem of «Lessepsian» migration of this family. *Israel J. Zool.*, 18: 169-178.
3 - Dulčić J., Lipej L., and Grbec B., 2002. Changes in the Adriatic fish species composition. *In*: Ozturk B., and Basusta, N. (eds.), Workshop on Lessepsian Migration Proceedings. Published by Turkish Marine Research Foundation, Istanbul.
4 - Golani D. 2002. Lessepsian fish migration-characterization and impact on the eastern Mediterranean. *In*: Ozturk, B. and Basusta, N. (eds.), Workshop on Lessepsian Migration Proceedings. Published by Turkish Marine Research Foundation, Istanbul.
5 - Šoljan T., 1975. I pesci dell'Adriatico. A. Mondadori, Verona.
6 - Dulčić J., Jardas I., Pallaoro A., and Lipej L., In press. On the validity of the record of silver pomfret *Pampus argenteus* (Stromateidae) from the Adriatic Sea. *Cybium.*
7 - Parin N.V., 1986. Hemiramphidae. *In*: Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., and Tortonese E. (eds.), Fishes of the North-eastern Atlantic and the Mediterranean. Vol. 2., pp. 620-622. UNESCO, Paris.
8 - Parin N. V., 1986. Exocoetidae. *In*: Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., and Tortonese E. (eds.). Fishes of the North-eastern Atlantic and the Mediterranean. Vol. 2. pp. 612-619. UNESCO, Paris.
9 - Rakaj N. 1995. Iktiofauna e Shqipërisë. Shtëpia Botuese «Libri Universitar», Tirana.
10 - Pallaoro A., and Dulčić J., 2001. First record of the *Sphyraena chrysotaenia* (Klunzinger, 1884) (Pisces: Sphyraenidae) from the Adriatic Sea. *J. Fish Biol.*, 59: 179-182.
11 - Parenti P., and Bressi N., 2001. First record of the orange-spotted grouper, *Epinephelus coioides* (Perciformes: Serranidae) in the Northern Adriatic Sea. *Cybium*, 25 (3): 281-284.
12 - Dulčić J., and Pallaoro A., 2002. First record of the Lessepsian migrant *Leiognathus klunzingeri* (Pisces: Leiognathidae) from the Adriatic Sea. *J. Mar. Biol. Ass. U.K.*, 82: 523-524.
13 - Dulčić J., and Pallaoro A., In press. First record of the filefish, *Stephanolepis diaspros* (Monacanthidae), in the Adriatic Sea. *Cybium.*
14 - Dulčić J., and Pallaoro A., In press. First record of the marbled spinefoot *Siganus rivulatus* forsskal, 1775 (Siganiidae) in the Adriatic Sea. *J. Mar. Biol. Ass. U.K.*
15 - Golani D., 1998. Distribution of Lessepsian migrants fish in the Mediterranean. *Ital. J. Zool.*, 65 suppl.: 95-99.
16 - Ben-Tuvia A., 1966. Red Sea fishes recently found in the Mediterranean. *Copeia*, 25: 254-275.

EFFECTS OF FISH FARMING ON THE DISTRIBUTION OF POLYCHAETES IN THE AEGEAN SEA

Zeki Ergen *, Melih Ertan Çinar And Ertan Dağli

Ege University, Faculty of Fisheries, Dep. of Hydrobiology, Izmir, Turkey - * ergen@sufak.ege.edu.tr

Abstract

The distributional patterns of polychaetes in the vicinity of fish cage farms were studied at 6 stations in the Aegean Sea. A total of 256 species belonging to 43 families were identified. Samples collected under the fish cages had relatively low diversity, but high densities of some opportunistic species such as *Capitella capitata* and *Lumbrineris gracilis*.

Keywords: Cage farming, Polychaeta, Aegean Sea

Introduction

Dense aquaculture activities in the coastal zone have resulted in decreasing the quality of sea-water and bottom sediments, creating many problems to human health, tourism and to the farmers. Polychaetes are often used as bioindicators of changes in the marine environmental conditions, mainly due to human activities (1).

The aim of this study is to investigate the polychaete communities in the vicinity of fish cage farms, and to determine the impacts of fish farming activities on their distribution.

Material and methods

Benthic samples were collected at six stations in the Aegean Sea (Fig. 1). At each station three samples were taken; one under cages, one at the vicinity of cages and one at a control site. Stations 2 and 4 were seasonally sampled, but only one season was considered in the comparison between sites. The samples were washed through 0.5 mm mesh size sieve, fixed with 10% formalin and preserved in 70% ethanol. Sampling and community data of samples were given in Table 1.

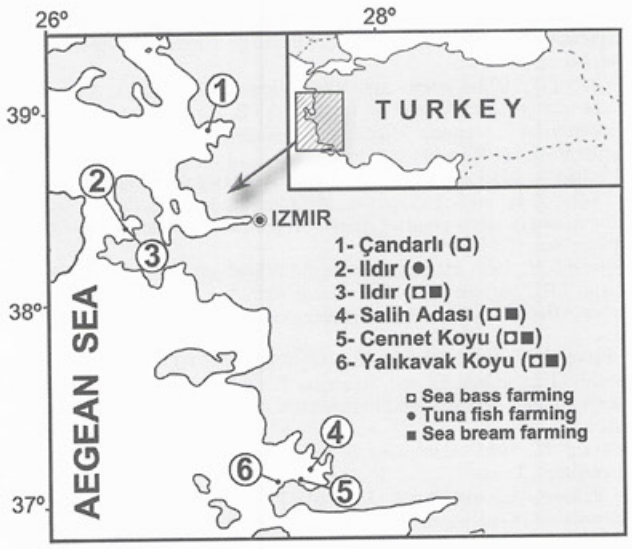


Fig. 1. Sampling sites in the Aegean Sea.

Results and discussion

A total of 256 species and 2795 individuals belonging to 43 families were identified. Syllidae were the most diverse family with 48 species (19%), followed by Sabellidae (6%), Cirratulidae (6%) and Phyllodocidae (6%). The Orbiniidae, Sphaerodoridae, Goniadidae, Scalibregmidae and Acrocirridae were not collected under the fish cages at all stations. The Syllidae dominated the *Posidonia oceanica* meadows and coralligenous substrate, and their diversity was greatest in the control sites whereas, Sabellidae and Cirratulidae were abundant under the cages.

The samples collected under cages included dense populations of *Capitella capitata* (30 ind.m^{-2} at sta. 1), *Protodorvillea kefersteini* (3060 ind.m^{-2} at sta. 3), *Nereis zonata* (30 ind.m^{-2} at sta. 4) and *Lumbrineris gracilis* (180 ind.m^{-2} at sta. 5; 110 ind.m^{-2} at sta.6), these species considered indicators of polluted or semi-polluted zones (Table 1). The sample from the cage farming of tuna fish at station 2 was exceptionally represented by high populations of *Paralacydonia paradoxa* (230 ind. m^{-2}) and *Macrochaeta clavicornis* (Sars) (230 ind.m^{-2}), which are indicators of clean waters. This is attributed to the recent date of the installation of the cages (June 2002), and to their location at the opening of the bay where the currents are relatively strong.

Table 1. Sampling and community data of samples collected under cages (A), at the vicinity of cages (B) and at a control site (C) of each station. R: Samples, D: Depth (meter), T: Sampling device (G: Grab, A: Dredge, S: Scuba-diving), B: Biotopes (M: Mud, Sm: Sandy mud, Ms: Mudy sand, C: Coralligenous substrate, P: *Posidonia oceanica* Delile, Sa: Sand), S: Number of Species, N: Number of Individuals.

S	R	Date	T	D	B	S	N	Dominant species
	A		G	50	M	24	34	*Capitella capitata* (Fabricius)
1	B	11/02	D	50	C	105	402	*Arichlidon reyssi* (Kat. Lau.& Ram)
	C		D	35	Sm	52	209	*Piromis eruca* (Claparède)
	A		G	25	P	64	234	*Paralacydonia paradoxa* (Fauvel)
2	B	02/03	D	45	M	56	334	*P. paradoxa*
	C		D	45	Sa	44	440	*Cirrophorus branchiatus* Ehlers
	A		S	12	Ms	30	572	*Protodorvillea kefersteini* (McIntosh)
3	B	07/96	S	12	P	40	75	*Paradoneis lyra* (Southern)
	C		S	12	P	18	27	*Kefersteinia cirrata* (Keferstein)
	A		D	25	M	12	17	*Nereis zonata* Malmgren
4	B	09/02	D	9	P	14	37	*Lumbrineris latreillii* (A&M Edwar.)
	C		D	14	P	7	13	*Eunice vittata* (Chiaje)
	A		G	32	M	25	95	*Lumbrineris gracilis* (Ehlers)
5	B	09/99	G	8	P	20	68	*Eunice vittata*
	C		G	30	Sa	30	96	*Nephthys hombergii* Savigny
	A		G	31	Ms	30	70	*L. gracilis*
6	B	11/99	G	31	Ms	15	20	*Cirriformia* sp.
	C		G	31	Ms	26	51	*Nematonereis unicornis* (Grube)

Shannon-Weaver's diversity index value ranges from 1.7 (A, Sta. 3) to 4.3 (C, Sta. 6). Pielou's evenness index value shows a similar trend, being higher at control sites, lower in samples collected under cages. High population densities of opportunistic species dominating organically polluted-sediment under cages diminished diversity and evenness values. The other samples collected under cages at stations had a diversity index value around 3. The samples collected near cages and far from cages presented diversified polychaete assemblages that appeared to be structured mainly by the habitat type and depth. At four stations, dense *Posidonia oceanica* meadows, very sensitive to pollution, exist at the vicinity of cages and control sites, showing undisturbed sediment structure. However, the disappearance of this phanerogam under cages at station 3 is obvious.

The ordination analyses of pooled abundance data of stations showed high similarities among stations, except station 1, where, contrary to other stations, a coralligenous substrate was sampled at the vicinity of cages that possessed a different faunal composition that was dominated by *Arichlidon reyssi* and *Syllis garciai*.

The present paper establishes that cage farming along the Aegean coast of Turkey affect the distribution of the polychaete assemblages, eliminating sensitive species and favouring opportunistic species.

References

1 - Pearson T. H., Rosenberg R., 1978. Macrobenthic succession in relation to enrichment and pollution of the marine environment. *Ocean. Mar. Biol. Ann. Rev.*, 16: 229-311.

FISHING CAPACITY AND FISHING ACTIVITY OF FOUR "RAPIDO" TRAWL FLEETS ALONG THE ITALIAN COASTS

Fabi G.[1] *, Sartor P. [2], Grati F. [1], Carpentieri P. [3]

[1] CNR - Istituto Scienze Marine Sezione Pesca Marittima, Ancona, Italy - * g.fabi@ismar.cnr.it
[2] Centro Interuniversitario Biologia Marina e Ecologia Applicata, Livorno, Italy - psartor@cibm.it
3 Dipartimento Biologia Animale e Uomo, Roma, Italy

Abstract

Fishing capacity and activity of four fleets using "rapido" trawl along the Italian coasts were investigated. Consistent fleets exist only in the Adriatic, while this gear is scarcely employed along the western Italian coasts. Boat length, GRT, engine power, fishing activity and total landings of the Adriatic fleets were considerably higher than those of the western basin vessels. These differences were reduced when landings per unit of effort are considered.

Key-words: rapido trawl, landings, fishing effort, Mediterranean Sea

Introduction

"Rapido" trawl is used in Italy to exploit sole and scallops. It resembles a beam trawl and consists of an iron frame provided with 3-5 skids and a toothed bar on its lower side. Nowadays it is largely used along the northern Adriatic coast, whereas few vessels operate with this gear in other Italian waters. To gather information for managing this fishery, a study on the characteristics of few Italian fleets using "rapido" was performed funded by EU (1), paying particular attention on fishing capacity and fishing activity.

Materials and methods

Four fleets were considered: Ancona and Rimini (northern Adriatic Sea), Viareggio (eastern Ligurian Sea) and Fiumicino (central Tyrrhenian Sea). Information on the main characteristics of vessels using "rapido" (GRT, boat length, engine power) and on fishing activity was collected at each harbour. From July 2000 to March 2002, data on monthly fishing days and total landings were recorded for each boat, through logbooks, interviews with fishermen and/or collection of auction documents.

Results and discussion

The "true" rapido fishing fleets exist only in the northern Adriatic Sea (Table 1), while along the western Italian coast its use, although more important in the past (2), is negligible at present, due to the reduced presence of suitable seabeds and to legislative restrictions issued in 1995 and still in force. The vessels of the two Adriatic fleets were considerably larger, in terms of length, GRT and engine power, than those operating in the western basin, allowing more gears of larger size to be towed.

Table 1. Main caracteristics of the boats, the gears and the fishnig activity of the "rapido" trawl fleets investigated. S.E. = standard error.

Harbour	Num. vessels	Gross Registered Tonnage		Length (m)		Engine power (kW)		Crew
		Mean	±S.E.	Mean	±S.E.	Mean	±S.E.	
Ancona	11	120.3	6.0	27.5	0.4	453.9	71.7	5-6
Rimini	9	87.3	9.4	24.3	0.9	382.9	20.7	5-6
Viareggio	2	25.0	-	20.0	-	134.0	-	2
Fiumicino	1	38.0	-	22.7	-	316.0	-	3

Harbour	"Rapido" trawl gears			Fishing activity			
	Num.	Width (m)	Speed (knots)	Days week	Hours day	Hauls day	Fishing ban
Ancona	4	4	7	3	24	15-18	30-45 days
Rimini	4	4	7	4	24	15-18	30-45 days
Viareggio	2	3	4.5-5	5	16	7-8	No
Fiumicino	2	3	4.5-5	5	16	7-8	No

In the northern Adriatic Sea "rapido" is used day and night, all year round and for 3-4 days a week, while in the eastern Ligurian and central Tyrrhenian Seas it is employed mostly during day and more unsteadily over the year, being alternated with otter trawl (Table 1).

These aspects explain differences in fishing activity (Fig. 1), which ranged from 218 to 429 and from 215 and 446 fishing days at Ancona and Rimini respectively, with the lowest values recorded in summer, when trawling is banned for about 45 days. On the other hand, it ranged between 47 and 85 days at Viareggio and between 5 and 41 at Fiumicino. Seasonal total landings were higher at Ancona (62-164 t) and Rimini (65-132 t) than at Viareggio (4-10 t) and Fiumicino (1-7 t). These differences decreased when landings per unit of effort were considered (Fig. 2): only the values of Rimini were significantly higher (one-way ANOVA, $p<0.05$) than those of the other ports.

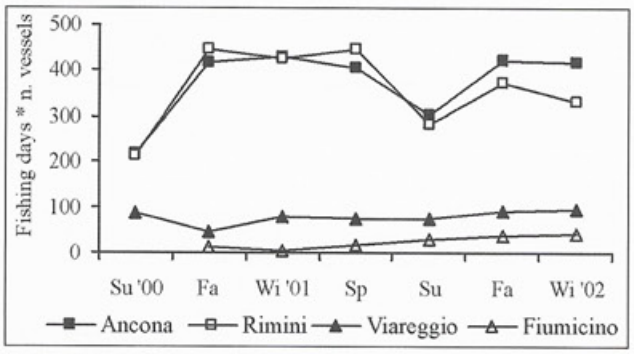


Fig. 1. Fishing activity performed by each "rapido" trawl fleet.

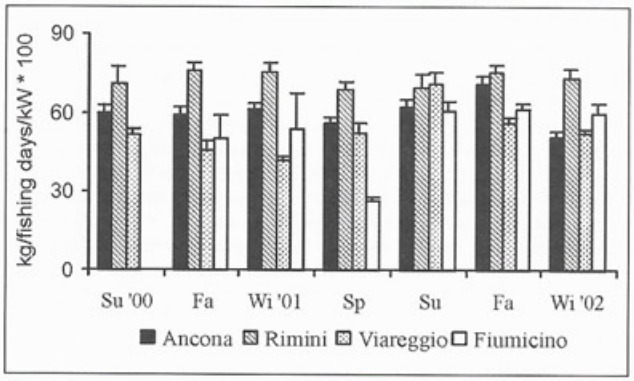


Fig. 2. Landings per unit of effort of each "rapido" trawl fleet.

References

1 - Fabi G., and Sartor P., 2002. Study on the mixed-species catches of the "rapido" trawl fishery along the Italian coasts. EU Study Contract N. 99/051, Final Report. 124 p.

2 - Recasens L., and Sartor P., 1995. Analyse comparative des captures des différents engins de pêche de fonds dans la zone littorale (<80 m de profondeur). *Rapp. Comm. int. Mer Médit.*, 34: 254.

CONTRIBUTION A L'ETUDE DE LA CROISSANCE ET L' AGE DE *BELONE BELONE* (BELONIDAE) DES CÔTES EST DE LA TUNISIE

Rafika Fehri-Bedoui *, Houcine Gharbi

Institut National des Sciences et Technologies de la Mer, Centre La Goulette, Tunisie - * Rafika.bedoui@instm.rnrt.tn

Résumé

La croissance et l'âge de *Belone belone gracilis* (Lowe, 1839), orphie des côtes Est de la Tunisie, ont été étudiés en se basant sur deux méthodes. La première directe a permis d'établir les relations morphométriques entre les différentes longueurs et la relation taille-poids du poisson (a et b). La deuxième méthode indirecte est basée sur l'échantillonnage mensuel. L'étude des structures en taille par la méthode de Bhattacharya a permis de déterminer L_∞, k et t_0 et d'estimer l'âge de chaque classe de taille.

Key words : Belone belone gracilis, Age, Growth, Eastern Mediterranean

Introduction

En Tunisie, les travaux de recherche concernant les Belonidés sont peu nombreux et les rares travaux réalisés (1) n'ont signalé que l'espèce *Belone belone gracilis*. Cette espèce peuple le littoral tunisien et pénètre même dans les lagunes (2). En 2002, la production toutes espèces confondues a été estimée à 500 tonnes. Cependant *Belone belone gracilis* représentait 80% des prises. Dans le but d'engager une étude dynamique de cette espèce, nous nous proposons de déterminer les paramètres de sa croissance.

Matériels et méthode

Les orphies étudiées proviennent de la pêche professionnelle dans la région Est de la Tunisie durant la période mai 2000 à avril 2001. Ce poisson est capturé à la senne et au filet maillant à des profondeurs inférieures à 20 m. Pour l'étude de la croissance relative, des relations morphométriques ont été établies entre les différentes longueurs et la relation taille-poids du poisson. Ainsi, l'étude biologique a concerné 209 individus dont 63 mâles, 91 femelles et 55 indifférenciés. Pour chaque poisson, nous avons mesuré Lt: longueur totale, Lc: longueur du corps (Lc = Lt – longueur de la tête) et Ls: longueur du corps mesurée jusqu'à à l'origine de la caudale. Les longueurs totales sont comprises entre 23,7 et 52 cm. Les poids plein (W_p), éviscéré (W_e) et éviscéré sans tête (W_{e-t}) ont été déterminés et exprimés en g. Cette dernière méthode nous permet d'estimer les paramètres de croissance a et b. D'un autre côté, pour la croissance absolue, nous avons fait appel à l'analyse des résultats de l'échantillonnage effectué mensuellement de mai 2000 à avril 2001. Les effectifs échantillonnés sont classés par mois et par classe de taille (intervalle 0.5 cm). Au total, l'effectif s'est élevé à 2378 individus. La croissance absolue a été établie à partir de l'analyse des distributions des tailles et leur décomposition en modes. Les différents modes obtenus correspondent à des pseudocohortes d'âges différents. Pour cette analyse, nous avons utilisé le logiciel FiSAT qui, faisant appel à la méthode de Bhattacharya, permet d'estimer les paramètres de la croissance. Ces derniers sont ajustés à l'équation de Von Bertalanffy.

Résultats

Méthode directe

Les relations morphométriques chez les mâles, les femelles et le global de *Belone belone* se présentent comme suit:

Femelle:

$Lt = 1{,}251\ Lc + 4{,}222\ R^2 = 0{,}983$; $Lt = 1{,}387\ Ls + 5{,}3125\ R^2 = 0{,}9777$

Mâle:

$Lt = 1{,}3829\ Lc + 1{,}2806\ R^2 = 0{,}9799$; $Lt = 1{,}541\ Ls + 2{,}3852\ R^2 = 0{,}9724$

Global:

$Lt = 1{,}3001\ Lc + 3{,}1696\ R^2 = 0{,}9837$; $Lt = 1{,}4422\ Ls + 4{,}2636\ R^2 = 0{,}9787$.

La relation taille-poids est de la forme $W = aL^b$. Les relations ont été établies entre les poids plein (W_p) et éviscéré (W_e) et L_t et entre le poids éviscéré sans tête (W_{e-t}) et la longueur du corps (L_c). Les équations correspondantes sont les suivantes:

Femelle:	$W_p = 0{,}0001L_t^{3,5536}$	$R^2 = 0{,}9681$;
	$W_e = 0{,}0003L_t^{3,3004}$	$R^2 = 0{,}9683$
	$W_{e-t} = 0{,}001L_c^{3,0399}$	$R^2 = 0{,}9655$
Mâle:	$W_p = 0{,}0003L_t^{3,2894}$	$R^2 = 0{,}9438$;
	$W_e = 0{,}0003L_t^{3,2488}$	$R^2 = 0{,}9399$
	$W_{e-t} = 0{,}0011L_c^{3,1993}$	$R^2 = 0{,}9362$
Global:	$W_p = 0{,}0002L_t^{3,4846}$	$R^2 = 0{,}9673$;
	$W_e = 0{,}0002L_t^{3,3352}$	$R^2 = 0{,}9717$
	$W_{e-t} = 0{,}012L_c^{3,1494}$	$R^2 = 0{,}967$

Méthode indirecte

L'analyse des distributions de taille et leur décomposition en modes par la méthode de Bhattacharya a permis d'établir une clé taille-âge et d'estimer les paramètres de croissances de *Belone belone gracilis* (Tab. 1). Les valeurs moyennes des tailles correspondantes à chaque classe de taille s'ajustent bien à l'équation de Von Bertalanffy qui s'exprime comme suit: $L_t = 61{,}4\ (1\text{-}e^{-0{,}109(t+2{,}889)})$ (Fig 1). Selon le même modèle, la croissance pondérale s'exprime comme suit: $W_p = 340{,}47\ (1\text{-}e^{-0{,}109(t+2{,}889)})^{3{,}4846}$.

Tab. 1. Paramètres de croissance et clé taille-âge de *Belone belone gracilis* (Méthode Bhattacharya).

Paramètres de croissance	Clé Taille-âge	
	Taille (cm)	Age (années)
$L_{t\infty}$= 61,4 cm	21,5	1
k= 0,109	25,623	2
t_0= -2,889	28,526	3
	32,241	4
	35,603	5
	38,079	6
	40,943	7

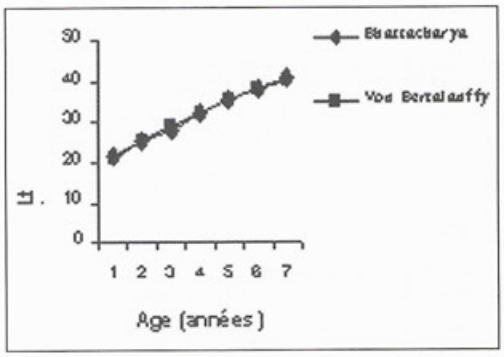


Fig. 1. Courbe de croissance linéaire de de *Belone belone gracilis* des côtes est de Tunisie.

Discussion

Les paramètres morphométriques de l'orphie présentent une bonne corrélation aussi bien chez les mâles que les femelles. Ceci prouverait que la croissance en longueur du corps s'accompagne simultanément avec l'allongement des mâchoires du poisson en aiguille.

Les relations taille-poids présentent des allométries majorantes chez les deux sexes. Cependant, la valeur assez élevée de b = 3,5536 chez les femelles pourrait être attribuée à l'augmentation du poids des gonades en période de reproduction. En effet, leur poids peut atteindre les 20% du poids total (3).

Les résultats de l'échantillonnage ont montré que les captures de la pêche professionnelle touchent essentiellement les individus ayant une taille supérieure à 37,5 cm; ils sont de ce fait matures et ont un âge supérieur à 5 ans (3). La taille L_∞= 61,4 cm de l'orphie des côtes tunisiennes est en deçà des tailles signalées (L_{stmax} = 90 cm) en Méditerranée.

Références

1 - Kartas F., and Trabelsi M., 1988. Données sur quelques caractères numériques des espèces du genre *Belone* (Poissons, Téléostéens) des côtes tunisiennes. *Rapp. Comm. Int. Mer Médit.*, 31, 2:258.

2 - Romdhane M .S., 1985. La lagune de Ghar El Melh: Milieu, peuplement, exploitation. Thèse 3ème cycle, Univ. Tunis, 245 p.

3 - Bedoui R., Gharbi H., and El Abed A., 2002. Période de reproduction et maturité sexuelle de *Belone belone gracilis* (Belonidae) des côtes Est et Sud de la Tunisie. *Vèmes Journées de l'ATSMer*, 21-24 déc. Aïn Draham. Tunisie. 4 p.

DEMERSAL FISH ASSEMBLAGES FROM THE CONTINENTAL SHELF AND UPPER SLOPE TRAWLING GROUNDS OFF SE SPAIN (WESTERN MEDITERRANEAN)

A. M. Fernández [1] * and M. García-Rodríguez [2]

[1] IEO. Centro Oceanográfico de Murcia, Pedro del Pinatar, Spain - * angel.fernandez@mu.ieo.es
[2] IEO. Servicios Centrales. Madrid , Spain

Abstract

The continental shelf and upper slope fish communities off SE Spain were studied based on data collected during the LEDER cruise in June 2002. Cluster and MDS analysis allowed the identification of four groups of hauls related to depth, which result in well defined communities. Similarity percentage analysis was used to identify the most discriminating species between communities. Ecological parameters are provided for comparison with other areas.

Key-Words: Fish assemblages, Demersal communities, Western Mediterranean

Introduction

Fish communities and the bathymetric distribution of their species are well known in some areas of the Spanish Mediterranean specially the Catalan Sea, the Balearic Islands and the Alborán Sea (1,2,3). The hydrological conditions of the continental shelf and upper slope off SE of Spain could be considered transitional between the north-western Mediterranean areas and the Alboran Sea. These characteristics could affect species distribution and community composition. The present study is the first analysis of the demersal fish communities in this area.

Materials and methods

Data were collected in June 2002. A total of 54 samples (hauls) were taken with the MEDITS sampling gear between depths of 36 and 578 m. Abundance and biomass data were transformed by double square root to reduce the effects of extreme values. A total of 107 species were recorded but pelagic species from the continental shelf and mesopelagic or bathypelagic species from the upper slope were omitted from the analysis as well as species recorded only in a single sample, since they could introduce some noise in the analysis. Cluster analysis and multidimensional scaling (MDS) were used for grouping similar samples. The PRIMER package (4) was used to carry out the analysis, based on the Bray-Curtis similarity index, Complete Linkage Clustering and UPGMA (Unweighted Pair-Group Mean Analysis). To establish which species contribute to the (dis)similarity between groups of samples, the SIMPER (similarity percentage analysis) routine was used. To test the differences between groups of samples an one-way layout ANOSIM test was employed. The ecological parameters abundance, biomass, species richness (S), mean species richness, Shannon-Wiener diversity index (H´) and evenness (J´) were determined for each group identified by cluster and MDS analysis.

Results and discussion

Analysis made on biomass and abundance data showed similar results. Cluster analysis and MDS (Fig. 1) showed four main groups of samples clearly related to depth which correspond to shallow areas (A), continental shelf (B), continental break (C) and upper slope (D) respectively. Similar bathymetric pattern has been described in other areas (1, 3). In shallow areas (less than 40 m deep) few samples were taken due to the existence of rocky bottoms and *Posidonia oceanica* sea-grass. The results of SIMPER for similarity within groups showed that in group B the most characteristic species were *Boops boops, Mullus barbatus, Serranus hepatus, Spicara maena, Pagellus acarne, Cepola macrophthalma, Mullus surmuletus* and *Lepidotrigla cavillone.* For group C, the most characteristic species were *Micromesistius poutassou, Helicolenus dactylopterus, Gadiculus argenteus* and *Lepidopus caudatus.* In the case of group D, the characteristic species were *Phycis blennoides, Lampanyctus crocodilus, Galeus melastomus, Etmopterus spinax, Nezumia aequalis* and *Hoplostetus mediterraneus.* ANOSIM test (R=0.868; significance level < 0.1%) confirmed the high dissimilarity between these assemblages. Species richness (S), diversity (H´) and evenness (J´) reached the highest values in group B whereas maximum values of abundance and biomass were obtained for group C. Group D showed the smallest values of abundance, biomass and S, but intermediate values of H' and J' (Table 1).

Table 1. Ecological parameters of the groups of samples resulting from cluster and MDS analyses (group A was not included because of the small number of samples).

	Group		
Parameter	**B**	**C**	**D**
Abundance ($N/10^3 m^2$)	10.3	48.3	3.4
Biomass ($g/10^3 m^2$)	359.3	1022.3	188.6
Species richness	59	54	22
Mean species richness	18.0	12.9	11.3
Diversity (H´)	1.98	0.96	1.19
Evenness (J´)	0.70	0.37	0.49
Mean depth (m)	80.3	217.3	521.3
Number of hauls	22	24	6

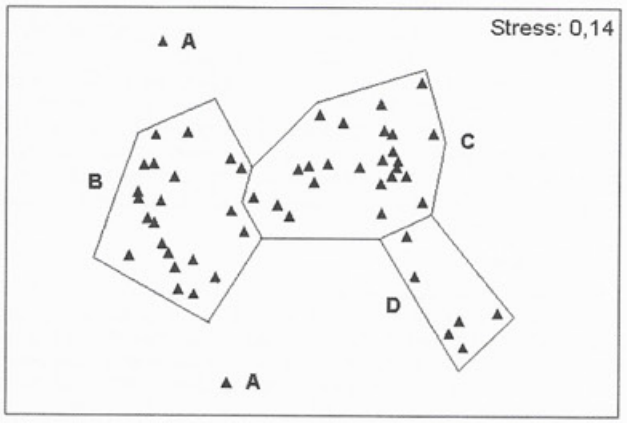


Fig.1. MDS plot of samples. Groups encircled by lines correspond to those obtained by cluster analysis.

References

1 - Demestre M., Sánchez P., and Abelló P., 2000. Demersal fish assemblages and habitat characteristics on the continental shelf and upper slope of the north-western Mediterranean. *J. Mar. Biol. Ass. U. K.*, 80: 981-988.

2 - Gil de Sola L., 1994. Ictiofauna demersal de la plataforma continental del mar de Alborán (Mediterráneo suroccidental ibérico). *Bol. Inst. Esp. Oceanog.*, 10 (1): 63-79.

3 - Massutí E., Reñones O., Carbonell A., and Oliver P., 1996. Demersal fish communities exploited on the continental shelf and slope off Majorca (Balearic Islands, NW Mediterranean). *Vie Milieu*, 46 (1): 45-55.

4 - Clarke K.R., and Warwick R.M., 1994. *Change in marine communities: an approach to statistical analysis and interpretation.* Natural Environment Research Council, UK, 144 p.

IS THE ZOOPLANKTON DECREASING? THE CASE OF 10 YEARS' STUDY IN THE BALEARIC SEA (WESTERN MEDITERRANEAN): 1993-2003

Mª Luz Fernández de Puelles

Spanish Oceanographic Institute. Baleares Laboratory, Palma de Mallorca, Spain - * mluz.fernandez@ba.ieo.es

Abstract

The zooplankton off Mallorca has been studied for ten years (1993-2003), and related to the main physico-chemical properties of the surface water. Data from a monitoring station at 75m depth were collected every 10 days, and zooplankton biomass and abundance were estimated, and the main zooplankton groups identified. A significant decreasing trend was observed in both zooplankton indices with increasing salinity. However, a decrease was observed during the warmest years (1994-1998), a linear temperature trend was found, mainly due to the cooling of later years.

Key-words: Hydrography, zooplankton, time-series, Balearic Sea

Introduction

The Balearic Sea is located in a boundary area between different water masses in the Western Mediterranean (1), where strong hydrographic annual variability is observed (2), related to changes in the planktonic community (3). In addition, plankton exhibits great variability over time, particularly at inter-annual level, in response to climatic forcing. The mechanisms controlling that variation are still far from understood and long-trend plankton studies are highly recommended in the Mediterranean (4, 5). They emphasize the need for assessing temporal trend to identify the causes of observed changes. Our goal is to describe the results of a 10 years' study of the zooplankton community and the environmental conditions in the Balearic Sea.

Material and methods

From April 1993 to April 2003 sea water and plankton samples were collected every 10 days from a neritic zone off Mallorca Island (39º28´54"N; 2º25´57"E). To collect hydrographic data 5l Niskin bottles were used at 0-15-25-50 and 75 m depth, and a CTD- Sbe19. Zooplankton was collected by a Bongo Plankton net of 20 cm diameter and 250 µm mesh by means of oblique haul (0-75 m). The zooplankton samples were subdivided, the biomass samples were frozen at -20ºC, and the composition samples were fixed in 5% neutralised formaldehide. The laboratory analysis followed a protocol detailed in previous study (6).

Results and discussion

Physical environment- Annual values of temperature based on measurements made synchronously with salinity were registered, and monthly data calculated. A clear seasonality was marked as a typical thermic regime of these temperate latitudes (1). Interannual variability was observed, with cooler winters during 1994, 1996 and 2000 (17.5ºC), and a warmer 1995 and 1998 (18.3ºC). During the study period, annual mean values increased particularly during 1997 and 1998. Because of this variability, a linear trend was found during the studied period. Although, an increase was observed during the spring and summer from 1995 to 1998. In general, the minimum temperature was measured in February-March (13.3ºC at 75m depth, 1994, 1996) and the maximum in late August (27.4ºC in 1998). The highest salinity values were registered during spring 1996 and 2000 (38.19), and the lowest in 1995 and 1998 (37.10). These lower values were related to recent Atlantic waters coming from the south (7). Higher salinities, detected mainly during 1996 and 2000, were related to northern Mediterranean waters (2). Due to the increase in annual values from 1998, an upward trend was observed in the area (R^2=0.56; p<0.05).

Zooplankton – The annual cycle of the mesozooplankton showed fluctuations, with peaks in winter and late spring. Biomass and abundance of zooplankton were higher during spring 1996 and 2000, almost entirely due to the presence of copepods. Significant correlation was found between both indices (R^2= 0.3; p<0.01). The highest zooplankton abundance was related to cooler temperature (17ºC, spring mean values) and higher salinity (>38), as noted by previous studies (7) when northern Mediterranean waters were more important in the Mallorca Channel. Lower salinity and warmer temperature in 1995 and 1998 were related to more recent Atlantic waters flowing in (3, 2).

We observed a close relation between the zooplankton and the surface water masses in the channel, particularly important during spring. They relate a cooler and saltier waters with higher increase of zooplankton. We confirm the considerable interannual variability in physico-chemical properties of the Balearic Sea, driving the main changes in zooplankton abundance. Even so, both indices - biomass (R^2=0.40; p<0.01) and abundance (R^2=0.12; p<0.05) – decreased during the 10 years' period. It would be useful to correlate the results of our study with large-scale changes in zooplankton in other areas of the Mediterranean and longer time-series.

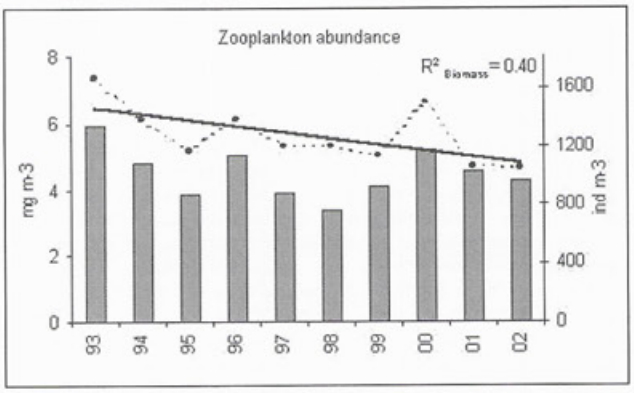


Fig. 1. Annual zooplankton biomass (dashed line) and abundance (bar) from April 1993 to April 2003.

References

1 - Estrada M, Vives F. and M. Alcaraz, 1985. Life and productivity in open seas. Pp. 150-199. *In*: Margalef R. (ed.), The Western Mediterranean. Pergamon Press. London.

2 - Pinot J.M., Lopez Jurado J.L. and M. Riera, 2002. The Canales Experiment (1996-1998). Interannual seasonal and mesoscale variability of the circulation in the Balearic channels. *Progr. in Oceanogr.*, 55 : 325-370.

3 - Fernandez de Puelles M.L., Pinot J.M. and J. Valencia, 2003. Seasonal and interannual variability of zxooplankton community in waters off Mallorca island (Balearic Sea, Western Mediterranean):1994-1999. *Ocean. Act.* (in press).

4 - Cataletto B., Feoli E., Fonda-Umani S. and Sund Cheng-Yong, 1995. Eleven years of time-series analysis on the net-zooplankton community in the Gulf of Trieste. ICES *J. mar. Sci.*, 52 : 669-678.

5 - Mazzocchi M.G. and M. Ribera d'Álcala, 1995. Recurrent patterns in zooplankton structure and succession in a variable coastal environment. *ICES J. mar. Sci.*,52 : 679-681.

6 - Fernandez de Puelles M.L., Jansa J., Gomis C., Gras D. and B. Amengual, 1997. Variación anual de variables oceanográficas y planctónicas en el Mar Balear. *Bol. Inst. Esp. Ocean.* 13(1 - 2): 13-33.

7 - Pinot J.M., Tintore J. and D. Gomis, 1994. Quasi-synoptic mesoscale variability in the Balearic Sea. *Deep Sea Res.*, 41 : 897-914.

NEW RECORDS OF *PARABLENNIUS PILICORNIS* (CUVIER, 1829)(PISCES, BLENNIIDAE) ALONG THE ITALIAN COASTS

F. Fiorentino [1] *, F. Massari [2], C. Vassallo [1]

[1] MaliRA-Group, Istituto di Ricerche sulle Risorse Marine e l'Ambiente - IRMA, sez. di IAMC, CNR, Mazara, Italy - * fabiof@irma.pa.cnr.it
[2] G.R.O. SUB Catania, Italy

Abstract

New records of *Parablennius pilicornis* (Cuvier, 1829)(Pisces, Blenniidae) along the Italian coasts are reported. Previous studies showed the species' presence only in one site along the Western Ligurian coast and in three sites in the Gulf of Palermo (northern Sicily). On the basis of underwater observations, occurrence of *P. pilicornis* is here described in north-western Sardinia and in other sites of southern Tyrrhenian. These findings may represent a progressive expansion of the species to the whole western Mediterranean Sea.

Keywords: Parablennius pilicornis, biogeography, Italy, Central Mediterranean

Introduction

The ringneck blenny, *Parablennius pilicornis* (Cuvier, 1829), is widely distributed in rocky bottoms of the western Indian Ocean, the eastern and southwestern Atlantic Ocean, and the western part of the Mediterranean Sea, including Morocco, Algeria, Spain and France (1, 2). Until a few years ago, it was considered absent from the Italian coasts (3). Its presence was reported only in three sites in the Gulf of Palermo (northern Sicily) (4) and in one site along the Ligurian coast (5). Given the concern about the variation of species' distribution in the Mediterranean Sea, and its possible link with global climate changes (6), new information on its distribution is here presented and discussed in the light of the current knowledge on its biogeographic distribution in the area.

Materials and methods

All results are coming from underwater observations. Specimens were photographed or fished with a polyethylene bag trap. The identification of the specimens was done on the basis of livery and morphological features. At least three basic color patterns are reported: basic light livery with a median band or with scattered dark brown patches, almost black (only males) and striking yellow (only females). Considering the morphological features easily recognizable during diving or on photos, the presence of typical supraorbital tentacle with 5 filiform appendages of similar size is remarkable (7).

Results and discussion

Results of *P. pilicornis* observations along the Italian coasts are reported in Table 1. All known liveries were recorded in the examined lot, without any site preference.

Table 1. New records of *Parablennius pilicornis* in Italian coasts. UWP = Author's archives of under water photos; ICUWPH = Italian competition of underwater photographic hunting of Italian Federation of Underwater Sports (FIPSAS); * =one specimen; ** =more than one specimens.

Date	Site	Sources and remarks
Sept. 1997	Porto Conte (North-western Sardinia)	UWP * (basic livery)
May 1998	Addaura (North-western Sicily)	UWP ** (basic livery)
May 1999	Addaura (North-western Sicily)	UWP ** (black, yellow, basic liveries)
Oct. 2000	Sferracavallo (North-western Sicily)	ICUWPH * (basic livery)
May 2001	Ganzirri (Strait of Messina)	UWP * (basic livery)
June 2001	Amantea (Tyrrhenian Calabria)	ICUWPH * (basic livery)
August 2001	Castellammare del Golfo (North-western Sicily)	UWP ** (basic livery)
May 2003	Addaura (North-western Sicily)	mature female, 80 mm TL * (basic livery)
July 2003	Sferracavallo (North-western Sicily)	UWP * (black livery)
August 2003	Castellammare del Golfo (North-western Sicily)	UWP ** (basic livery)
Sept. 2003	Panarea (Aeolian Islands)	UWP * (yellow livery)

The only dissected specimen was a female (80 mm TL, 68 mm SL and 5.50 g of body weight) with an ovary weight of 0.20 g and large, transparent eggs.

Our observations expand the known geographical distribution of *P. pilicornis* in the Italian coasts. After the first reports of the species along the coasts of northwestern Sicily and the eastern Ligurian Sea, no more are available in the literature. It must be noted that the assemblages of blenniid fish were studied earlier in the Ligurian and Tyrrhenian Sea, down to Capo Vaticano (Calabria) (8). Twelve species out of the 20 blennies occurring in the Italian seas (9) were reported, with slight variation in species composition among sites. Although the thermophilic species *Scartella cristata* was recorded at 21 of the 25 sampling sites, no evidence of *P. pilicornis* was given.

Even if the Italian competitions of underwater photographic hunting have been held since the 80's throughout the Italian seas, the species was photographed only twice. Furthermore, even though one of the authors routinely dives in the eastern coasts of Sicily (Ionian Sea), no specimen of *P. pilicornis* was ever observed in the area.

The presence of the species in many sites of northern Sicily (southern Tyrrhenian) suggests that *P. pilicornis* is, at present, a stable component of the blenniid assemblage along this coast, marking an apparent eastward expansion of the species in the Mediterranean. The presence of the species in the northwestern coast of Sardinia, in front of the Balearic Islands, where its occurrence is well documented (1), gives a greater value to the species occurrence in the eastern Ligurian coast (5) and in the Gulf of Lions (2).Finally, the presence of the species in Amantea (Tyrrhenian coast of Calabria), north of the Capo Vaticano station, where *P. pilicornis* was not reported earlier (8), suggests that the species expanded from the northern Sicilian coast to the Calabrian one.

According to us all these records are sign of the species' progressive expansion to the whole western Mediterranean Sea. This might be interpreted as a step in the more general extension of geographical distribution of subtropical Atlantic species, due to the climatic variation which can affect the current regime in the Mediterranean (2)

Acknowledgements. Many thanks to Tullio Foti, who provided photos and information on the specimen sighted off Ganzirri (Strait of Messina), and to Marco L. Bianchini and Carlo Pipitone, for their helpful suggestions.

References

1 - Patzner R.A., 1985. Die Blenniiden von Ibiza (Balearen) und ihre Verbreitung im West-Mittelmeer (Pisces: Teleostei: Blennioidea). *Senk. Biol.*, 65(3-6): 179203.

2 - Quignard J.P., and Tomasini J.A., 2000. Mediterranean fish biodiversity. *Biol. Mar. Medit.*, 7(3): 166.

3 - Tortonese E., 1987. Pesci del Mediterraneo: recenti studi intorno alla sistematica e distribuzione. *Quaderni Istituto Idrobiologia Acquacoltura G. Brunelli* (Sabaudia), 111 p.

4 - Catalano E., Vitturi R., Zava B., and Macaluso M., 1985. Ritrovamento di *Parablennius pilicornis* (Cuvier, 1829) nelle acque italiane e suo cariotipo. *Atti Soc. Ital. Sci. Nat. Museo Civ. Stor. Nat. Milano*, 126(3-4): 155164.

5 - Balma G.A.C., Bath H., and Delmastro G.B., 1989. A new record of *Parablennius pilicornis* (Cuvier, 1829) from the Italian sea (Osteichthyes: Blennidae). *Nova Thalassia*, 10: 99102.

6 - Andaloro F., and Rinaldi A., 1998. Fish biodiversity change in Mediterranean Sea as tropicalisation phenomenon indicator. *in:* D'Angelo E.G., and Zanolla C. (eds.), Indicators for assessing desertification in the Mediterranean, ANPA (Rome), pp. 201-206.

7 - Cid Ruiz J.M., 1993. Blenidos del Meditérraneo. Anarpa (Madrid), 214 p.

8 - Nieder J, La Mesa G., and Vacchi M., 2000. Blenniidae along the Italian coasts of the Ligurian and the Tyrrhenian sea: community structure and new records of *Scartella cristata* for northern Italy. *Cybium*, 24(4): 359369.

9 - http://www.faunaitalia.it/checklist/vertebrates/perciformes.html

REPRODUCTIVE BIOLOGY OF *CHLOROPHTHALMUS AGASSIZI* IN THE CENTRAL-WESTERN MEDITERRANEAN

Follesa M.C. *, Cabiddu S., Davini M.A., Porcu C., Cau A.

Department of Animal Biology and Ecology, University of Cagliari, Italy - * follesac@unica.it

Abstract

160 specimens of *Chlorophthalmus agassizi* with total length between 6.6 and 18.8 cm were caught in the Sardinian Sea. Microscopic analysis showed six stages of oocyte development. Spawning occurred in Summer.

Key-words: Chlorophthalmus agassizi, hermaphroditism, reproduction, Mediterranean Sea

Introduction

Chlorophthalmus agassizi Bonaparte, 1840, shortnose greeneye, is a bathydemersal monoecious species (1). Though abundant in Mediterranean Sea where it has a rather wide geographic distribution (2, 3), the current knowledge on its biology is limited, especially on its reproductive cycle. This paper studied its reproductive period.

Materials and methods

Samples were caught with experimental trawl surveys (Autumn and Summer) carried out in the Sardinia Sea as part of national and international (2) projects in 2002, and from samplings in the months not covered by the experimental surveys. For each month, the gonads of several individuals were collected stratified based on size.

Stages of oocyte development were based on those proposed by Forberg (4) and adapted to the studied species. Oocytes were measured and counted by stage and the Nucleoplasmatic Ratio (NPR) was calculated: $NPR=Vn(Vc-Vn)^{-1}$, where Vn = nucleus volume and Vc = cytoplasm volume.

Results and discussion

The gonads were made up of two distinct components: the ovarian and the testicular components. The ovarian component presented a double sacciform structure elongated in the abdominal cavity. The oviduct is one and gathers the mature sexual products of both ovaries. The testicular portion, included in the median zone of each ovary, was made up of seminiferous tubules and ended in an ampoule.

Following histological analysis of the gonads of 160 specimens caught from March to November with a TL from 6.6 to 18.8 cm, six oocyte development stages were identified (Fig. 1):

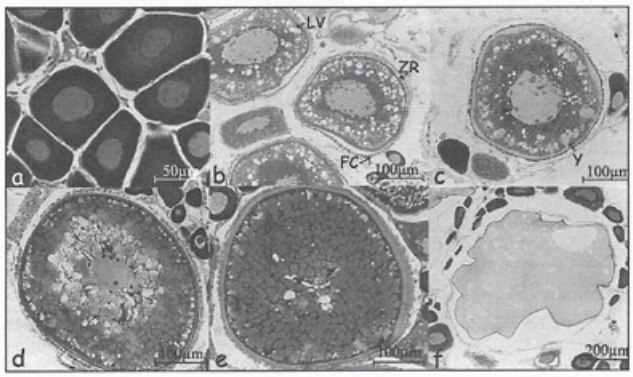


Fig. 1. Oocyte developmental stages: Basophils (a), Lipid vesicles (b), Primary vitellogenesis (c), Secondary vitellogenesis (d), Tertiary vitellogenesis (e), and Translucent (f).

B (*Basophils*): oocytes with a uniform cytoplasm, strongly basophilic and homogeneous. NPR=0.211; diameter=20-70 µm (Fig. 1a).

LV (*Lipidic Vesicles*): oocytes with weakly basophilic cytoplasm, which contained lipid vesicles. Follicular Cells (FC) and the "Zona Radiata" (ZR) appeared. NPR=0.187; diameter=70-210 µm (Fig. 1b).

Y1 (*Primary vitellogenesis*): the oocytes presented drops of protein vitellin (Y=yolk) scattered in the cytoplasm and lipid vesicles increased in number; the follicular cells started to thin out and the ZR to thicken. NPR=0.056; diameter=210-270 µm (Fig. 1c).

Y2 (*Secondary vitellogenesis*): the cytoplasm was acidophilous; the drops of protein vitellin increased in number and size and started to unite into progressively larger drops; the ZR appeared very thick and the follicular cells continued to spread. NPR=0.021 diameter=270-500 µm (Fig. 1d).

Y3 (*Tertiary vitellogenesis*): the drops of protein vitellin were completely joined together as well as the lipid vesicles. The nucleus migrated to the periphery of the oocyte until it disappeared completely. Diameter >500 µm (Fig. 1e).

T (*Translucent*): the oocyte was large and characterised by clarification of the protein vitellin. The oocyte was ready to be shed (Fig. 1f).

Four stages of development have been assigned to the male portion of the gonad: primary spermatocyte, secondary spermatocyte, spermatid, and sperm.

Two periods of oocyte development were identified in a year: 1) spent ovary, (an ovary with immature oocytes: B, LV); 2) ovary with oocytes belonging to all the stages of maturation and sperms which were also mature. The reproductive season started in May and ended in September with a reproductive peak in July. In the mature ovaries the contemporary presence of oocytes at progressive stages of development was pointed out (asynchronous ovary), the eggs were shed several times during a reproductive season.

It has been possible to hypothesise a simultaneous type of hermaphroditism. During the reproductive season, in fact, the presence of mature male and female elements was observed (TL>9 cm). The species seems to be sequentially protandric hermaphroditic: very small individuals (TL 5-8 cm) presented immature ovaries during all the months of the year, they always showed mature sperm.

Nevertheless the adopted reproductive strategy is still not clear. Self-fertilisation could be possible for anatomical reasons (the male and female genital tracts meet at one and the same opening), moreover, the gonads contemporaneously present mature female and male sexual elements. However, *C. agassizi* lives in large shoals, which suggests that meeting a sexual partner would not be difficult. This hypothesis is further confirmed by the presence of a luminous organ of symbiotic bacteria in the perianal area (5), which could be used for sexual attraction, being an intraspecific system of communication.

References

1 - Merrett N.R., 1990. Chlorophthalmidae. Pp. 351-360. *In:* Quero J.C., Hureau C., Karrer A., Post and Saldanha L. (eds.), Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris.

2 - Relini G., Bertrand J., and Zamponi A., (eds) 1998. Sintesi delle conoscenze sulle risorse da pesca dei fondi del Mediterraneo centrale (Italia e Corsica). *Biol. Mar. Medit.*, 6 (suppl. 1): 165-168.

3 - Sulak K.J., 1986. Chlorophthalmidae. Pp. 412-413. *In:* Whitehead P.J., Bauchot M.L., Hureau J.C., Nielsen J. and Tortonese E. (eds.), Check-list of the fishes of the North-eastern Atlantic and the Mediterranean (CLOFNAM). UNESCO, Paris; and ONU, Paris.

4 - Forberg K.G., 1982. A histological study of development of oocytes in capelin, *Mallotus villosus villosus* (Muller). *J. Fish Biol.*, 20: 143-154.

5 - Somiya H., 1977. Bacterial bioluminescence in chlorophthalmid deep-sea fish: a possible interrelationship between the light organ and the eyes. *Experentia,* 33/7: 906-909.

PRELIMINARY DATA ON THE BIOLOGY OF *ALEPOCEPHALUS ROSTRATUS* RISSO, 1820 IN THE CENTRAL-WESTERN MEDITERRANEAN

Follesa M.C. *, Cabiddu S., Pesci P., Sabatini A., Cau A.

Department of Animal Biology and Ecology, University of Cagliari, Italy - * follesac@unica.it

Abstract

This note deals with 107 specimens of *Alepocephalus rostratus* caught in the Sardinian Channel at depths between 950 and 1190 m. Its frequency of numerical abundance increased with depth. The standard length (SL) of the specimens caught ranged between 13 and 45 cm for females and 13 and 36 cm for males. The length-weight relationship was $TW=0.0063SL^{3.113}$ for sexes combined. The main prey identified in the stomachs were the tunicate *Pyrosoma atlanticum* as well as crustaceans.

Key words: deep sea fish; Alepocephalus rostratus; Mediterranean Sea

Introduction

Alepocephalus rostratus Risso, 1820, the only known representative of the family Alepocephalidae in the Mediterranean Sea (1), occupies a dominant position among the typical bathyal species and its biology has been studied mainly in the Catalan Sea (NW Mediterranean) (2-3). In this note we present preliminary data on its biology based on specimens caught in the Sardinian Channel (central-western Mediterranean).

Materials and methods

Samples were collected from 12 experimental trawl hauls (mesh size 40 mm, stretched) carried out in the Sardinian Channel at depths between 800 and 1200 m (4 at a mean depth of 800 m, 4 at 1000 m, and 4 at 1200 m) during summer 2003. A total of 107 specimens were caught, which were measured for standard length (SL, cm), weighed (total weight, TW, g), sex was identified and state of gonad was determined microscopically. The length-weight relationship was estimated for sexes combined. Finally, a preliminary analysis of stomach contents was done for 55 specimens, with prey identified to the lowest taxonomic level.

Results

A. rostratus was caught at depths between 950 and 1190 m. The number of specimens caught was zero between 800 and 900 m and gradually increased with depth, making up 6% in 900-1000 m and 11 % in 1100-1200 m. In the Sardinian Sea it was found at depths between 550-780 m (4) as in the remaining part of the western Mediterranean (5).

Of the 107 specimens caught 62 were females, 30 males whereas sex was not determined for 15 individuals. Their SL ranged between 13 and 45 cm for females, 13 and 36 cm for males and 13-18 cm for indeterminate specimens. The sex ratio (F:M) was 2.06 in favour of females.

The length-weight relationship was $TW=0.0063SL^{3.113}$ for sexes combined ($N=104$; $R^2=0.95$; $SE_b=0.64$), indicating positive allometry.

The analysis of the stomach contents of 55 individuals indicated a large number of empty stomachs (41 out of 55). The diet was dominated by the tunicate *Pyrosoma atlanticum* (N%=81%), crustaceans (N%=16%) and, to a lesser extent, cephalopods (N%=3%). The diet composition was similar to that reported from the Catalan Sea (1).

References

1 - Markle D.F., and Quero J.-C., 1984. Alepocephalidae. Pp. 228-253. *In*: P.J.P Whitehead, M.-L. Bauchot, J.-C. Hureau, J. Nielsen and E. Tortonese (eds.), Fishes of the North-eastern Atlantic and the Mediterranean. UNESCO, Paris,Vol.1.

2 - Stefanescu C., Lloris D., and Rucabado J., 1992. Depth size trends in western Mediterranean demersal deep-sea fishes. *Mar. Ecol. Prog. Ser.,* 81: 205-213.

3 - Carasson M., and Matallanas J., 1990. Preliminary data about the feeding habits of some deepsea Mediterranean fishes. *J. Fish Biol.,* 36: 461-463.

4 - Cau A., 1980. Secondo contributo alla conoscenza dell'ittiofauna dei mari circostanti la Sardegna meridionale (Osteichthyes). *Quad. Civ. Staz. Idrobiol. Milano,* 8: 39-43.

5 - Raimbault R., 1963. Notes sur certaines espèces ichthyologiques capturées au cours des campagnes de l'Institut des Pêches en Méditerranée (1957-1961). *Rév. Trav. Inst. Pêches Marit.*, 27 (1).

DIVERSITY OF THE DINOFLAGELLATE GENUS *ALEXANDRIUM* IN THE MEDITERRANEAN SEA

Santiago Fraga *, Isabel Bravo, Roberto González, Nagore Sampedro, Esther Garcés, Magda Vila, Jordi Camp, Memé Masó, Mariagrazia Giacobbe, Antonella Lugliè and Olympia Gotsis

* Instituto Español de Oceanografía, Subida á Radio Faro 50, 36390 Vigo, Spain - Santiago.fraga@vi.ieo.es

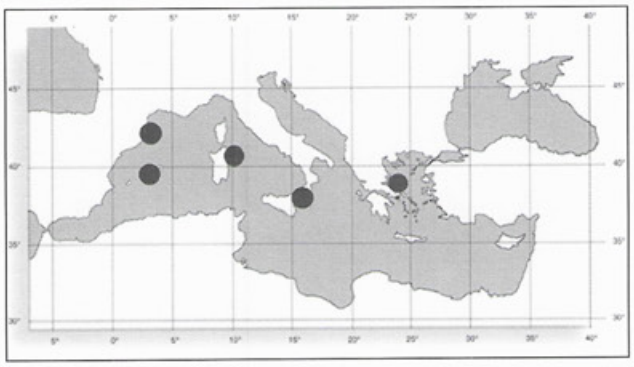
Abstract

Harmful Algal Blooms (HAB) are a growing problem in the world. The dinoflagellate *Alexandrium*, with 12 species recorded from the Mediterranean Sea, is one of the most important genera causing HAB. Some *Alexandrium* species produce potent Saxitoxins that may enter the food web through filter feeding mollusks, and cause intoxications in humans.

Alexandrium may also produce massive blooms in confined areas like beaches or harbours, that, even when non toxic, affect tourism, an important industry in the Mediterranean.

Keywords : Harmful Algal Blooms, Alexandrium, Mediterranean

The EU project strategy ((EVK3-CT-2001-00046) (http://www.icm.csic.es/bio/projects/strategy) focuses on the dinoflagellate genus *Alexandrium*. This genus includes species causing Paralytic Shellfish Poisoning (PSP), and most Harmful Algal Blooms (HAB) in the Mediterranean. Problems associated with this genus have increased in the last decade. The project analyzes different aspects of *Alexandrium* in the Mediterranean in order to develop a theoretical framework of its expansion. A sampling network has been developed in four areas along the northern Mediterranean (Fig.1), and a database has been created with the input of the STRATEGY network. One of the objectives of this network is to follow the progress of *Alexandrium* species in the region and to compare areas with the same bloom events.



The propagation of the genus *Alexandrium* within the Mediterranean is difficult to assess as reliable distributional information is scarce. Routine monitoring (mainly related to shellfish farming) is not addressed to elucidate if an increment or/and a species propagation is actually occurring. Identification of the blooming species requires taxonomic expertise and careful examination of the plate pattern, uncommon in routine analysis of plankton samples, so we suspect some reports may be misidentifications. Most bloom descriptions are published in the "grey" literature and in most cases, only the first detection in a specific area is described. Therefore a key point in the study of the expansion of *Alexandrium* is to learn how many species are present in the Mediterranean, and to trace their actual distribution.

Nine species of *Alexandrium* have been obtained in culture from vegetative cells or from resting cysts, that, in addition to another species already in culture, make an important collection of strains, and the source of material for works in progress. With two other species, already reported from the Mediterranean, a total of 12 species is known from the sea. Balech (1) has divided genus *Alexandrium* in two subgenera: *Alexandrium* and *Gessnerium* depending on the contact of plates 1' and Po which is direct in the first and absent in the second. The type species of the genus is *A. minutum*, described from Alexandria, Egypt (2), but widespread in the Mediterranean, and known from blooms elsewhere in the sea. This species is toxic (PSP). *Alexandrium catenella*, a very toxic species frequently causing summer blooms in harbours (3) or in coastal lagoons with shellfish farms, is more common in the western Mediterranean. Among the non-toxic species of concern to recreational use is *A. taylori*. This species blooms in the pristine waters of highly frequented beaches turning the water turbid, and providing a source of complaints by tourists that think it is some kind of pollution (4). *Alexandrium* cf. *peruvianum* was found in the Catalan coast but its potential toxicity is yet unknown, but of concern as *A. peruvianum* is a close relative of *A. ostenfeldii*, a species which is toxic in the North Atlantic. *Alexandrium tamutum*, a new species (5), was already observed in the northern Adriatic, off Naples, Sardinia and the Catalan coasts. The other species are not so important as some of them are very rare or non toxic, and hence harmless.

List of species:

Subgenus *Alexandrium*

A. minutum - Widespread in the Mediterranean. Toxic bloom species.
A. catenella - Western Mediterranean. Very toxic bloom species.
A. tamutum - Adriatic, Tyrrhenian, and Catalan coast. Non Toxic.
A. tamarense - East and West Mediterranean. Toxic and non toxic strains.
A. affine - Alboran Sea. Non toxic.
A. andersonii - Italy and Greece. Toxic and non toxic strains.
A. cf. *peruvianum* - Catalan coast. Toxicity unknown.

Subgenus *Gessnerium*

A. taylori - East and west Mediterranean. Non toxic bloom species
A. pseudogonyaulax - Western Mediterranean - Unknown toxicity
A. margalefi - Western Mediterranean. Unknown toxicity
A. balechii -Tyrrhenian Sea. Non toxic.
A. foedum. -Tyrrhenian Sea. Toxicity unknown.

References

1 - Balech E, 1995. The genus *Alexandrium* Halim (Dinoflagellata). Sherkin Island Marine Station. Sherkin Island, Co. Cork, Ireland.151 p.
2 - Halim, Y., 1960. *Alexandrium minutum, n. gen. n. sp.* dinoflagelle provocant des eaux rouges. *Vie Milieu*, 11: 102-105.
3 - Vila, M., Garcés, E., Masó, M. and Camp, J., 2001. Is the distribution of the toxic dinoflagellate *Alexandrium catenella* expanding along the NW Mediterranean coast? *Mar. Ecol. Prog. Ser.*, 222: 7383.
4 - Garcés, E., Masó, M., Camp, J., 1999. A recurrent and localised dinoflagellate bloom in a Mediterranean beach. *J. Plankton Res.*, 21: 23732391.
5 - Montresor, M., John, U., Beran, A., Poletti, R. and Medlin, L. 2002. *Alexandrium tamutum sp. nov.*, a new species closely related to *A. minutum*. Abstracts of the X International Conference on Harmful Algae. St. Pete Beach, Florida. p. 204.

HYDROBIOLOGIE DE LA BAIE D'ANNABA (ALGÉRIE NORD EST): CARACTÈRES PHYSICO-CHIMIQUES ET BIOMASSE CHLOROPHYLLIENNE

Frehi H. [1], Ayada M. [1], Kara M.H. [1] * et Coute A. [2]

[1] Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie
[2] Muséum National d'Histoire Naturelle, Département des milieux et peuplements aquatiques, Paris, France

Résumé

L'étude des paramètres physico-chimiques des eaux de la baie d'Annaba, entre janvier et décembre 2002, montre que les stations côtières sont caractérisées par des températures élevés, une légère dessalure, une forte turbidité et de fortes concentrations en sels nutritifs (Ammonium, Nitrate et Phosphate). Les teneurs élevées en chlorophylle *a* indiquent un état d'eutrophisation des eaux de la baie.

Mots clés: baie d'Annaba, MED, température, salinité, sels nutritifs, chlorophylle a

Introduction

En plus des déversements naturels des oueds "Seybouse" et "Boudjemâa", la baie d'Annaba reçoit des rejets domestiques et industriels, sans traitement préalable. Cependant, mis à part les travaux (1) et (2), la situation actuelle de l'environnement côtier est peu connue.

L'objectif de ce travail est de suivre les variations des paramètres physico-chimiques des eaux de la baie d'Annaba, en relation avec les apports continentaux. Il s'agit d'évaluer leur niveau d'enrichissement, dans l'espace et dans le temps, et de déterminer l'impact sur la biomasse chlorophyllienne.

Matériel et méthodes

La côte d'Annaba constitue un golfe situé à l'extrême Est de l'Algérie. La baie d'Annaba est située dans la partie ouest de ce golfe, comprise entre l'oued Seybouse à l'Est et le Cap de Garde à l'Ouest. Les mesures et les prélèvements d'eau sont effectués en surface, au niveau de 3 stations pendant l'année 2002. Les deux premières reçoivent directement les apports de l'oued Seybouse et les rejets d'un complexe d'engrais phosphatés (Asmidal). La troisième est loin de tout rejet, mais soumise directement aux influences des eaux du large.

Les paramètres mesurés sont: la température, la salinité, la transparence, les sels nutritifs (phosphates, nitrates, ammonium) (3) et la chlorophylle *a* (4).

Résultats et interprétation

La comparaison des données obtenues au niveau des trois stations considérées dans la baie d'Annaba a révélé l'existence de deux zones distinctes. La première (A), située au Sud Est de la baie (stations 1 et 2), est caractérisée par des températures relativement élevées (entre 16,8° C en janvier et 28,8° C en septembre), des eaux fortement turbides et une légère dessalure (35,1 à 37,6‰). La seconde (B), située au Nord Ouest de la baie (station 3), présente des températures comprises entre 14,8 et 25,5° C et une salinité relativement homogène, entre 37,1 et 37,9‰.

Concernant les sels nutritifs (Tab. 1), il existe un gradient de concentrations décroissant du Sud-Est au Nord-Ouest, dû aux influences continentales (rejets urbains et industriels). Ce gradient est plus marqué pour l'ion ammonium dont les valeurs sont extrêmement élevées (5,06 à 272,82 µmole.l^{-1} dans la station 1 et 43,91 à 798,65 µmole.l^{-1} dans la station 2), ce qui s'explique par l'influence du principal rejet industriel (Asmidal) sur la qualité des eaux côtières. En effet, les concentrations en cet élément varient entre 0 et 1,86 µmole.l^{-1} dans la station 3, retrouvant les valeurs d'oligotrophie enregistrées en Méditerranée Nord-Occidentale (5).

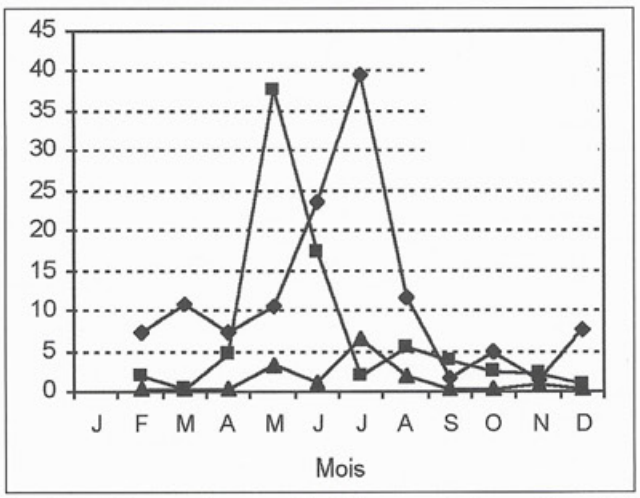


Fig. 1. Variations spatio-temporelles de la concentration en chlorophylle α dans la baie d'Annaba au cours de l'année 2002.

Les plus fortes concentrations en chlorophylle *a* sont obtenues au cours des mois de mai à juillet. Avec des teneurs inférieures à 2 µg.l^{-1} dans la station 3, les concentrations atteignent des valeurs très élevées dans les stations 1 (39,51 µg.l^{-1}) et 2 (37,6 µg.l^{-1}) (Fig. 1). D'après la classification de (6), la baie d'Annaba est considérée globalement comme moyennement eutrophe. En effet, la concentration moyenne enregistrée (6,60 µg.l^{-1}) se situe dans l'intervalle de 5 à 20 µg.l^{-1}.

Tab. 1. Variations spatiales et temporelles de la concentration des éléments nutritifs (ammonium, nitrate, phosphate) dans la baie d'Annaba au cours de l'année 2002.

Elément	Ammonium (µmole.l^{-1})			Nitrates (µmole.l^{-1})			Phosphates (µmole.l^{-1})		
Stations	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
J 2002	32,76	418,65	0	3,8	48	1,15	2,11	6,20	0
F	272,82	268,15	0	13,95	18,30	0,13	1,99	1,07	0
M	64,51	171,65	1,86	9,24	2,30	0,06	3,03	5,46	0
A	87,91	192,15	0,71	37,36	48,64	0,06	1,92	4,83	0
M	21,66	798,65	0,56	1,45	6,96	0,06	1,06	10,73	0,03
J	5,06	77,21	0	0,87	9,82	0,11	2,12	5,40	0
J	26,01	59,21	0	5	17,26	0,03	5,96	10,05	0
A	18,96	43,91	0	4,47	6,27	0,11	1,65	6,12	0
S	29,32	57,32	0	2,1	5,47	0,03	1	6,07	0
O	55,57	63,82	0,16	13,4	18,01	0,06	2,36	6,60	0
N	210,07	477,22	1,66	29,37	66,66	0,83	0,82	6,40	0,18
D	211,82	250,15	0,81	58,36	52,78	1,20	0,46	1,48	0

Références

1 - Frehi H., 1995. Etude de la structure et du fonctionnement du système phytoplanctonique dans un écosystème côtier: eutrophisation de la Baie d'Annaba. Thèse de Magister, Université d'Annaba, Algérie. 160 p.

2 - Ounissi M., Frehi H., et Khelifi-Touhami M., 1998. Composition et abondance du zooplancton en situation d'eutrophisation dans un secteur côtier du golfe d'Annaba (Algérie). *Ann. Inst. Océanogr.*, 74(1): 13-28.

3 - Aminot A., et Chaussepied M., 1983. Manuel des analyses chimiques en milieu marin. Eds CNEXO, Brest, 395 p.

4 - Lorezen C. J., 1967. Determination of chlorophyll and phéopigment: spectrophotometric equation. *Limnol. Océanogr.*, 12: 227-343.

5 - Conan P., Izdar E. et Menioui M., 1998. Variabilité hydrologique et biologique du Golfe du Lion.II. Productivité sur le bord interne du courant. *Océanol. Acta*, 21: 767-782.

6 - Bricker S.B., Clement C.G., Pirhala D.E., Orlando S.P., and Farrow D.R.G., 1999. National estuarian eutrophication assessment. Effects of nutrient enrichement in the Natin's estuaries. NOAA. National ocean service. Special projects office and the national center for coastal ocean science. Silver spring, MD., 71 p.

SHRINKAGE EFFECTS ON SARDINE LARVAE *(SARDINA PILCHARDUS)* CONSERVED BY ETHANOL AND LIQUID NITROGEN

A. García *, D. Cortés, L. Quintanilla and T. Ramírez

Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Fuengirola, Málaga, Spain - * agarcia@ma.ieo.es

Abstract

Sardine larval shrinkage observed under different conservation agents, liquid nitrogen and ethanol, is assessed. The degree of shrinkage was affected by the type of conserving agent. While shrinkage observed in ethanol was independent of size, liquid nitrogen conserved specimens were size dependent. Highest shrinkage occurred in ethanol. Care is recommended in measurements, because manipulation of larvae can affect enlargement of body size.

Keywords: shrinkage, sardine, ethanol, liquid nitrogen

Introduction

Accurate estimates of larval length are essential in studies on the early life histories of fish. Measurements of larval length are used in order to estimate age, growth and nutritional condition.

Shrinkage of larvae, during fixation, may be a source of error, necessitating the use of adjustments to convert from preserved to fresh measurements. The degree of shrinkage may vary and depend on the type of conservation agent (1; 2; 3), species preserved (3), and larval size and age (2; 4).

Use of ethanol is recommended for the preservation of larvae for age estimation from daily rings in otoliths (5), whereas, for age estimation and biochemical analysis, freezing by liquid nitrogen is recommended (6).

Material and methods

Sardine larvae were collected by means of a 1 m Bongo net (1mm mesh) towed repeatedly at surface during 7-10 minutes at nightime. Sardine larvae were sorted and standard length (SL) measured by an image analysis system. After measurement, each larva was individually conserved in an eppendorf using three conservation methods: (1) stored in liquid nitrogen (LN); (2) 96% ethanol (OH), and (3) in LN and sea-water (LN+SW). The number of larvae analysed for each conservation agent were: (1) LN-conserved: 120 larvae of sizes 9.1-23.8 mm (8% average shrinkage); (2) OH-conserved: 150 larvae of sizes 8.3-24.5 mm (9% average shrinkage); and (3) LN+SW-conserved: 120 larvae of sizes 9.8-34.2 mm (6% average shrinkage).

The conserved larvae were measured after 45 days. Those conserved in LN were defrosted prior to measurement. To avoid bias, as on board, the same measuring device and person did the measurements. To test the effect of larval weight on shrinkage, those conserved in LN were wet weighed, after SL measurement. To assess the effect of manipulation on larval size, the conserved larvae LN + SW were measured twice; the first measurement without manipulation by simply defrosting the ice pellet in a Petri dish, while the second measurement was carried out after transferring the larvae to a slide by means of a paintbrush.

Results and discussion

The results of t-test for dependent samples show that all the conservation agents used have a shrinkage effect on sardine larvae ($p<0.001$). Maximum shrinkage was observed in ethanol-preserved larvae. Linear relationships of conserved size versus fresh size showed that shrinkage is size-dependent in LN, while ethanol-conserved larvae were independent of size. The linear regressions of conserved SL on fresh SL for each conservation method are:

1) LN SL(fresh)= 1.11*SL(conserved)-0.41 ($R^2 = 0.94$, n=120)

2) OH SL(fresh)= 0.96*SL(conserved)+1.94 ($R^2 = 0.94$, n=150)

3) LN+SW SL(fresh)= 0.99*SL(conserved)+0.86 ($R^2 = 0.94$, n=120)

To test the effect of conservation method and shrinkage, a two-way ANOVA was carried out on 5 previously defined size classes (<10, 10-13, 16-19, >19 mm). The results showed that all conservation methods do not cause an equal shrinkage effect, the degree of shrinkage is not the same for all size classes and there is an effect of the conservation method used and the size classes on shrinkage ($p<0.001$). A post-hoc comparison of means (Tukey HSD test) was subsequently done to verify the results of the two-way ANOVA.

The results showed that mean shrinkage was significantly ($p<0.001$) affected by size class in LN-preserved larvae, causing a shrinkage increase with larval size, while those larvae conserved in LN+sea-water, mean shrinkage was not significantly affected by size class ($p>0.05$). For larvae conserved in 96% alcohol, mean shrinkage showed a similar degree of shrinkage in all size classes ($p>0.999$), therefore size-independent (Fig. 1).

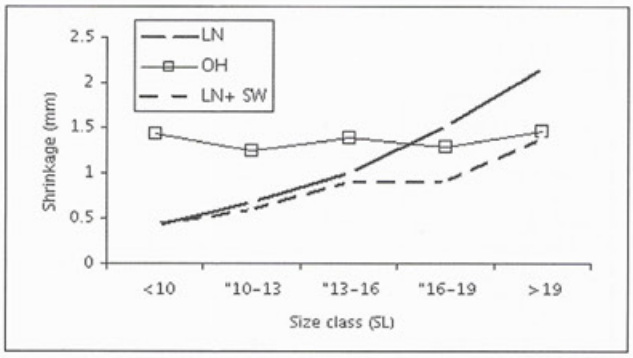


Fig. 1. Mean shrinkage of sardine larvae by conservation agent and size class.

To assess the effect of weight on shrinkage, an ANOVA was applied on the weighed LN conserved larvae. The results indicated that weight significantly ($p<0.001$) affects shrinkage, increasing with weight.

Lastly, to test the effect of manipulation to measure LN-conserved larvae, a t-test was applied to compare measurements of non-manipulated and manipulated larvae. The results showed that manipulation significantly ($p<0.001$) affects size causing body size enlargement.

It is important in larval studies to have accurate measurements at live length. This study contributes to assess the effect of conservation methods, on larval size and weight, as well as, the effect of manipulation on the enlargement of body size.

References

1 - Theilacker, G.H., 1980. Changes in body measurements of larval northern anchovy, *Engraulis mordax* , and other fishes due to handling and preservation. *Fish. Bull.,* 78(3), 685-692.

2 - Hjoerleifsson, E. and Klein-MacPhee, G., 1992. Estimation of live standard length of winter flounder *Pleuronectes americanus* larvae from formalin-preserved, ethanol-preserved and frozen specimens. *Mar. Ecol. Prog. Ser.*, 82(1): 13-19.

3 - Fey, D.P., 1999. Effects of preservation technique on length of larval fish: Methods of correcting estimates and their implication for studying growth rates. *Bull. Sea Fish. Inst. Gdynia.* 155: 47-51.

4 - Hay, D.E., 1982. Fixation shrinkage of herring larvae: Effects of salinity, formalin concentration, and other factors. *Can. J. Fish. Aquat. Sci.*, (39)8: 1138-1143.

5 - Brothers, E.B., 1987. Methodological approaches to the examination of otoliths in aging studies. Pp. 319-330. In: Summerfelt, RC; Hall, GE (eds.) Age and growth in fish. Int. Symp. on Age and Growth in Fish, Des Moines, IA (USA), 9 Jun 1985.

6 - Buckley, L.J., and Bulow, F.J., 1987. Techniques for the estimation of RNA, DNA, and protein in fish. Pp. 345-354. In: Summerfelt, RC; Hall, GE (eds.) Age and growth in fish. Int. Symp. on Age and Growth in Fish, Des Moines, IA (USA), 9 Jun 1985.

SMALL-SCALE FISHERIES OF THE ALICANTE GULF: THE CASE OF SANTA POLA PORT AS A PRELIMINARY APPROACH

Mariano García-Rodriguez [1] * and Angel M. Fernández [2]

[1] Instituto Español de Oceanografía, Servicios Centrales, Madrid, Spain - * mariano.garcía@md.ieo.es
[2] Instituto Español de Oceanografía, Centro Oceanográfico de Murcia, San Pedro del Pinatar, Murcia, Spain

Abstract

The artisanal fleet operating in Alicante Gulf was analysed from data collected at the Santa Pola port using, multivariate analysis and GLM. Monthly landings/boat from 1994 to 2002 were used to describe activity groups, identify discriminant species, characterise catch composition by gear and obtain a derived abundance index for selected species. The results suggested that the fishery was more or less stable throughout the years.

Key-Words: Small-scale fisheries, Western Mediterranean, Spain

Introduction

Small-scale fisheries in the Spanish Mediterranean are of limited importance when compared with trawl and purse seine fisheries. Nevertheless, its social and economic importance is high. The artisanal fleet exceeds 2,800 small (< 10 m) boats using more than 20 different gears, usually two or more per boat. It is characterised by highly diversified catches in terms of species as well as by wide geographic dispersion of landings, a fact rendering data collection difficult. In Alicante Gulf, 12 ports with artisanal activity exist, with more than 150 boats landing daily. The Santa Pola port represents more than half of the activity (57% of boats), with more than 300 t landed per year.

Materials and methods

Monthly landings cumulated by boat and species and without gear indication were collected from selected vessels that landed more than 100 days per year in the Santa Pola port during 1994-2002 (compiled by the RIM-IEO). In order to identify different activity groups of the artisanal fleet (i.e., métiers), principal components analysis (PCA) was performed on a matrix containing percentage contribution of 26 species to the total monthly catch by vessel for the period studied. In addition, agglomerative hierarchical grouping (AHG) was applied to identify and classify each monthly-landing (vessels) in each corresponding activity group. The specific composition of the landings of each group obtained were compared with the specific composition of the different gears described previously (1) for a reference year (2000). The comparison allowed us to regroup the results into groups that defined some of the different gears currently used in the area. To analyse the variation of the CPUE for the target species selected in each case a Generalised Linear Model, GLM, (2), which included factors such as vessel, year and month was used. The model chosen was: $\mathrm{Ln}\mu_{cym}=\alpha+\delta_c+\theta_y+\lambda_m+\varepsilon_{cym}$, where μ_{cym} is the expected catch rate obtained by vessel class c in year y in month m; α is the catch rate obtained by vessel class 1 in January 1994; δ_c is the efficiency of vessel class c relative to class 1; θ_y is abundance in year y relative to 1994; λ_m is abundance in month m relative to January and ε_{cym} is the deviation between the observed catch rates and the expected value for c. An analysis of deviance was carried out in order to evaluate the significance of the factors in the model. Analyses were performed using S-PLUS 2000 (3).

Results and discussion

The total number of selected boats during the 9-year period was 51 (mean: 25 different boats/year). PCA showed that 6 main components explained 73% of total variance. The 8 most discriminant species (or species groups) identified were: *Mullus spp.*, *Merluccius merluccius*, *Octopus spp.*, *Sparidae*, *Sepia officinalis*, *Conger conger*, shellfish (*Ruditapes* + *Donax* + *Chamelea*) and mixed 1 (*Sparidae* + *Scorpaenidae* + *Labridae*). Cluster showed 9 main activity groups and subsequent groupings provided 7 different gears. The most discriminant species for PCA also defined the gear grouping, as well as its catch species composition (Table 1). The GLM selected explained up to 48% of deviance for the total CPUE. The most important factors identified were vessel (25%), followed by year (16%) and month (7%). For the species, differences existed between nominal and standardised CPUE's, resulting in standardised ones being lower than nominal ones, especially for *C. conger* and *Sparidae* (Table 2). In general, the fishery was more or less stable with a maximum CPUE in 1997 decreasing slowly thereafter. Selected species were fished all year round, with the exception of *S. officinalis* (fishing season: January to May). In general, the results agree with previous descriptions of the fishery in the area (1), suggesting that the methodology applied can be adequate for use in small-scale fisheries studies.

Table 1. Specific catch composition and percentage contribution of each species/ group to total catch, of the seven main gears identified in the Alicante Gulf area.

Species/Group	Bottom long line	Surface long line	Trammel net	Mullet trammel	Cuttlefish trammel	Hake gillnet	Dredge
C.r conger	13.1	3.5	-	-	-	-	-
C. hippurus	-	1.3	-	-	-	-	-
M. merluccius	-	-	-	-	-	77.7	-
mixed 1	5.3	-	21.4	17.3	13.7	-	1.2
mixed 2	8.8	1.0	6.3	6.7	4.8	4.0	-
mixed 3	8.0	-	4.6	4.4	3.1	1.9	-
Mullus spp	-	-	16.4	42.0	6.1	2.2	-
Octopus spp	6.0	-	21.5	11.8	26.2	-	-
others	20.2	3.7	5.0	4.8	10.4	6.8	3.0
Scomber spp	5.1	-	-	-	-	3.5	-
Scorpainidae	-	-	9.3	4.4	-	-	-
S. officinalis	-	-	10.6	4.8	35.7	-	1.1
S. dumerili	6.9	-	-	-	-	-	-
shellfish	-	-	-	-	-	-	92.7
Sparidae	26.5	1.8	4.9	3.7	-	3.9	2.0
X. gladius	-	88.6	-	-	-	-	-

Table 2. Main characteristics of the more discriminant species identified in the analysis.

Species/ Group	Gear	Nominal CPUE mean ± SD (kg/boat/day)	Standardised CPUE ± SD (kg/boat/day)	Deviance % Explained GLM	Annual Trend	Season	Maximum CPUE
Mullus spp	Mullet trammel	17.69 ± 9.51	14.24 ± 1.04	47.35	Irregular Max.1997 Min.1998	All year	October-November
M. merluccius	Hake gillnet	62.5 ± 32.7	52.11 ± 1.18	65.74	Stable Max.2000 Min.2002	All year; since 1996	May-August
Octopus spp	Trammel net	10.13 ± 10.15	7.32 ± 1.05	54.32	Sinusoidal Max.1995 Min.2002	All Year	January-May
Sparidae	Bottom long line	13.5 ± 12.22	6.51 ± 1.07	36.57	Sinusoidal Max.1997 Min.2001	All Year	April and Autumn
C. conger	Bottom long line	6.61 ± 10.87	1.69 ± 1.12	46.10	Sinusoidal Max.1997 Min.1999	All year	Autumn and Winter
S. officinalis	Cuttlefish trammel	17.8 ± 7.5	14.15 ± 1.12	80.41	Irregular Max.1997 Min.2002	January to May	February

References

1 - Fernández A. M., and Esteban A., 2003. La pesquería artesanal de Santa Pola (S.E. de la Península Ibérica). Descripción y actividad en el periodo 1992-2000. *Inf. Téc. Inst. Esp. Oceanogr.* 181, 49 p.

2 - McCullagh P., and Nelder J.A., 1989. Generalized Linear Models (2nd ed.). Chapman and Hall, London. 509 p.

3 - Becker R. A., Chambers, J.M., and Wilks A.R., 1988. The new S language. A programming environment for data analysis and graphics. Wadsworth and Brooks/Cole Advanced Books Software, Pacific Grove, California. 702 p.

LES CHAETOGNATHES DE LA MER MÉDITERRANÉE: INVENTAIRE ET REPARTITION

Ghirardelli E. [1] *, Casanova J.-P. [2]

[1] Dipartimento di Biologia, Università Trieste, Italy – * ghirarde@univ.trieste.it
[2] Laboratoire Biologie animale (Plancton), Université de Provence, Marseille, France

Résumé

En Méditerranée, 26 espèces de chaetognathes ont été signalées (1, 2). En réalité, seule la présence de quatre espèces benthiques et de 16 espèces planctoniques est certaine. Les mentions de trois d'entre elles sont erronées, deux sont à vérifier et l'une est probablement accidentelle et ne peut donc actuellement figurer dans l'inventaire. Enfin, quelques espèces de spadelles des grottes obscures restent à décrire.

Mot clés: Chétognates, Mer Méditerranée

Depuis quelques années, des inventaires faunistiques sont dressés pour les aires maritimes de nombreux pays: c'est le cas pour les chaetognathes de l'Afrique du Sud, de la Belgique ou de l'Italie (2). Celui du Maroc est connu depuis longtemps (3). Il était donc intéressant d'actualiser l'inventaire de ces organismes sur l'ensemble de la Méditerranée, complétant ainsi celui dressé par Furnestin (1) pour les seules espèces planctoniques, les plus nombreuses. Cette mise au point s'avère nécessaire au moment où l'étude de la biodiversité devient une préoccupation internationale.

1. Espèces présentes en Méditerranée

1.1 Espèces benthiques

Archeterokrohnia palpifera Casanova,1986 a été draguée à 2000m au sud-ouest de la Corse (4) et à 1500 m au large de Haïfa (JPC, obs. pers.). Il faudrait continuer les prospections dans la couche d'eau surmontant le fond dans les plaines bathyales où vivent ces espèces bentho-planctoniques.

Spadella birostrata Casanova, 1987 vit sur le fond entre 150 et 555m en mer d'Alboran, et entre 200 et 463m au large des côtes provençales.

Spadella cephaloptera Busch, 1851 est une espèce néritique commune sur l'ensemble des côtes méditerranéennes.

Spadella ledoyeri Casanova, 1986 est connue de deux grottes sous-marines obscures près de Marseille. Il semblerait que ce biotope soit favorable à la spéciation, comme l'indique la présence d'autres formes originales dans diverses grottes sous-marines (5).

1.2. Espèces planctoniques

Eukrohnia hamata Möbius, 1875. Quelques exemplaires ont été signalés avec certitude en mer d'Alboran (6) où elle reste accidentelle.

Krohnitta subtilis Grassi, 1881 est une espèce à distribution orientale, commune à l'est de l'axe corso-sarde.

Pterosagitta draco Krohn, 1853 est présente dans le bassin occidental, où elle jalonne le trajet du courant atlantique.

Sagitta bierii Alvariño, 1961 n'est mentionnée que dans les eaux libanaises (7) et en mer d'Alboran (8).

Sagitta bipunctata Quoy & Gaimard, 1827 est une espèce du large, signalée dans toute la Méditerranée.

Sagitta decipiens Fowler, 1905 est une forme de la mi-profondeur, ubiquiste en Méditerranée (1, 9).

Sagitta enflata Grassi, 1883 est l'espèce superficielle la plus commune en Méditerranée.

Sagitta friderici Ritter-Zahony, 1911 est d'origine atlantique; particulièrement fréquente le long des côtes nord-africaines, elle est signalée jusqu'à Villefranche-sur-Mer au nord et au large d'Israël à l'est (7).

Sagitta hexaptera d'Orbigny, 1835 est l'espèce la plus grande de la Méditerranée (taille > 5 cm); c'est une ubiquiste du mésoplancton profond.

Sagitta lyra Krohn, 1853 a à peu près la même distribution et le même comportement que l'espèce précédente.

Sagitta megalophthalma Dallot & Ducret, 1969. Découverte à Villefranche-sur-mer, cette espèce mésoplanctonique a été trouvée aussi à Naples et en Méditerranée orientale (10).

Sagitta minima Grassi 1881 vit près des côtes comme au large, et est signalée dans toute la Méditerranée.

Sagitta planctonis Steinhaus, 1896 est indicatrice du courant atlantique en Méditerranée occidentale; elle y est donc moins profonde que dans le proche Atlantique (1).

Sagitta serratodentata Krohn, 1853 est mésopélagique. Indicatrice d'eaux à forte salinité (37-38‰), elle a une distribution orientale.

Sagitta setosa Müller, 1847 est néritique et tolère des faibles salinités, d'où son abondance à l'embouchure des fleuves (Rhône, Pô). On signalera ses plus grandes longueurs dans les "lacs" de l'Ile de Mljet, en moyenne Adriatique (11), et en mer Noire où l'on avait cru avoir affaire à une espèce différente que l'on avait appelée *S. euxina* (12).

Sagitta tasmanica Thomson, 1947 a une origine océanique. Sa fréquence en Méditerranée diminue entre Gibraltar et les eaux tunisiennes.

2. Espèces "incertaines"

La présence de *Spadella musculosa* Doncaster, 1903 et de *Spadella profunda* Doncaster, 1903, draguées entre 100 et 1100m de profondeur (13) dans le golfe de Naples devrait être confirmée. Il n'est pas impossible, en effet, que des espèces benthiques vivent en profondeur en Méditerranée, comme c'est le cas dans l'Atlantique. Par ailleurs, quelques spécimens isolés, récoltés dans des grottes sous-marines obscures, appartiennent probablement à des espèces de spadelles nouvelles et restent à décrire (5).

Les espèces planctoniques suivantes: *Sagitta pseudoserratodentata* Tokioka, 1939, *S. elegans* Verril, 1873 et *S. macrocephala* Fowler, 1905 ont été signalées par erreur en Méditerranée. Quant à la mention d'un individu de *S. neglecta* Aida, 1897 au large d'Alexandrie (14), elle pourrait résulter d'un transport accidentel à partir de la mer Rouge où l'espèce est présente.

Références

1 - Furnestin M.-L., 1970. Chaetognathes des campagnes du "Thor" (1908-11) en Méditerranée et en mer Noire. *Dana-Report*, 79: 1-51.
2 - Ghirardelli E., 2004. Chaetognatha. *Fauna d'Italia* (à paraître).
3 - Furnestin M.-L., 1957. Chaetognathes et zooplancton du secteur atlantique marocain. *Rev. Trav. Inst. Pêches marit.*, 21(1-2): 1-356.
4 - Casanova J.-P.,1986. Découverte en Méditerranée d'un chaetognathe nouveau du genre archaïque profond *Archeterokrohnia*: description et signification biogéographique. *Rapp. Comm. Int. Mer Médit.*, 30 (2), P-III 4: 196.
5 - Casanova J.-P., 1992. Les chaetognathes cavernicoles de la Méditerranée nord-occidentale: adaptation et spéciation, comparaison avec l'Atlantique. *Bull. Inst. Océanogr. Monaco,* NS 9: 83-100.
6 - Camiñas J. A., 1986. Sobre los Quetognatos neriticos del Mar de Alborán I. Variaciones cuantitativas y distribución. *Bol. Inst. Esp. Oceanog.*, 3(1): 13-22.
7 - Lakkis S. 1977. Les Chaetognathes des eaux libanaises. Observations faunistiques et écologiques. *Rapp. Comm. int. Mer Médit.,* 24(10): 137-138.
8 - Dallot S., Goy J., Carre C., 1988. Peuplements de carnivores planctoniques gélatineux et structures productives en Méditerranée occidentale. *Oceanologica Acta*, N°SP: 193-209.
9 - Batistic M. 1998. The seasonal population structure and vertical distribution of *Sagitta decipiens* Fowler and *Sagitta lyra* krohn in the South Adriatic pit. *Rapp. Comm. int. Mer Médit.,* 35: 372-373.
10 - Dallot S., Ducret F., 1969. Un Chaetognathe mésoplanctonique nouveau: *Sagitta megalophthalma* sp.n. *Beaufortia,* 17(224): 13-20.
11 - Vucetic T., 1957. Zooplankton investigations in the Sea Water Lakes "Malo Jezero" and "Velico Jezero" on the Island of Mljet (1952-1953). *Acta Adriat.,* 6(4): 3-45.
12 - Elian L., 1960. Observations systématiques et biologiques sur les chaetognathes qui se trouvent dans les eaux roumaines de la Mer Noire. *Rapp. Comm. int. Mer Médit.,* 15(2): 359-366.
13)- Doncaster L., 1903, *in* S. Lo BIANCO, 1903. Le pesche abissali eseguite da F.A. Krupp col yacht Puritan nelle adiacenze di Capri ed in altre località del Mediterraneo. *Mitt. Zool. Stn Neapel*, 16: 266-268.
14 - Guerguess S. K., Halim Y., 1973. Chaetognathes du plancton d'Alexandrie 2. Un spécimen mûr de *Sagitta neglecta* Aida en Méditerranée. *Rapp. Comm. int. Mer Médit.,* 21(8): 497-498.

ACOUSTIC-GEOSTATISTICAL ASSESSMENT AND HABITAT–ABUNDANCE RELATIONSHIPS OF SARDINE IN THE HELLENIC SEAS

M. Giannoulaki [1] *, A. Machias [1], C. Koutsikopoulos [2], S. Somarakis [1, 2], N. Tsimenides [1]

[1] Institute of Marine Biology of Crete, Iraklio, Crete, Greece - * marianna@imbc.gr

[2] University of Patras, Dept. of Biology, Patra, Greece

Abstract

Acoustic and environmental data from six research surveys (in summer and winter) in the Aegean and Ionian Seas were analysed to examine the spatial structure of sardine populations using geostatistical techniques, and study the spatial distribution of sardine in relation to environmental regimes using cumulative distribution function analysis. Geostatistical analysis showed that sardine formed meso- to large-scale patches. Generally, within the range of available measurements, sardine was significantly ($p<0.05$) associated to more productive inshore waters. This was more pronounced during the winter period.

Keywords: sardine, spatial distribution, geostatistics, environmental variable selection, Hellenic Seas

Introduction

In the Hellenic seas, sardine (*Sardina pilchardus* Walb.) forms the basis of commercially important fisheries comprising 11.4% of the mean total marine landings (1). The knowledge of the spatial organization of small pelagic fish stocks such as sardine is essential because it may affect both stock catchability and the results of assessment surveys and contributes to the understanding of fundamental ecological processes affecting the population (2). The present paper presents preliminary results on sardine's spatial structure in the coastal waters of Hellas, as well as its association with environmental parameters, based on the combination of data from concurrent hydroacoustic and hydrographic surveys.

Materials and methods

Acoustic data were collected during four research surveys (summer 1998, 1999 and winter 1999, 2000) onboard the R/V *Philia*, carried out along predetermined transects in the Central Aegean and Ionian Seas. The acoustic equipment used was a Biosonic Dual Beam 120 kHz V-Fin Echosounder. Acoustic echoes were registered continuously along transects and were integrated over one nm (Elementary Distance Sampling Unit). Sardine echoes were discriminated from those of other fishes by the characteristic echogram shape of the schools and back-scattered energy of single targets (3). Hydrographic sampling was performed over a grid of predetermined stations. At each station vertical profiles of fluorescence were obtained with a WetLabs fluorometer and zooplankton samples with a WP2-net. The study area was divided into seven sub-areas and geostatistical analysis was applied to study the spatial structure of sardine populations (4). In addition, we used cumulative distribution functions analysis (CDFs) to investigate the spatial distribution of sardine in relation to environmental regimes (5).

Results and discussion

The estimated autocorrelation range of omnidirectional variograms indicated that sardine formed meso- to large-scale patches (i.e. autocorrelation range varied from 2 nm to 15 nm). Specifically, sardine exhibited an autocorrelation range that generally agreed with the one observed for other sardine species and sub-species [*Sardinops sagax:* in the southern Benguella region ≈10 nm (6), *Sardina pilchardus pilchardus:* in the Catalan Sea and in the Bay of Biscay ≈ 8 nm (2 and references therein)]. The smallest ranges (2 to 6 nm) were observed in small gulfs (i.e. North Evoikos Gulf and Patraikos Gulf).

CDFs analysis (Table 1) revealed that sardine in the Central Aegean Sea was significantly ($p<0.05$) associated to the more productive inshore waters during summer, whereas the opposite was observed in the Ionian Sea. The latter could be attributed to differences in habitat selection between small (<100 mm) and large individuals (>100 mm) and respective differences in the length frequency distributions between the two areas (Fig. 1). In the winter, when sardine reproduction takes place in Hellenic waters, it was positively associated to areas of high productivity, in both regions.

Table 1. Indices of parameter selection by sardine. S: index of parameter selection; D: test statistic; p-value: probability of statistical significance of parameter selection based on randomization test. NS=Non significant.

		Central Aegean Sea			Ionian Sea		
Season	Parameters	S	D	p-value	S	D	p-value
Summer	Bottom depth (m)	-43.83	7.98	0.000	-3.94	4.62	0.039
	Zooplankton volume (ml/m^2)	176.60	9.22	0.000	-1965.82	6.74	0.000
	Mean Chl-a (µg/lt)	-38.75	2.96	NS	-15.02	2.66	NS
Winter	Bottom depth (m)	-59.16	4.17	0.003	-46.75	5.23	0.003
	Zooplankton volume (ml/m^2)	72.12	4.73	0.000	70.77	7.78	0.000
	Mean Chl-a (µg/lt)	29.91	3.59	0.001	-8.62	2.862	NS

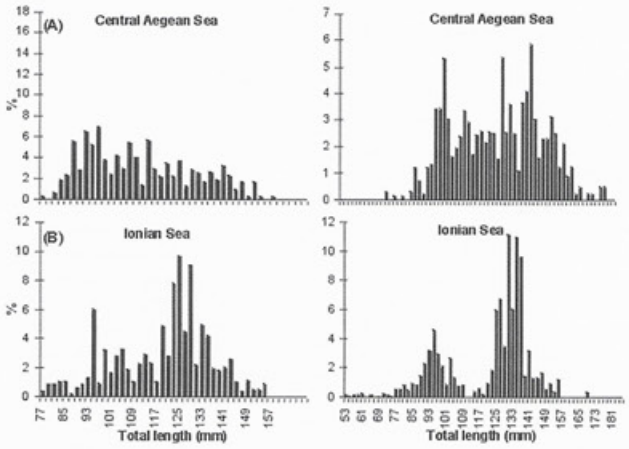


Fig. 1. Length frequency distribution of sardine (A) in July 1998 and (B) in June 1999.

References

1 - Stergiou K.I., Christou E.D., Georgopoulos D., Zenetos A., and Souvermezoglou C., 1997. The Hellenic Seas: Physics, chemistry, biology and fisheries. *Oceanogr. Mar. Biol. Ann. Rev.*, 35: 415-538.

2 - Freon P., Misund O.A., 1999. Dynamics of Pelagic Fish Distribution and Behaviour: Effects on Fisheries and Stock Assessment. Fishing New Books, Oxford.

3 - Masse J., 1996. Acoustic observations in the Bay of Biscay: Schooling, vertical distribution, species assemblages and behaviour."*Sci. Mar.* 60, Suppl.2: 227-234.

4 - Rossi R.E., Mulla D.J., Journel A.G., Franz E.H., 1992. Geostatistical tools for modelling and interpreting ecological spatial dependence. *Ecol. Monogr.*, 62(2): 277-314.

5 - Swain D.P., and Kramer D.L., 1995. Annual variation in temperature selection by Atlantic cod *Gadus morhua* in the southern Gulf of St. Lawrence, Canada, and its relation to population size. *Mar. Ecol. Prog Ser.*, 116: 11-23.

6 - Barange M., and Hampton I., 1997. Spatial structure of co-occurring anchovy and sardine populations from acoustic data: implications for survey design. *Fish. Oceanogr.*, 6(2): 94-108.

ECOLOGICAL AND MATHEMATICAL ASPECTS OF A PLANKTON COMMUNITIES MODEL

Jean-Marc Ginoux *, Bruno Rossetto, Jean-Louis Jamet
Université de Toulon et du Var, Equipes ISO-EBMA, Laboratoire PROTEE, LA GARDE cedex, France
* ginoux@univ-tln.fr , rossetto@univ-tln.fr, jamet@univ-tln.fr

Abstract
In this article we studied an ecological model transcribing the behavior of a trophic chain with three levels of interaction. The values of the parameters of the model lead us to regard it as a slow fast autonomous dynamic system. We could establish the equation of the slow surface on which the attractor is leaned, thus connecting the three variables in the slow field in the form of a state equation.

Key words : Plankton modeling, Slow-Fast Dynamics

The ecological point of view

Since 1995, seasonal variations of the plankton community (phytoplankton and zooplankton) in Toulon Bay (Var, France) have been studied [1, 2]. Plankton communities differently affected by anthropogenic inputs of Toulon area have been studied regularly in two sites (Little Bay, polluted, and Large Bay, non polluted).

The average of nitrate and orthophosphate concentrations and the abundance and diversity of plankton communities during annual cycles in these bays exhibit inherent features as the pattern shape of limit cycles as well as the apparent period of intrinsic evolution of phytoplankton and zooplankton separately considered.

So, we have searched a model able to transcribe the observed behaviour of plankton communities and to fit with our data.

Among the different autonomous predator-prey models taken under consideration in the literature [3-10], we searched the most *simple and consistent* model with functional responses for growing, predation and mortality susceptible to lead to a limit cycle and to fit with our data. To this aim, we were interested by the Rosenzweig-Mac Arthur model [11].

Modelling

The Rosenzweig-Mac Arthur model [11] for a three trophic level interaction is involving nutrients (nitrates and orthophosphates, N), planktonic algae (phytoplankton, P) and herbivorous zooplankton (Z). It's the so-called NPZ model. It is composed of limited functional responses : a logistic prey (N), a Holling type II predator (P), and a Holling type II top-predator (Z). Predator's per-capita predation rate has the Holling type II form [10]. All parameters used are chosen in a biological range.

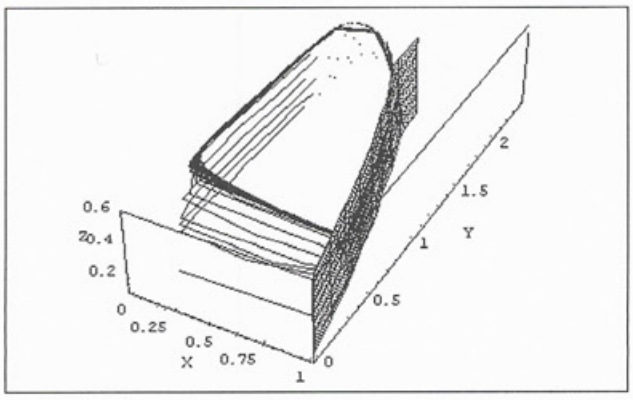
Note that the Rosenzweig-Mac Arthur model was developed from the previous works of Volterra [4] and Lotka [5]. The addition of limited functional responses made it possible to lead to the model of Rosenzweig-Mac Arthur. Nevertheless, if only one limitation term is removed, there is no more limit cycle.

Moreover, as the turn-over of each variable is in a ratio of ten, we have been lead to focus our interest on slow-fast autonomous dynamic systems [12, 13, 14].

Mathematical aspects

Under certain conditions, the dimensionless system is singularly perturbated with three times scales. The rates of change for the prey, the predator and top-predator range from fast to intermediate to slow, respectively [12, 13]. We give the equation of a slow manifold on which the attractor lies. Since, a state equation relying the three variables is established.

Some simplications could be brought to the model of Rosenzweig-Mac Arthur in order to make a study in two dimensions of it.



References

1 - Jamet J.-L., Ferec-Corbel A.-S., 1996, Seasonal variations of the zooplankton community in a littoral marine ecosystem : Toulon Bay (Var, France). *Mar. Life*, 6: 15-20.
2 - Jamet J.-L., Bogé G., Richard S., Geneys C., Jamet D., 2001. The zooplankton community in bays of Toulon area (northwest Mediterranean Sea, France). *Hydrobiologia*, 457: 155-165.
3 - Verhulst P.F., 1838. Notice sur la loi que suit la population dans son accroissement. *Corresp. Math. Phys.*, X: 113-121.
4 - Volterra V., 1926. Variazioni e fluttuazioni del numero d'individui in specie animali conviventi. *Mem. Acad. Lincei*, III: 31-113.
5 - Lotka A.J., 1925. Elements of Physical Biology. Williams and Wilkins, Baltimore.
6 - Gompertz B., 1825. *Phil. Trans.*, 115: 513.
7 - Gause G.S., 1934. The struggle for existence. Williams and Wilkins, Baltimore.
8 - Watt K.E.F., 1960. *Can. Entomol.*, 92: 674.
9 - Ivlev V.S., 1961. Experimental Ecology of the Feeding Fishes. Yale Univ. Press, New Haven, Conn.
10 - Holling C.S., 1959. Some characteristics of simple types of predation and parasitism. *Can. Entomol.*, 91: 385-398.
11 - Rosenzweig M.L., and Mac Arthur R.H., 1963. Graphical representation and stability conditions of predator-prey interactions. *Am. Nat.*, 97: 209-223.
12 - Deng B., 2001. Food chain chaos due to junction-fold point. *Am. Inst. Phys.*, 11: 514-525.
13 - Ramdani S., Rossetto B., Chua L., and Lozi R., 2000. Slow manifold of some chaotic systems - laser systems applications. *Int. J. Bifurc. Chaos*, 10: 2729-2744.
14 - Rinaldi S., and Muratori S., 1992. Slow-fast limit cycles in predator-prey models. *Ecol. Model.*, 61: 287-308.

CEPHALOPODS ASSEMBLAGES FROM THE SOUTHERN TYRRHENIAN SEA

Daniela Giordano [1] *, Teresa Bottari [1], Barbara Busalacchi [1], Paola Rinelli [1], Silvestro Greco [2]
[1] IAMC – CNR, Messina, Italy
[2] ICRAM, Roma, Italy

Abstract

The Teuthofauna assemblages of the Southern Tyrrhenian Sea were studied utilising data derived from five International Mediterranean bottom trawl surveys. A total of 25 cephalopod species were found between 18 and 652 m depth. The assemblages were analysed with Bray-Curtis similarity index. Four main groups were defined: inshore, shelf, slope and midslope. *Allotheuthis media* was the dominant species inshore, *Illex coindetii* on the shelf, *Todaropsis eblanae* on the slope, and *Todarodes sagittatus* for the last group.

Key words: Cephalopods, Faunal assemblages, Mediterranean Sea

Introduction

The geographic and bathymetric distributions of demersal cephalopods have been studied in great detail in the Mediterranean (1,2,3,4), since many species are of commercial interest. The present work analyses the structure of the cephalopod assemblages in order to provide information concerning their distribution inshore, on shelf, slope and midslope in the Southern Tyrrhenian Sea.

Material and methods

The material was collected at depths ranging from18 to 652 m, between 1995 and 1999, in the Southern part of the Tyrrhenian Sea (central Mediterranean), between Suvero Cape (Calabria) and S. Vito Cape (Sicily), as part of the MEDITS project funded by the European Community.

A fishing vessel equipped with an experimental trawl net with 20 cm stretched mesh size in the cod-end, and 2-2.5 m of vertical opening was used. A total of 139 hauls were carried out, randomly allocated into five bathymetric strata (5). All cephalopods were identified and counted on board. A multivariate approach, on the basis of the calculation of a triangular similarity matrix (group-average linkage), by depth, year and abundance (number of specimens/hour), according to Bray-Curtis with the relative dendrogram was elaborated (6). The abundance values were also analysed by means of univariate indices, in relation to the four assemblages evidenced by cluster analysis: total number of taxa (S), total number of individuals (N), richness of Margalef (d), Shannon-Wiever diversity (H') and Pielou's evenness (J) indices

Results and discussion

A total of 25 cephalopod species were collected, belonging to three orders and eight families. The following species - *Onychoteuthis banksii, Ancistroteuthis lichtensteinii* and *Abralia veranyi* - were caught only once. *Sepia officinalis* was confined to shallow waters, less than 68 m deep. Half of the species had a wide bathymetric range that included the shelf and the beginning of the slope. The widest bathymetric distribution was that of *Eledone cirrhosa* (72-584 m), *Scaeurgus unicirrhus* (38-549 m), *Todaropsis eblanae* (61-613 m) and *Pteroctopus tetracirrhus* (118-633 m). *Alloteuthis subulata*, *Octopus vulgaris* and *Eledone moschata* were found only on the continental shelf; whereas *Octopus salutii* and *Rossia macrosoma* were collected only in depths greater than 200 m. *Histioteuthis bonnelli* was found exclusively in the deepest zone.

The dendrogram (Fig. 1) showed four clusters: I, inshore (<100 m); II, shelf (80-200 m); III, slope (200-600 m); IV, midslope (360-580 m). The inshore group was characterized by *Allotheutis media* and *Loligo vulgaris*. In the shelf group, *Illex coindetii* and *Allotheutis media* prevailed, followed by *Sepia orbignyana*, *Sepia elegans* and *Scaeurgus unicirrhus*. The slope group was characterized by *Todaropsis eblanae*. In the midslope, consisting of few hauls, *Todarodes sagittatus* was the prevalent species.

Analysing the univariate indices, elaborated for the four groups, the highest biodiversity was observed in the shelf. In this zone, the highest values of Margalef and Shannon Weaver indices were recorded as well as the highest number of species and individuals. The highest values of H' can be explained by the relative homogeneity in abundances of the most frequent species. However a trend was observed according to the depth as evidenced also by the cumulative abundance curve, in which the shelf group showed the highest biodiversity and the middle-slope the lowest. In this last group both "d" and "H'" values recorded the lowest values (0.973 and 1.063 respectively). Finally the Evenness (J') values ranged from 0.616 to 0.661. The higher values era recorded for the last cluster. Also in the second cluster his values is quite high.

The 25 cephalopod species recorded in this study account for 42.4% of the species known from the Mediterranean (7).

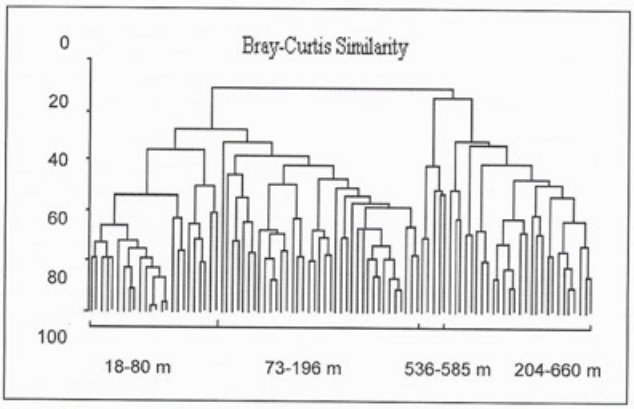


Fig. 1. Dendrogram showing similarities between hauls for the five surveys. Mean depth of each haul is presented.

References

1 - Sanchez P., Belcari P., and Sartor P., 1998. Composition and spatial distribution of cephalopods in two north-western Mediterranean areas. *S. Afr. J. mar. Sci.*, 20: 17-24.
2 - Ruby J.J., and Knudsen J., 1972. Cephalopoda from the Eastern Mediterranean. *Israel J. Zool.*, 21: 83-97.
3 - Jereb P., and Ragonese S., 1994. The Mediterranean teuthofauna: Towards a biogeographical coverage by regional census. II. Strait of Sicily. *Boll. Malacologico*, 30 (5-9): 161-172.
4 - González M., and Sánchez P., 2002. Cephalopod assemblages caught by trawling along the Iberian Peninsula Mediterranean coast. *Sci. Mar.*, 66 (Suppl. 2): 199-208.
5 - Bertrand J.A., Gil de Sola L., Papaconstantinou C., Relini G., and Souplet A., 2002. An international bottom trawl in the Mediterranean: the MEDITS programme. 1995 ICES Annual Science Conference, CM 1997/y:03: 16 p.
6 - Clarke K.R., and Warwick R.M., 1994. Change in marine communities: an approach to statistical analysis and interpretation. Plymouth: Plymouth Marine Laboratory, 144 p.
7 - Mangold K., and Bolesky S., 1988. Mediterranean Cephalopod Fauna. In: M.R. Clarke and E.R. Trueman (eds.), Etology and Neontology of Cephalopods, The Mollusca, 12: 315-330. San Diego, Academic Press.

CHARACTERISTICS OF SUMMER GENERATION OF ADRIATIC MYSID *HEMIMYSIS LAMORNAE* (COUCH, 1856) FROM THE AQUARIUM POPULATION, EVALUATION FOR AQUACULTURE APPLICATION

Nikša Glavić *, Pero Tutman, Valter Kožul and Boško Skaramuca

IOR, Split, Laboratory for Ecology and Aquaculture, Dubrovnik, Croatia - * galvic@mailcity.com

Abstract

A population of Marine mysid *Hemimysis lamornae* from aquarium pools was statisticaly analysed, and was found to consist of 41% males (TL 4,44668±0,489 mm), 28% females (TL 4,5727±0,5425 mm) and 31% juvenile individuals (TL 2,2103±0,7364 mm). Average egg count were 4,166±6,06 eggs/female. Larger females carried more eggs and young than smaller females.

Keywords: Mysidacea, Hemimysis, population, fecundity, aquaculture

Introduction

New live food sources for aquaculture are sought for every day (1. 2), which can have a great influence for development of aquaculture of several, mainly invertebrate species. Aside from *Brachionus plicatilis* and *Artemia salina*, several mysid species are evaluated and used as live food in larval production of marine cephalopods (3. 4), and other species are being evaluated as potential candidates for aquaculture use (5. 6). These results represent preliminary data on the potential of *Hemimysis lamornae* as a valuable live food organism.

Materials and methods

The samples of *Hemimysis lamornae* populations were collected from the Dubrovnik aquarium concrete pools during October and November, 2002, using a circular frame plankton net (500 µm mesh size) towed through the mysid cloud. The animals were preserved in 5% buffered seawater formaldehide prior to measurements. The specimens were measured under binocular microscope utilizing a ocular micrometer with a printer. Total length (TL) was measured as the distance between the tip of rostrum, between the eyestalks and the posterior end of the telson, including the spine on it. Along with the TL measure the sex composition and the egg-count/fecundity were also recorded and analyzed at this point. The juveniles have not been further analyzed and systhematized beyond determining the lack of maturity characteristics such as the penises and pouch in the males and females respectively.

Results

The length (TL)-frequency distribution on the cumulative histogram (Fig.1) shows two diferent cohorts within this population, one that consists of juvenile animals (2,210391±0,736434mm, N=93), and other that consists of mature males (4,446668±0,489045, N=123) and females (4,57278±0,542526, N=84). The distribution of TL in the male and female group differed only by frequency, and otherwise showed no statistical difference (ANOVA, $p<0,05$). The sex/maturity composition of *H. lamornae* population as percentages was 0,41:0,28:0,31 (males:females:juveniles). Brood size, i.e. the number of larvae in the marsupium showed a positive correlation with total length of females (TL) (Fig. 2), which indicates that larger females produced larger broods.

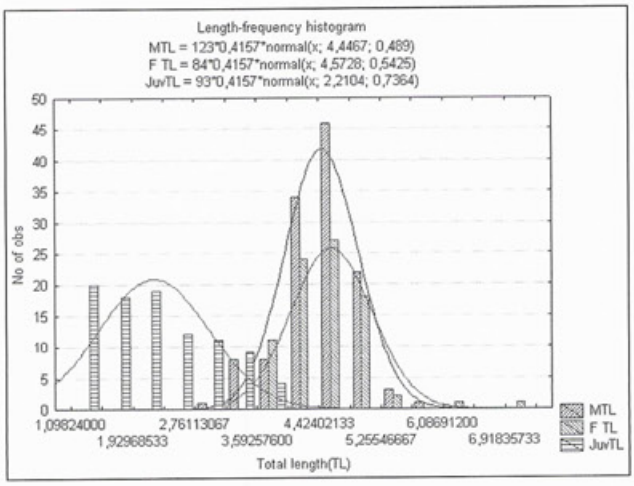


Fig. 1. Length-frequency distribution of *H. lamornae* population.

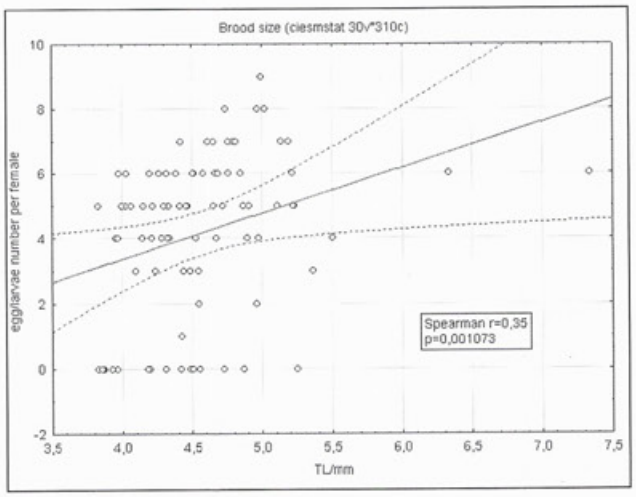


Fig. 2. Female TL/brood size regression plot.

Discussion

Some basic data are given on the summer population of marine mysid *Hemimysis lamornae*. Length-frequency distribution within the whole group of animals divided by sex and maturity criteria showed bimodal distribution, with two groups, one of young animals, and the other of adult males and females. The animals reached maturity at approximately 3,0-3,5 mm (Fig. 1).

The results of the brood size analysis corroborate the hypothesis on positive correlation with the female size (Fig. 2) (7), which is correct for our single stage sample, but changes with different season (8), and remains to be determined for *H. lamornae* by sampling throughout the year.

References

1 - DeRusha, R., H., Forsythe, J., W., Dimarco F., P. and Hanlon, R., T., 1989. Alternative diets for maintaining and rearing cephalopods in captivity. *Laboratory and Animal Science*, 39: 306-312.

2 - Kuhn, A., H., Bengtson, D., A. and Simpson, K., L. 1991. Increased reproductionby misids (*Mysidopsis bahia*) fed with enriched *Artemia spp.* nauplii. *American Fisheries Society Symposium*, 9, 192-199.

3 - Forsythe , J., W. and Hanlon, R., T., 1980. First rearing of *Octopus joubini* Robson, 1929 on mysidacean and caridean shrimps. *Bulletin of the American Malacological Union,* 42-45.

4 - Lee, P., G., Turk, P., E., Yang, W., T. and hanlon, R., T., 1994. Biological characterictics and biomedical applicatilns of the squid *Sepioteuthis lessoniana* cultured through multiple generations. *Biomedical Bulletin* (Woods Hole), 186: 328-341.

5 - Domingues, P., M., Turk, P., E., Andrade, J., P. and Lee, P., G., 1998. pilot scale production of mysid shrimp in a static water system. *Aquaculture international*, 6: 387-402.

6 - Domingues, P., M., Fores, R., Turk, P., E., Lee, P., G. and Andrade, J., P., 2000. Mysid culture: lowering costs with alternative diets. *Aquaculture Research*, 31: 719-728.

7 - Mauchline, J., 1965. Breeding and fecundity of *Praunus inermis* (Crustacea, Mysidacea). *J. mar. biol. Ass. U. K.*, 45: 663-671.

8 - Mauchline, J., 1971. The biology of *Paramysis arenosa* (Crustacea, Mysidacea). *J. mar. biol. Ass. U. K.*, 51: 339-345.

DYNAMICS OF FISH INVASIONS IN THE MEDITERRANEAN: UPDATE OF THE CIESM FISH ATLAS

D. Golani [1] *, L. Orsi-Relini [2], E. Massuti [3] and J-P. Quignard [4]

[1] Department of Evolution, Systematics and Ecology, The Hebrew University Jerusalem, Israel - * dgolani@cc.huji.ac.il
[2] Laboratori di Biologia Marina ed Ecologia Animal, Genova, Italy
[3] IEO-Centre Oceanografic de les Balears, Palma de Mallorca, Spain
[4] Laboratoire d'Ichthyologie méditerranéenne, Université Montpellier II, France

Abstract

This paper constitutes an update of exotic fish species that have been recorded in the Mediterranean since the publication of the *CIESM Atlas of Exotic Species in the Mediterranean – Fishes* in April 2002. Five new fish species have been recorded and eight fish species have extended their distribution in the Mediterranean.

Keywords: CIESM, Fish, Exotic, Mediterranean, Update

The *CIESM Atlas of Exotic Species in the Mediterranean – Fishes* (1), was published in April 2002 and included 90 species recognized as exotic to the Mediterranean. It summarized all the scientific literature to that date. In the two years since its publication, the dynamics of the process of invasions has been demonstrated by the addition of five new fish species to the Mediterranean. Furthermore, eight fish species have extended their Mediterranean distribution.

New Invaders

• Striped eel catfish, *Plotosus lineatus* (Thunberg, 1787) (Family: Plotosidae) – This venomous catfish has been found in large numbers on sandy substrate at depths of 10-35 m along the coast of Israel (2). Several incidents of injury from this species have been reported in its new habitat.

• Seahorse *Hippocampus fuscus* Rüppell, 1838 (Family: Syngnathidae) – This western Indian Ocean and Red Sea species was first recorded in the Mediterranean from the coast of Israel (3). It was found in rocky habitats at depths up to 10 m. This species has already spread to southern Turkey (M. Gokoglu, personal comm.).

• Almaco jack, *Seriola rivoliana* Cuvier, 1833 (Family: Carangidae) – This eastern Atlantic species was recorded from the African continental shelf near Lampedusa Island (4).

• Bluebarred parrotfish, *Scarus ghobban* Forsskål, 1775 (Family: Scaridae) – A single specimen was recorded from rocky substrate at Shiqmona near Haifa Bay, Israel (5).

• The flatfish *Solea (Microchrius) boscanion* Chabanaud, 1926 (Family: Soleidae) – Five specimens were recorded at the Iberian coast of Spain on soft substrate between 45-65 m depth (6).

Range Extensions

• *Enchelcore anatine* (Lowe, 1839) – A single specimen was recorded from Turkey (7). Previously this eastern Atlantic migrant was known in the Mediterranean only in Israel and Greek waters.

• *Fistularia commersonii* Rüppell, 1835 – This species experience a population explosion along the coast of Israel and subsequently spread westward. It has been recorded at Antalya, Turkey, the island of Rhodes (8) and Cretan waters (Scazzocchio, pers. comm.); it has recently reached the shores of Southern Italy (Azzurro, pers. comm.).

• *Leiognathus klunzingeri* (Steindachner, 1898) – This species was recorded recently in the southern Adriatic (9).

• *Sphyraena chrysotaenia* Klunzinger, 1884 – the record of this species from the southern Adriatic (10) was published prior to the publication of the CIESM Fish Atlas and should be included.

• *Sphyraena flavicauda* Rüppell, 1838 – Two specimens of this species have been reported from Antalya Bay, Turkey(11); it was hitherto known only from a single specimen off the coast of Israel.

• *Siganus luridus* Rüppell, 1828 – This species was sighted and photographed from Cretan waters in 2002 (P. Wirtz, pers. comm.).

• *Acanthurus monroviae* Steindachner, 1876 – Several specimens of this west African species were sighted and photographed off the Mediterranean coast of Algeria in late 2001 and August 2002. Previously it was known in the Mediterranean only from a single specimen in Israel and another specimen in southern Spain (F. Hemida pers. comm.).

• *Torquigener flavimaculosus* Hardy and Randall, 1983 – A specimen of this species was photographed in 2002 in Fethiye, Turkey (M. Bilecenoglu, pers. comm..). Hitherto it was known only from Haifa Bay, Israel.

Increase in abundance

• *Spratelloides delicatulus* (Bennett, 1831) – Formerly known only by two specimens off the Mediterranean coast of Israel, its population has increased greatly in the last two years; many specimens were collected using beach seine along the sandy shore of Israel (12).

Nomenclature changes

The species formerly known in the Mediterranean as *Apogon nigripinnis* Cuvier, 1828, should be referred to as *Apogon pharaonis* Bellotti, 1874. *A. nigripinnis* is restricted to the eastern Indian and western Pacific Oceans (13).

References

1 - Golani D., Orsi-Relini L., Massuti E. and Quingard J.-P, 2002. CIESM Atlas of Exotic Species in the Mediterranean. Vol. 1. Fishes. (F. Briand, ed.). CIESM Pub. Monaco. 254 p.
2 - Golani D., 2002. The Indo-Pacific striped eel catfish, *Plotosus lineatus* (Thunberg, 1787), (Osteichtyes: Siluriformes) a new record from the Mediterranean. *Scientia Marina,* 66: 321-323.
3 - Golani D. and Fine M., 2002. On the occurrence of *Hippocampus fuscus* in the eastern Mediterranean. *J. Fish Biol.,* 60: 764-766.
4 - Castriota L., Grecot S., Marinot G. and Andaloro F., 2002. First record of *Seriola rivoliana* Cuvier, 1833 in the Mediterranean. *J. Fish Biol.,* 60: 486-488.
5 - Goren M. and Aronov A., 2002. First record of the Indo-Pacific parrotfish *Scarus ghobban* in the eastern Mediterranean. *Cybium,* 26: 239-240.
6 - Massuti E., Reina-Hervas J.A., Lloris D. and Gil de Sola L., 2002. First record of *Solea (Microchirus) boscanion* (Osteichthyes: Soleidae) in the Mediterranean Sea, with data on other sympatric soleid species. *J. Mar. Biol. Assoc., U.K.,* 82: 907-911.
7 - Yokes B., Dervisoglu R. and Karacilk B., 2002. An investigation of the marine biological diversity along Likya shores. *Sualti Bilim ve Teknoloji Toplantisi Bildiriler Kitabi Istanbul.* 2000: 166-181. (in Turkish).
8 - Corsini M., Kondilatos G. and Economidis P.S., 2002. Lessepsian migrant *Fistularia commersonii* from the Rhodes marine area. *J. Fish Biol.,* 61: 1061-1061.
9 - Dulcic J and Pallaoro A., 2002. First record of the lessepsian migrant *Leiognathus klunzingeri* (Pisces: Leiognathidae) from the Adriatic Sea. *J. Mar. Biol. Assoc. U.K.,* 82: 523-524.
10 - Pallaoro A. and Dulcic J., 2001. First record of *Sphyraena chrystaenia* (Klunzinger, 1884) (Pisces, Sphyraenidae) from the Adriatic Sea. *J. Fish Biol.,* 59: 179-182.
11 - Bilecenoglu M., Taskavak E. and Kurt K.B., 2002. Range extension of three lessepsian migrant fish (*Fistularia commersoni, Sphyraena flavicauda, Lagocephalus suezensis*) in the Mediterranean. *J. Mar. Biol. Assoc., U.K,.* 82: 525-526.
12 - Golani D., 2002. Lessepsian fish migration – characterization and impact on the eastern Mediterranean. Pp. 1-9. *In*: Öztürk B. and Basusta A. (eds.), Workshop on Lessepsian Migration. *Turk. Mar. Res. Found.* Istanbul.
13 - Gon O. and Randall J.E., 2003. A Review of the Cardinalfishes (Perciformes: Apogonidae) of the Red Sea. *Smithiana. Pub. Aquat. Biodiv.* 1, 1-46.

DYNAMIQUE STRUCTURALE ET ESPÈCES INDICATRICES DU ZOOPLANCTON DE LA CÔTE D'ALACANT (SE D'ESPAGNE, MÉDITERRANÉE OCCIDENTALE)

David Gras

Institut d'Ecologia Litoral, El Campello (Alicante), Espagne - d.gras@ecologialitoral.com

Résumé

L'étude comparée du zooplancton entre les différents milieux du littoral d'Alacant a permis d'établir l'évolution saisonnière de leurs structures zooplanctoniques et de sélectionner un certain nombre d'espèces qui constituent des indicateurs de conditions de l'environnement (confinement, dilution, exposition aux rejets polluants, courants marins).

Mots clés: zooplancton, indicateur, littoral, Méditerranée occidentale

Au cours des échantillonnages réalisés en divers points du littoral d'Alacant, s'est présentée l'opportunité d'établir d'une part la dynamique de la succession structurale du zooplancton et d'autre part de sélectionner des espèces indicatrices qui caractérisent les différentes zones.

Les échantillons ont été pris dans quatre stations de prélèvement, sélectionnées selon les particularités hydrographiques qu'elles pouvaient présenter: A- Côte de Campello, prise comme témoin des conditions typiquement néritiques; B- Albufereta, zone confinée, exposée aux rejets générés par l'agglomération métropolitaine adjacente; C- Embouchure du fleuve Segura, pour évaluer l'effet de ses effluents; et D- L'île de Tabarca, située en mer ouverte, pour détecter les zooplanctontes allochtones. Les prélèvements ont été réalisés chaque mois, couvrant un cycle annuel (de janvier à décembre 2000). Les échantillons ont été obtenus par pêche oblique au moyen d'un filet modèle WP-2 de vide de maille de 200 µm. Le zooplancton a été fixé avec du formol à 4% neutralisé avec du borax. Le recensement zooplanctonique a été réalisé à partir de sous-échantillons aliquotes du prélèvement original.

La communauté zooplanctonique est constituée par des espèces néritiques et épiplanctoniques, en conformité avec le caractère littoral des échantillons (1) (2). En automne, uniquement, s'observent des planctontes d'origine allochtone (océaniques et/ou sub-superficiels) introduits par l'action des tempêtes. Dans la fraction néritique, des espèces thermophiles (Cladocères *Evadne spinifera* et *Evadne tergestina*, Copépodes *Temora stylifera* et *Farranulla rostrata*, Mollusque Ptéropode *Creseis acicula*, Tuniciers *Oikopleura longicauda* et *Doliolum nationalis*) et psychrophiles (Copépodes *Centropages typicus* et *Corycaeus brehmi*) peuvent s'établir selon leurs affinités thermiques et présentent des catégories de distribution nettement saisonnière.

Dans ce cadre général chaque station de la région étudiée présente certaines singularités dans leur composition zooplanctonique, puisqu'elles révèlent des espèces caractéristiques des particularités de leur milieu. À l'Albufereta (B), le confinement provoque la diminution de la richesse spécifique et de l'abondance du plancton autochtone, et représente en plus un empêchement à l'incorporation du zooplancton allochtone (déclin de la diversité); ainsi, tant l'isolement que l'exposition élevée aux rejets justifie la présence d'indicateurs de l'eutrophisation et de la forte variation du milieu (Cladocères *Podon polyphemoides* et *Podon intermedius*, Copépodes *Acartia discaudata*, *Acartia latisetosa* et *Acartia grani*, et le Tunicier *Oikopleura dioica*) (3). À l'embouchure du fleuve (C) se détectent les espèces indicatrices de l'eutrophisation, de la forte variabilité du milieu, et surtout des indicateurs de dilution (le Rotifère *Synchaeta* spp., le Chétognathe *Sagitta setosa*, et la larve du Polychète *Magelona*) (4), spécialement en automne, période pendant laquelle le débit du fleuve augmente la dilution. À l'île de Tabarca (D) il existe une plus forte présence du zooplancton allochtone d'automne (plus haute diversité): Narcoméduse *Solmaris leucostyla*, Siphonophores *Eudoxoides spiralis*, *Abylopsis tetragona* et *Bassia bassensis*, Copépodes *Eucalanus attenuatus*, *Rhincalanus nassutus*, *Calocalanus pavo* et *Centropages violaceus*, Ostracode *Conchoecia haddoni*, Tuniciers *Fritillaria pellucida* et *Fritillaria borealis*. La présence du contingent allochtone auquel il faut ajouter le Copépode *Pontella lobiancoi* indicateur des eaux atlantiques, est également considérable en raison de son exposition à la mer ouverte, (5).

Références

1 - Vives F., 1966. Zooplancton nerítico de las aguas de Castellón (Mediterráneo occidental). *Inv. Pesq.*, 30: 49-166.

2 - Furnestin M. L., 1979. Aspects of the zoogeography of the mediterranean plankton. Pp. 191-254. *In:* Van der Spoel and Pierrot Bults (eds.), Zoogeography and diversity in plankton. Bunge Scientific, Utrech.

3 - Patriti G., 1972. Étude préliminaire des effets de la pollution globale sur le peuplement plantonique des ports Nord de Marseille. *Mar. Biol.*, 12: 300-308.

4 - Specchi M. et Fonda-Umani S., 1983. La communauté néritique de la région des embouchures du Pô. *Rapp. Comm. int. Mer Médit.*, 28(9): 197-199.

5 - Furnestin M. L., 1966. Plancton et Hydrologie. Pp. 7-30. *In:* Éléments de planctonologie appliquée. Institut Scientifique et Technique des Pêches Maritimes, Paris.

RETENTION AND DISCARDS BY SOLE GILLNET FISHERY IN THE ADRIATIC SEA

Fabio Grati *, Gianna Fabi and Giuseppe Scarcella
CNR - Istituto di Scienze Marine, Sezione Pesca Marittima, Ancona, Italy - * f.grati@ismar.cnr.it

Abstract
Observations onboard of vessels using gillnets for common sole (*Solea vulgaris*) in three mooring places of northern Adriatic were carried out for two years for analysing the quali-quantitative composition of retention and discarding. Catch data showed that the retained part was greater than the discarded one. Discard of high valuable species was practically nil independently from size; a size-dependent discard was observed only for *Trigla lucerna*. Discards of non-commercial species were made up of few dominant species, such as the crabs *Liocarcinus vernalis*, *Goneplax rhomboides* and *Corystes cassivelaunus*.

Key-words: discard, gillnet, Solea vulgaris, Adriatic Sea

Introduction

Gillnets for common sole is the set nets mainly used by northern Adriatic artisanal fishers. It is employed all year round on the coastal soft bottoms inside 3 nm offshore, following a seasonal pattern with the highest values in summer and the lowest ones in winter. This gillnet is characterised by low height (1.6-2.5 m) and buoyancy of floatings allowing the gear to partially lay down on the seabed thus favouring the capture of benthic fishes. The most common mesh sizes used are the 64 and 68 mm (stretched) ones.

In 1999-2000 a research was carried out on three small-scale fleets (Senigallia, Ancona, Portonovo) to increase the knowledge on this fishery.

Materials and Methods

Data on the quali-quantitative catch composition (for retained and discarded fractions) were collected onboard of randomly chosen professional vessels. A total of 24 observations were carried out from spring to fall, when fishing activity is most intense, without any interference with fisher's *modus operandi*. The catch was subdivided in target species (*Solea vulgaris*), kept by-catch (retained fraction except common sole), discard of commercial species (discard C; damaged specimens or smaller than legal size) and discard of non-commercial species (discard NC; species without any commercial value). All specimens in catches were identified, measured and weighed. Seasonal catch per effort (CPUE) was computed pooling together data recorded per season of the two sampling years and standardized as kg caught per 5,000 m of gillnet in one hour at sea.

Results

Fifty-nine taxa (37 fishes, 13 crustaceans, 7 molluscs, 2 echinoderms) were recorded. Discard C included the highest number of taxa, followed by retained fraction and discard NC.

Seasonal CPUE ranged from 5.0±1.9 to 8.1±3.7 kg/5,000m/h. The retained fraction far exceeded the discard one, increasing gradually from spring to fall (Fig. 1); *S. vulgaris* represented from 18 to 33% of the total, while *Squilla mantis*, *Trigla lucerna* and *Solea impar* dominated the kept by-catch.

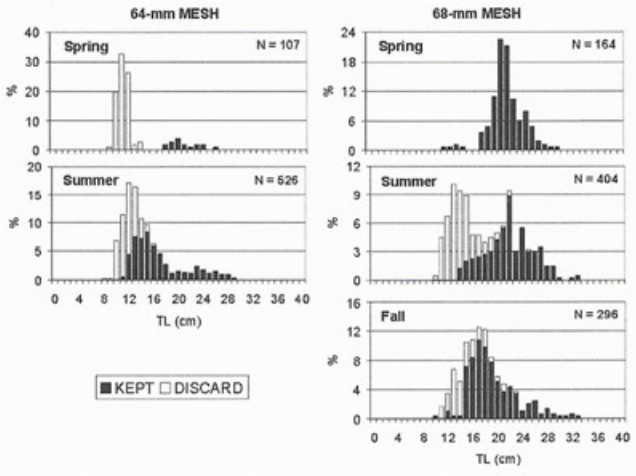


Fig. 1. Length-frequency distribution of *T. lucerna* gillnet catches.

Percentage contribution of discard NC on the total catch noticeably decreased from spring to fall, while discard C was constant among seasons (Table 1). The species composition of discard C greatly changed with season: *Aporrhais pespelecani* dominated in spring, *T. lucerna* and *S. mantis* in summer, and *S. mantis* and *Ostrea edulis* in fall. Although *A. pespelecani* is commercially important for artisanal trawling, in the set net fishery it is commonly discarded because of its low abundance. *S. mantis* and other fish species were generally represented by few individuals damaged by scavenger gastropods and crustaceans, while discards of *T. lucerna* mainly included specimens smaller than the size at first maturity in the area (24.0 cm TL; Fig. 1; 1). For the 64-mm mesh 84% of total catch of this species was discarded in spring and 45% in summer; for the 68-mm mesh discarding of tub gurnard was nil in spring, but amounted to 46 and 28% in summer and fall respectively. *Alosa fallax*, *Liocarcinus vernalis*, *Goneplax rhomboides* and *Corystes cassivelaunus* dominated discard NC, although their percentage contribution to this fraction noticeably changed among seasons.

Table 1. Composition of seasonal catches by weight and percentage importance of different categories.

		Spring	Summer	Fall
Solea vulgaris	**Total Weight**	**0.88**	**1.79**	**2.66**
	% on total catch	**18**	**27**	**33**
Kept by-catch	**Total Weight**	**2.50**	**3.54**	**4.78**
	% on total catch	**51**	**53**	**60**
Discard C	*Aporrhais pespelecani*	0.23		
	Bolinus brandaris		0.09	
	Boops boops	0.03		
	Ostrea edulis			0.11
	Squilla mantis		0.15	0.15
	Trachurus mediterraneus			0.07
	Trigla lucerna	0.04	0.14	
	Others	0.02	0.02	0.01
	Total Weight	**0.32**	**0.40**	**0.34**
	% on total catch	**6**	**6**	**4**
Discard NC	*Alosa fallax*	0.05	0.02	0.03
	Corystes cassivelaunus	0.19		
	Goneplax rhomboides		0.22	0.16
	Liocarcinus vernalis	0.99	0.66	0.01
	Others	0.01	0.01	0.01
	Total Weight	**1.24**	**0.91**	**0.21**
	% on total catch	**25**	**14**	**3**

Conclusions

The sole gillnet is more species-selective than other set nets (2). Discarding for this fishery was low, although all individuals were dead when rejected. Among the commercial species, a size-dependent discarding occurred only for *T. lucerna*, whose juveniles concentrate from spring to fall in the coastal area (1) where easily enmesh in set nets independently from mesh size because of their particular body shape (3). Discard NC consisted of few dominant decapod species, some of which play an important role in the diet of several highly valuable fishes (i.e. scienids; 4).

References

1 - Froglia C., 1984. Presupposti bio-ecologici e tecnici per una nuova regolamentazione della pesca a strascico entro le tre miglia dalla costa. Rep. for Marine Merchant Ministry, 104 p.

2 - Fabi G., Grati F., and Sbrana M., 2002. Attrezzi della piccola pesca utilizzati in funzione della successione stagionale e dell'eco-etologia delle specie ittiche in due aree costiere (Tirreno settentrionale e medio Adriatico). Rep. for Agricultural and Forestry Policies Ministry. 159 p.

3 - Fabi G., and De Ranieri S., 1998. Trammel and gill net selectivity in the Adriatic and Tyrrhenian sea. Rep. for EC-DG XIV. 162 p.

4 - Fabi G., Panfili M., and Spagnolo A., 1998. Note on feeding of *Sciaena umbra* L. (Osteichthyes: Sciaenidae) in the Central Adriatic sea. *Rapp. Comm. Int. Mer Médit.*, 35 (2): 426-427.

RELATIONSHIP BETWEEN THE HYDRODYNAMICS AND THE COMMUNITY STRUCTURE OF ZOOPLANKTON IN THE ALGERIAN COASTS

Hafferssas Aziz * and Seridji Rabea

Laboratoire d'Ecosystème Pélagique, Faculté des Sciences Biologiques, USTHB., B.P.64 El Alia, Bab Ezzouar, Alger, Algérie

Abstract

The spatial variation in zooplankton biomass, abundance and species composition in relation to hydrography and chlorophyll *a* (Chl *a*) was studied in the upper 200 m of the water column. Both the biomass and the abundance of zooplankton were low in the two oligotrophic systems and increased sharply toward the frontal zone. A total of 82 copepod species were identified, and three groups distributed along well defined environmental gradients characterising the distribution of physical variables and Chl *a* were revealed.

Key words: Algerian coasts, copepods, biomass

Method and Materials

The total number of stations with physical, chemical and biological measurements was 17 (1). At each station, vertical profiles of temperature, salinity and Chl *a* were obtained using a Rosette sampler SEABIRD, equipped with fluometer. Various depth strata were then sampled at 10 m intervals from the surface to the bottom. Zooplankton samples were collected using a WP2 closing net Zooplankton is sampled by vertical net hauls from 200 m to the surface. The dataset was composed of three matrices representing the environmental data collected at the 17 stations, the total abundance for the most 23 most important copepods species at the various depth strata and the biomass of the all zooplankton communities.

Results and Discussion

Temperature and salinity proprieties

The upper 150 m of the water column was characterised by a influence of Modified Atlantic Water (MAW), as evidenced by the low salinities (from 36.5 to 37.5).The vertical structure of the water column demonstrated a strong halocline in the 20-60 m depth range with a narrow thermocline at the bottom of this feature. From 150 to 300 m depth range the salinities values varied widely (37.5 – 38.30) and the temperatures were around 14.25 °C (at 150 m), rising to 13.07 - 13.23 °C. (at 300 m). This lowest temperature is identified as the relative minimum of potential temperature (θ_{min}) mainly characterised the Winter Intermediate Water (WIW). Above the WIW, at 350-500 m depth range we found the Levantine Intermediate Water (LIW). Our findings have also been reported by (3).

Chl *a* concentrations

Surface Chl *a* concentrations were generally low (<1 mg m^{-3}). A chlorophyll *a* maximum layer (> 0.30 mg Chl *a* m^{-3}) was observed over the entire stations. The depth of DCM was rather stable around 40–99 m. At the Inshore MAW and Offshore SMW stations, depth-integrated chlorophyll *a* ranged between 11 and 50 mg m^{-2}. Chlorophyll *a* exceeded this range at stations located at the frontal area. Here the values ranged from 65.49 (station 111) to 175.03 mg m^{-2} (station 54). Same results were found in the Alboran sea (sites 1 and 5) (4)

Copepod species composition and abundance

A total of 81 taxa was recorded in the Algerian coast (1). In the upper 200 m depth range total copepod abundance varied considerably, ranging from 18.12 to 1330.66 ind. m^{-3} (0–200 m). Highest abundances were associated with the frontal zone and the lowest with stations to the south and north of the front in oligotrophic waters. Zooplankton abundance are much higher in the offshore rich band corresponding to a frontal system. This has already been observed by many authors (5, 6). PCA of log transformed abundance data revealed three main groupings of populations along the Algerian coasts. The first group included five species with abundance maxima in the frontal region. The second group, included species with numerical abundance maxima was recorded at the inshore MAW stations. The third group included 13 species. This group had a broad distribution; the species were recorded in upper 200 m layer of the frontal, coastal and offshore waters

Zooplankton biomass and composition

Previous study in the Algerian coasts have described general aspects of vertical and horizontal distribution of the zooplankton biomass. As mentioned, the mean values recorded in the frontal stations (21.89 ± 1.32 $mg.m^{-3}$) were 7 times higher than those recorded in the MAW Inshore (3.41 ± 0.70 $mg.m^{-3}$) and SMW offshore stations (3.35 ± 0.55 $mg.m^{-3}$). Elevation of zooplankton standing stock in the upper water column (0-200 m), particularly in the frontal system (52.56 ± 2.95 $mg.m^{-3}$), has been attributed to an increase in the biomass of the smallest size fraction (100-300 µm) (49.01 ± 3.11 $mg.m^{-3}$).

Relationships between parameters

The results of PCA showed that two components explained 42.75 % of total variance. The first component, which explained 25.39 % of the variance, was significantly correlated to the temperatures values in and below the thermocline, surface salinity, halocline, integrated Chl *a* concentrations in the top 100 m and the Chl *a* maximum values at the subsurface. In addition, the total biomass and the biomass of small size fraction were inversely correlated to the first axis. The second component, which explained 19.16 % of the variance, was significantly correlated to surface Chl *a* concentrations and the biomass recorded in the 300-500 µm size fraction. The projections of all variables in a bidimensional plane defined by the first two components mirrored the link between the species of the first group (maximum abundance of species predominately herbivores), Chl *a* maximum values at subsurface, total zooplankton biomass and the standing stocks in the smallest size fraction (100-300 µm). The relationships between phytoplankton and zooplankton biomass have been suggested earlier (7).

The significance of the second group of species (dominant coastal copepods) is essentially linked to the Chl *a* concentrations in the 0-10 m depth range. The coastal cluster was also associated with the 300-500 µm biomass size fraction.

The third group of species was associated with temperatures values in and below the thermocline and with the salinities values recorded at uppermost layer (0-10 m) and in the halocline. On the other hand, species were significantly correlated to the standing stocks of the largest zooplankters (> 500µm).

Literatures cited

1 - Seridji R. and Hafferssas A., 2000. Copepod diversity and community structure in the Algerian basin. *Crustaceana,* 73 (1): 123.

2 - Motoda M., 1953. New plankton samples. *Bulletin of Faculty of Fisheries, Hokkaido University,* 5 (2): 149151.

3 - Perkins H. and P. Pistek. 1990. Circulation in the Algerian basin during June 1986. *Journal of Geophysical Research,* 95: 15771585.

4 - Videau C., A. Sournia, L. Prieur and M. Fiala. 1994. Phytoplankton and primary production characteristics at selected sites in the geostrophic Almeria-Oran front system (SW Mediterranean Sea). *Journal of Marine System, 5:* 235-250.

5 - Pingree R.D., Foster G.R. and P.G.K. Morrison. 1974. Turbulent convergent tidal fronts. *Journal of Marine Biological Association U. K.,* 54: 469479.

6 - Yamamoto T. and S. Nishizuwa. 1986. Small-Scale zooplankton aggregations at the front of a Kuroshio warin core ring. *Deep Sea Research,* 33: 17291740.

7 - Paffenhôffer G.A., Atkinson L.P., Lee T.N., Verity P.G. and L.R. Bulluck. 1995. Distribution and abundance of thaliaceans and copepods off the southeastern U.S.A. during winter. *Continental Shelf Research,* 25 (2/3): 255280

ABUNDANCE OF CLADOCERANS IN THE ERDEK BAY (SW MARMARA SEA)

Ozgur Emek Inanmaz *, Cetin Keskin

Canakkale Onsekiz Mart University, Faculty of Fisheries, Canakkale, Turkey - * emek1@turk.net
Istanbul University, Fisheries Faculty, Laleli, Istanbul, Turkey - seahorse@istanbul.edu.tr

Abstract

In this study abundance of Cladocerans were examined in the Erdek Bay (SW Marmara Sea) during the period of July 2000 to May 2001. Samples were collected from eight stations by horizontal houl using standard plankton net. In the study, totaly six species were found. Annual average abundance of Cladocera in the Erdek Bay was calculated as 734,89 ind./m^3 and total abundance of zooplankton consisted of 29.7% of Cladocerans. Cladocera reached maximum abundance in the summer.

Key words: Cladocera, Abundance, Marmara Sea

Introduction

Marmara Sea plays an important role as an acclimatization zone, a biological corridor or a biological barrier on the spreading of marine fauna and flora between the Mediterranean and Black Seas. Regarding the coastal artisanal fishery, Erdek Bay has a significant importance in the Marmara Sea. According to the researchers (1, 2) coastal areas of this bay are suitable breeding and nursery grounds for the larvae and juvenile fish. Marine zooplankton has a important role in the food chains of the sea as they transfer energy from the phytoplankton to higher trophic levels. Marine cladocerans predominate mainly in coastal ecosystems and contribute significantly to zooplankton abundance. For that reason we aimed to determine their abundance and contribution to total zooplankton.

Methods

Samples were collected from eight stations horizontally (Fig. 1) and monthly intervals with 115 µm mesh size standard plankton net and results were evaluated seasonally (Table 1).

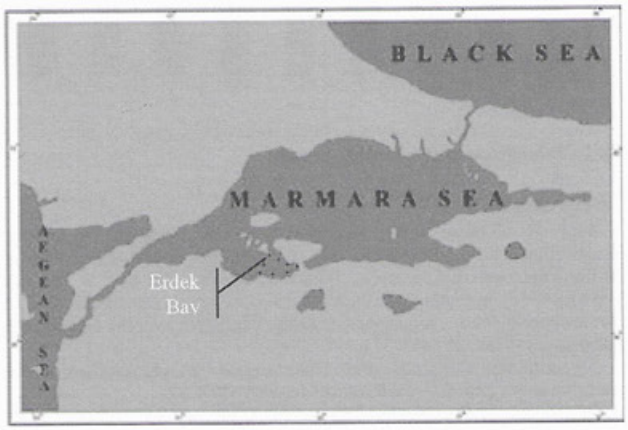


Fig. 1. Study area.

Table 1. Seasonal average abundance (ind/m^3)of species of Cladocera, total Copepoda and other zooplankton (Chetognatha, Appendicularia, Annelida, Bivalve veliger etc.).

	Summer	Autumn	Winter	Spring
P. avirostris	360.75	39.75	0.13	0.13
E. tergestina	268.75	5.25	-	-
E. spinifera	0.13	0.75	-	-
E. nordmanni	-	0.13	-	22.75
P. polyphemoides	0.75	0.63	1.88	32.63
P. intermedius	-	-	-	0.5
Total Cladocera	**630.38**	**46.51**	**2.01**	**55.51**
Copepoda	**44**	**558.25**	**294.75**	**153.00**
Other	**71.27**	**184.02**	**293.90**	**185.26**
Total zooplankton	**745.65**	**788.78**	**590.66**	**394.27**

Results

Six species of Cladocera have been determined in the Erdek Bay:
Penilia avirostris Dana, 1849
Evadne nordmanni Lovén, 1835
Evadne spinifera Müller, 1868
Evadne tergestina Claus,1877
Pleopsis polyphemoides Leuckart, 1859
Podon intermedius Lilljeborg,1853

P. avirostris and *E. tergestina* were found dominant in summer while *P. polyphemoides* and *E. nordmanni* were found in spring. Other species of Cladocera were found rarely in all seasons. As it can be seen from table 1 there is a negative correlation between Cladocera and Copepoda (r: -0.65, P<0.05).

Discussion

Study results showed that Cladocerans contribute significantly to zooplankton abundance. Some researchers reported that *P. avirostris*, *E. tergestina*, *P. polyphemoides* and *E. nordmanni* appeared highly concentrations in stagnant and polluted waters (3,4). For that reason Erdek Bay should be observed periodically.

It can be seen that there is a competition between Copepoda and Cladocera (r: -0.65, P<0.05). Similar results reported by Tarkan *et al.* (5). We think that interactions between Copepoda and Cladocera affected seasonal variation of zooplankton.

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References

1 - Inanmaz, O.E., 2001. Abundance and Distribution of Cladocera Populations in the Erdek Bay. MSc Thesis. University of Istanbul. Science Institute. 58 p.
2 - Keskin, C., 2002. Composition of Juvenile Fish Populations of Erdek Bay (Marmara Sea). PhD. Thesis. University of Istanbul. Science Institute. 83 p.
3 - Apostolopoulou, M.M., Kiortsis, V. ,1977. Notes écologiques sur les Cladocères marins de Grèce. *Rapp. Comm. int. Mer Médit.*, 24, 10: 113-114.
4 - Lakkis, S., 1981. Les Cladoceres Des Eaux Libanaises: Observations Faunistiques et écologiques. *Rapp. Comm. int. Mer Médit.*, 27, 7: 155-157. Monaco.
5 - Tarkan, A.N., Morkoç, E., Sever, T.M., 2000. Izmit Körfezi Baskın Zooplankton Türleri. S: 468-474. Marmara Denizi 2000 Sempozyumu Bildiriler Kitabı. Yayın No: 5. ISBN 975-97132-1-7. Istanbul.

ZOOPLANKTON STRUCTURE IN THE MARMARA SEA IN AUGUST 2000

Melek Isinibilir * and Ahmet N. Tarkan
Istanbul University, Fisheries Faculty, Laleli, Istanbul, Turkey - * melekis@istanbul.edu.tr

Abstract

Quantitative composition and abundance of zooplankton have been investigated in the Marmara Sea. Samples were collected at 9 stations, from 1 to 9 August, 2000. *Noctiluca miliaris* was the dominant species, with maximum density reaching 217779 ind/ m^3.

Keyword: Noctiluca miliaris, Mesozooplankton, Marmara Sea

Introduction

The Marmara Sea, a small intercontinental basin with a total volume of 3378km^3, carries the less saline Black Sea (17-18ppt) water into the Aegean Sea in the upper layer, and the more saline Mediterranean Sea water (39ppt) into the Black Sea in the lower layer via the Turkish Straits (1). Although recently some studies were made on the zooplankton structure of the Turkish Black Sea (2), there have been few investigations on zooplankton of the Marmara Sea (3, 4). In this study, quantitative composition and abundance of zooplankton have been investigated in August 2000.

Material and methods

Material was collected at 9 stations from 1 August till 9 August, 2000 (Fig. 1). Samples were taken vertically with a 200 µm, 57 cm diameter, WP2 plankton net. All zooplankton samples were preserved in 4 % buffered formaldehyde. The jellyplankton samples were identified and counted onboard.

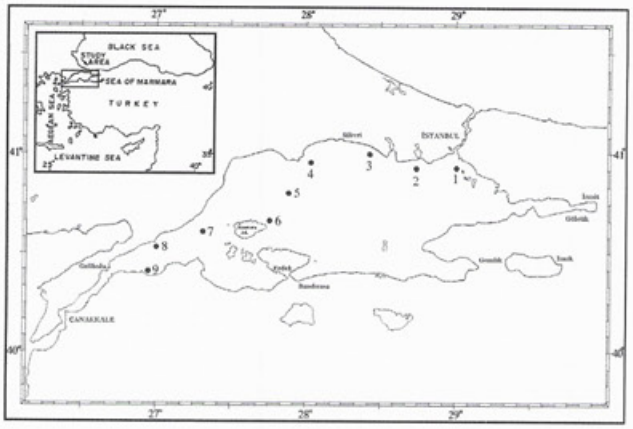

Fig. 1. Location of sampling stations in the Marmara Sea.

Results and discussion

The zooplankton was separated into three main groups: macro-jellyfish, mesozooplankton and *Noctiluca miliaris*, because of its enormous quantity. In the Marmara Sea, macrojellyfish consist of *Mnemiopsis leidyi, Pleubrochia pileus* and *N. miliaris* in this study. While *M. leidyi* was sampled in all stations, *Aurelia aurita* was found only at two stations. While the maximum number of *P. pileus* was observed at the first station as 1,33 ind/m^3, the maximum number of *M. leidyi* was recorded at the seventh station (26,66 ind/m^3).

The zooplankton of the Marmara Sea was found to consist of five groups. These were the Copepoda, Cladocera, meroplankton, *N. miliaris* and "Others" consisting of Appendicularia, Chaetognatha and Foraminifera. Compared to all other zooplankton groups, *N. miliaris* were the dominant taxon (Fig. 2): in August 2000 it made up 99,9 % of the mesozooplankton at the first station with the maximum density of 217779 ind/ m^3. This species was dominant as well in stations 2,3,4 and 6, while it was not found at the stations 8 and 9, situated at the far west.

The maximum abundance of Cladocera (5950 ind/m^3) was recorded at the station 8, in center of Çanakkale Strait, where the lowest number of *Mnemiopsis* occurred. Copepoda are dominate marine zooplankton (5), but came third in 30m water masses of the Marmara Sea in August 2000. In 1977, the abundance of zooplankton in the northern Marmara was 284 ind/m^3 (3). In August 1992, the zooplankton was drastically reduced to 33 ind.m^{-3} in the northern Marmara (4). In this study, the mesozooplankton increased in the northern Marmara to 3050 ind/m^3. Long term trends show fluctuation of mesozooplankton in the Marmara Sea. In recent years the water quality of the Sea deteriorated due to continual increase in the input of nutrients and pollutants. As a result, the zooplankton community structure has changed and the density of *N. miliaris*, a pollution tolerant species, increased. This result is consistent with previous studies conducted in the Black Sea (7).

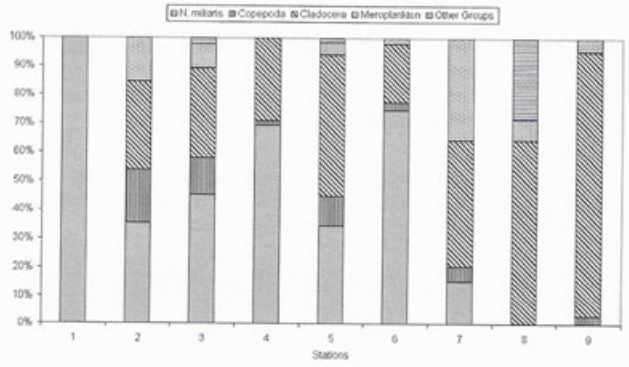

Fig. 2. Percentage of zooplankton groups.

References

1 - Benli H., Tarkan A.N., Sever T.M. 2001. Comparision of the mesozooplankton composition the southwestern Black Sea, Sea of Marmara and eastern Aegean Sea. *Turkish J. Marine Sciences,* 7: 163-179

2 - Kıdeys A.E., Kovalev A.V., Shulman G., Gordina A., Bingel F. 2000. A review of zooplankton investigations of the Black Sea over the last decade. *J. Marine Systems*, 24: 355-371.

3 - Cebeci M. and Tarkan, N. 1990. Distribution of zooplankton organisms in the Marmara Sea. I.*U. Su Urunleri Dergisi* 4(1): 69.

4 - Shiganova, T. A., A. N. Tarkan, A. Dede, & M. Cebeci, 1995. Distribution of the ichthyo-jellyplankton *M. leidyi* (Agassiz,1865) in the Marmara Sea (October 1992). *Turkish J. Marine Science*, 1: 3-12.

6 - Unal E., Shmeleva A.A., Zagarodnyaya J., Kıdeys A. 2000. Zooplankton structure and copepod species of the Sea of Marmara in spring 1998. Pp. 493-499. In: Oztürk *B.*, Kadıoglu M. and Oztürk H. (eds.), The Symposium of The Marmara Sea 2000, TUDAV. Istanbul (in Turkish).

7 - Zaitsev Yu.P., Polishchuk L.N., Nastenko E.V., Trofankhuk G.M. 1988. Very high concentrations of Noctilica miliaris Suriray in the neustal layer of the Black Sea. *Doklady Acad. Nauk Ukr. SSR*, 10: 67-69.

SEPIA OFFICINALIS L. IN THE COMMERCIAL TRAMMEL NET CATCHES IN THE NORTH ADRIATIC IN AUTUMN-WINTER

I. Jardas *, P. Cetinić, J. Dulčić, M. Kraljević, S. Matić Skoko, A. Pallaoro, A. Soldo
Institute of Oceanography and Fisheries, Split, Croatia - * jardas@izor.hr

Abstract

Sepia officinalis made 7.1% and 11.7 % of the total commercial trammel net catches in the North Adriatic during autumn-winter. Mantle length ranged from 8.2 to 23.2 cm (mean = 13.9 ± 1.83 cm) and weight from 84.0 to 1,054 g (mean = 300.7 ± 115.8 g). Two dominant length classes were identified. The value of the exponent *b* of the length-weight relationship was 2.5559.

Keywords: cuttlefish, trammel net catches, North Adriatic

Introduction

Generally, cuttlefish, *Sepia officinalis*, is east Atlantic and Mediterranean demersal, neritic species occurring predominantly on sandy and muddy bottoms from the coastline to about 200-250 m depth, but most abundant in the upper 100 m (1, 3-6). It is one of the most abundant Adriatic cephalopod species, occurring in the catches of different inshore and offshore fishing gears all over the year (1-3), particularly in warmer months (1, 2) and at depths less than 60 m (2, 3). Seasonal offshore-inshore (vertical) migrations have been reported for both Mediterranean and Adriatic stocks (1, 3, 5, 6). In early spring, Adriatic individuals leave deeper water, where they spent the winter at 50-60 m depth, to migrate into shallower ones (10-30 m) for spawning (in April-July). The North Adriatic is one of the most important cuttlefish fishing areas (1).

This study deals with commercial trammel net ("listarica") fishing in the North Adriatic during autumn-winter in respect of quantitative participation, length frequency distribution, age, and length-weight relationship of cuttlefish in the catches.

Material and methods

Samples were collected during December 2002 and January-February 2003 from 51 commercial trammel net (so-called "listarica", operating only in North Adriatic, for fishing *Solea*) catches (6,057 nets were used) in the North Adriatic over an area of 410 km^2 along the west Istrian Peninsula north of 45° 23', Lovrečica Cove, to the territorial sea frontier in Piran Bay and at depths down to 30 m. The construction characteristics of the trammel nets were: length 18-20 m, depth up to 1 m, mesh bar length of external and internal panels 160 and 40 mm respectively. Overall, 225 specimens were analysed. Mantle length (*ML*) was measured to the nearest 0.1 cm and weight to the nearest 1 g. The commonly used length-weight relationship was applied: $W = a\ (ML)^b$. Age was determined on the basis of length frequency distribution.

Results and discussion

Overall, 48 fish, 5 edible crustacean (Stomatopoda, Decapoda) and 3 cephalopod species were identified. Two species dominated the catches, both in terms of numbers and weight (*W*): common sole (70.9% and 70.4%) and cuttlefish (7.1%, and 11.7%). CPUE (catch per one net) was *No ind.* = 0.82 and *W* = 0.17 kg for whole catch, *No ind.* = 0.58 and *W* = 0.12 kg for common sole, and *No ind.* = 0.06 and *W* = 0.02 kg for cuttlefish. Consequently, low fishing efficiency of "listarica" trammel nets in relation to cuttlefish was established.

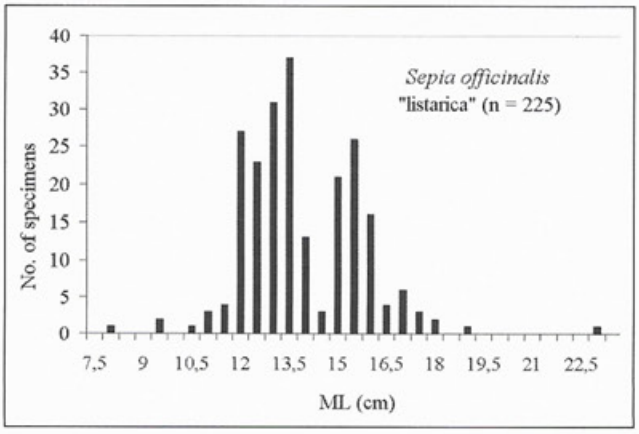

Fig. 1. *Sepia officinalis:* Length frequency distribution.

Cuttlefish *ML* and weight ranged from 8.2 to 23.1 cm (mean = 13.9 ± 1.83) (Fig. 1) and from 84 to 1,054 g (mean = 300.7 ± 115.1 g).

The slope (value *b*) of the length-weight relationship (Fig. 2) was $b = 2.5559$ ($SE_b = 0.073$) and differed significantly from 3 (*t*-test, = 7.15, $t_{crit} = 2.576$, $p < 0.05$), as it has been reported in previous studies (2, 4), indicating negative allometric growth.

The *ML* frequency distribution exhibited two main modes: at 13.5 and 15.5 cm.

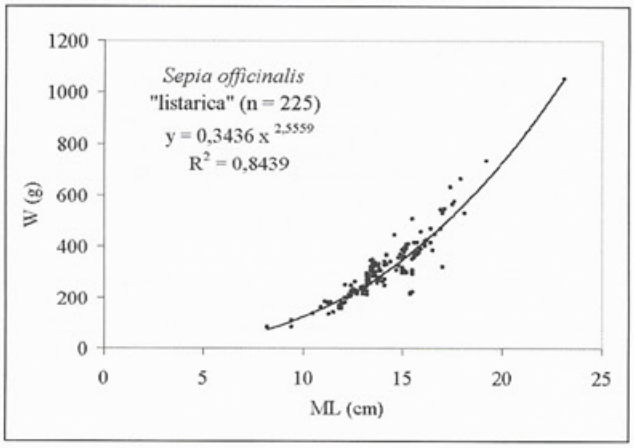

Fig. 2. *Sepia officinalis:* Length-weight relationship.

References

1 - Grubišić F., 1988. Fishes, crustaceans and bivalves of the Adriatic. Naprijed, Zagreb, 239 p. (in Croatian).

2 - Jardas I., Pallaoro A., Cetinić P., Dulčić J., 2001. Cuttlefish, *Sepia officinalis* L., in the trammel bottom set catches along the Eastern Adriatic coast (Croatia). *Rapp. Comm. int. Mer Médit.*, 36: 277.

3 - Mandić S., Stjepčević J., Dragović R., 1982. Migrations of some cephalopod species in the South Adriatic. *Stud. Mar. Kotor*, 11-12: 95-101 (in Croatian).

4 - Manfrin Piccinetti G., Giovanardi O., 1984. Données sur la biologie de *Sepia officinalis* L. dans l'Adriatique obtenues lors des expéditions Pipeta. *FAO Rap. Pêches*, (290): 135-138.

5 - Mangold K., Boletzky S. v., 1987. Cephalopodes. Pp. 633-714. *In*: Fischer W., Bauchot M.-L., Schneider M. (ed.), Fiches FAO d'identification des espèces pour les besoins de la pêche. Méditerranée et mer Noire, 1. FAO, Rome.

6 - Roper C.F.E., Sweeney M.J., Nauen C.E., 1984. FAO species catalogue. Vol. 3. Cephalopods of the world. *FAO Fish. Synop.*, (125), Vol. 3: 277.

MORTALITY OF *PAGELLUS ERYTHRINUS* OFF MONTENEGRIN COAST (SOUTH ADRIATIC)

Aleksandar Joksimovich
Institute of Marine Biology, Kotor, Serbia and Montenegro - maza@cg.yu

Abstract
Estimates of total and natural instantaneous mortality rates of *Pagellus erythrinus* are presented, with emphasis on the differences in mortality rates between two areas (exploited open sea; Boka Kotorska Bay where trawling is forbidden). Results obtained were also compared with previous data from a period when the surveyed area was almost unexploited.

Key words: Pagellus erythrinus, Trawling, Mortality, Montenegrin coast

Introduction

Red pandora, *Pagellus erythrinus*, is the only previously investigated (1, 2) species at the Montenegrin shelf. Until 1990 only one trawler with a 132 kW engine power operated in this region with mean annual fishing effort of 70 days. Since 1991 the number of trawlers increased, reaching 37 boats in 1998. Their number and fishing effort decreased since 1999 but a decline of biomass from 1998 to 2000 was observed (3). We estimated the total and natural instantaneous mortality rates of *P. erythrinus* and the results were compared with earlier data for the same area (2) and from Middle Adriatic (4).

Material and methods

Samples were collected from May 1997 to May 1999, with commercial trawlers. Ten hauls were performed in Boka Kotorska Bay and 20 in the open sea. The length and weight of 3201 individuals were measured. The linearized length converted catch curve (5) and the von Bertalanffy growth parameters of the species (6) were used to estimate total instantaneous mortality rates (Z). Natural mortality (M) was estimated from two empirical formulas (7,8).

Results and discussion

The estimated Z values (Figs. 1 and 2) were: Z = 0.518 ($P_{0.05}$<0.001) in Boka Kotorska Bay, and Z = 0.806 ($P_{0.05}$<0.001) on the open sea, while the mean values of M were 0.510 and 0.525. The slopes of the two regression lines differed significant (P<0.005).

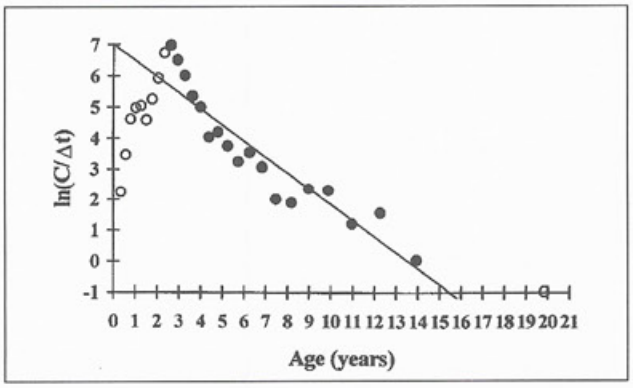

Fig. 1. Linearized length converted catch curve for Boka Kotorska Bay.

The estimated values showed that Z was about 30% grater in the open sea than in the Bay. Estimates of Z (2), obtained for the years 1964 and 1965, were: Z = 0.641 for Bay and Z = 0.591 for the open sea. It is obvious that such differences in mortality rates between the two areas were insignificant. This might be explained by the very low fishing effort in the open sea in that period (3). For Middle Adriatic channels, Z was 1.57 (4). Such a large value can be attributed to intensive trawl fishing.

The significantly higher value of Z in open sea than in the Bay may be explained by the increase in fishing effort in open sea from 1991 on.

Trawling is still forbidden in the Bay. This is one possible reason that Z did not change significantly since previous studies (2). Thus, *Pagellus erythrinus* was influenced mostly by natural mortality M, since estimated values of Z and M were almost identical. Insignificantly higher value of Z, when compared with M in the Bay, may be accounted for relatively low fishing effort with artisanal and sport gears. Exploitation rate (E), which is only 0.189, confirms this.

The exploitation rate in open sea, 0.356, was <0.5, a value indicating overfishing. Our results probably show that *Pagellus erythrinus* is not yet overfished. This might be related to existence of refugees near the coast being therefore unreachable to trawlers.

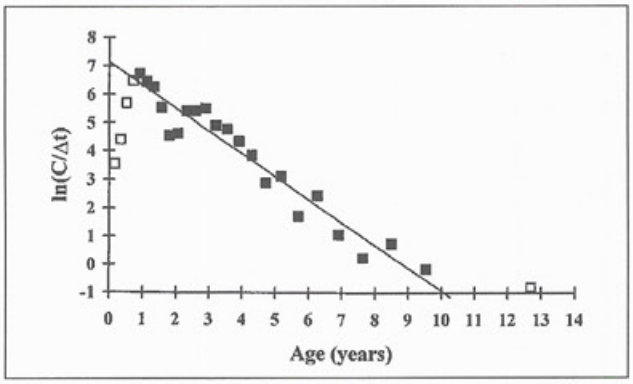

Fig. 2. Linearized length converted catch curve for open sea.

References

1 - Lepetic V., 1965., Sastav i sezonska dinamika ihtiobentosa i jestivih avertebrata u Bokokotorskom zalivu i mogućnosti njihove eksploatacije. *Studia Marina*, 1: 164 p.
2 - Rijavec L., 1975., Biologija i dinamika populacije *Pagellus erythrinus* (L.) u Bokokotorskom zalivu i otvorenom podrucju juznog Jadrana. *Stud. Marin*, 8: 3-110.
3 - Regner S. and Joksimovic A., 2001., Estimate of demersal biomass of the Montenegrin shelf (South Adriatic). *Stud. Marin.*, 23 (1): 33-40.
4 - Zupanovic S and Rijavec L., 1980., Biology and population dynamics of *Pagellus erythrinus* (L.) in the insular of the Middle Adriatic. *Acta Adriat.*, 21(2): 203-226.
5 - Pauly D., 1983., Lenght-converted catch curves. A powerful tool for fisheries research in the tropics. *ICLARM Fishbyte*, 1 (2): 9-13.
6 - Joksimovic A., 2001., Growth of pandora, *Pagellus erythrinus* (Linnaeus, 1758) from the Montenegrin shelf (South Adriatic) *Rapp. Com. int. Mer Médit.* 36: 278.
7 - Rikhter V.A., and Efanov V.N., 1976., One of the approaches to estimation of natural mortality of fish populations. *ICNAF Res. Doc.*, 76/VI/8: 12 p.
8 - Pauly D., 1980., On the interrelationship between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, 39 (2): 175-192.

TROPHIC HABITS OF *ARISTAEOMORPHA FOLIACEA* (DECAPODA: ARISTEIDAE) IN THE EASTERN MEDITERRANEAN

Kostas Kapiris * and Chryssi Mytilineou

National Centre for Marine Research, Institute of Marine Biological Resources,
Aghios Kosmas, Hellinikon, Athens, Greece - * kkapir@ncmr.gr

Abstract

The diet composition (abundance, prey occurrence, diversity) and feeding activity (vacuity and repletion index) of *Aristaeomorpha foliacea* were examined. The main prey items identified were Natantia, osteichthyes, gastropods and crustaceans. Feeding intensity was lower during the highest reproductive activity (summer) than in other seasons. Diet composition did not differ significantly (P>0.05) with sex, although the weight of the stomach content was generally higher in females than males.

Key-words: feeding, Aristaeomorpha foliacea, Ionian Sea, deep-water shrimp

Introduction

The deep-water shrimp *Aristaeomorpha foliacea* (Risso, 1827) constitutes a commercially important species for the Central Mediterranean [1]. The aim of this study is to present preliminary data on its feeding habits in the E. Ionian (E. Mediterranean).

Materials and methods

Three seasonal surveys (April, July and September 2000) were carried out in the northern part of the Greek Ionian Sea, at depths ranging from 300 to 1200 m. The samples were fixed immediately after capture, in 10% formalin. In total, 448 females (17.6-63.5 mm carapace length, CL) and 317 males (14.5-56.4 mm CL) were examined. In the laboratory the CL and the body weight (BW) were recorded. The stomach was removed and their content was weighted (SC). Prey items were identified at the order level. Fishes, echinoderms and sipuncula were counted as a single prey item per stomach, because it was not possible to establish the exact number of prey items. The unidentified mollusks and crustaceans were reported as "molluscs" and "crustaceans". Seeds and macrophytes were reported as "plant debris". The diet composition was expressed by the relative abundance (A) and the percent frequency of occurrence (O) for each type of prey and stomach. Trophic diversity was established using the Shannon index. The vacuity index (VI) was estimated as follow: (empty stomachs/total number of stomachs)X100. The stomach fullness was recorded using the repletion index: RI = (SC/BW)X100.

Table 1. Diet composition (relative abundance % A, frequency of occurrence % O) of *A. foliacea* per survey and sex, E. Ionian Sea.

Sex	MALES						FEMALES					
Month	April		July		Septem.		April		July		Septem.	
Pray	A	O	A	O	A	O	A	O	A	O	A	O
MOLLUSCA	1.9	1.9	4.1	3.7	0.6	0.7			2.0	2.1		
Bivalvia	4.8	4.9	1.2	1.2	2.0	2.2	7.7	7.9			2.8	2.9
Gastropoda	0.9	0.9	4.7	4.3	4.8	5.1	8.8	6.8	6.2	3.2	4.2	4.3
Scaphopoda							0.5	0.5				
Cephalopoda	1.9	1.9	2.4	2.4	1.3	1.4			2.5	2.7	4.7	4.8
Ceph. eggs											0.9	0.9
POLYCHAETA			2.4	2.4	2.0	2.2	1.5	1.7	2.0	2.1	1.8	1.9
NEMATODA									0.5	0.5		
SIPUNCULA			0.6	0.6	1.3	1.4						
CRUSTACEA	4.8	3.9	5.9	6.2	6.9	7.4	8.4	9.0	3.6	3.8	6.6	6.7
Decapoda Natantia	37	38.4	27.5	27.9	29.6	29.6	27.4	28.9	29.0	30.4	28.3	28.0
Other Decapoda	1.9	1.9	2.4	2.4			1.0	1.1	2.0	2.1	0.4	0.4
Brachyura			1.2	1.2	1.3	1.4	2.0	2.2	3.6	3.8	5.6	5.8
Amphipoda			2.4	2.4	3.4	3.7			2.0	2.1	4.2	4.3
Isopoda			1.8	1.8	0.6	0.7	1.0	1.1	1.0	1.0	0.9	0.9
Tanaidacea									0.5	0.5		
Ostracoda	2.8	2.9	1.8	1.86			0.5	0.5	0.5	0.5		
Copepoda					1.3	0.7	4.1	1.1				
Euphausiacea	0.9	0.9	2.4	2.4	1.3	1.4	1.0	1.1	3.1	3.2	1.8	1.9
Mysidacea									0.5	0.5	1.4	1.4
Reptantia					2.7	2.9					0.4	0.4
FISHES	16.5	16.6	14.3	14.9	13.1	14.0	13.4	14.7	16.0	16.8	14.6	14.9
Scales	8.6	8.8	10.1	10.5	5.5	5.9	6.2	6.8	8.8	9.2		
UNIDENTIFIED	3.8	3.9	1.2	1.2	2.7	2.9	1.5	1.7	1.0	1.0	2.3	2.4
Soft tissues	4.8	4.9	6.5	6.8	7.5	8.1	4.1	4.5	5.1	5.4	11.3	11.5
Plant debris	2.8	2.9	0.6	0.6	2.0	2.2	3.1	3.4	1.5	1.6	2.8	2.9
FORAMINIFERA	3.8	2.9	2.9	1.2	7.5	3.7	3.6	2.2	3.1	1.6	0.9	0.9
HYDROZOA			0.6	0.6			1.0	1.1				
ECHINIDERMA									0.5	0.5	1.4	0.4
Ophiuroidea												
Mud	0.9	0.9	1.8	1.8	0.6	0.7	1.5	1.7	2.5	2.7	0.4	0.4
Micromollusc remains	0.9	0.9					0.5	0.5			0.9	0.4
RADIOLARIA					0.6	0.7	0.5	0.5	0.5	0.5		
CHAETOGNATH			0.6	0.62								
Plastics, Other									1.0	1.0	0.4	0.8

Results and discussion

For both sexes, the most common components of the diet were fragments of Natantia, Osteichthyes, Gastropods and Crustacea (Table 1). These four categories made more than 55 and 60% of the total prey items in female and male stomachs, respectively. The (SC) differed significantly (Mann-Whitney test, P<0.05) in all surveys between the two sexes and was always higher in females (Table 2). This was attributed to the larger size of females when compared to males.

The diversity index (DI), which did not differ significantly between sexes (Mann-Whitney test, P>0.05), although was higher in July, at the peak of the spawning activity (Table 2).

Empty stomachs were found during all seasons; VI was highest in July for both sexes and lowest in April for males and in September for females, a fact indicating that feeding activity is lower during the reproductive period (July-September, [2]) than at the end or after it. VI was significantly (Mann-Whitney test, P<0.05) higher in females during April and July, a fact possibly related to the greater volume of their gonads.

RI varied among surveys. The highest mean value was in September for males and in April for females (Table 2). This fact could be related to the highest abundance of the heavy prey items (Crustaceans, Gastropods), in the stomachs of both sexes. The lowest RI value was recorded in April for males and in July for females.

Table 2. Average values of stomach content, repletion, vacuity and diversity index of *A. foliacea* per survey and sex, E. Ionian Sea.

SURVEY	SEX	SC (g)	RI (%)	DI	VI (%)
April	Males	0.117	1.07	0.945	10.94
	Females	0.343	1.72	1.078	16.81
July	Males	0.138	1.10	1.104	15.56
	Females	0.156	0.86	1.091	18.63
September	Males	0.151	1.25	1.011	12.16
	Females	0.383	1.28	1.047	11.21

The species is characterized as an extremely fast and active predator [3, 4]. This agrees with our results, since the majority of the food items consumed were large and mobile organisms (e.g. Natantia, fishes). The findings of the present study are in accordance with those of other studies [3, 4].

References

1 - D'Onghia G., Maiorano P., Matarrese A. and Tursi A., 1998. Distribution, biology, and population dynamics of *Aristaeomorpha foliacea* (Decapoda, Natantia, Aristeidae) in the North-Western Ionian Sea (Mediterranean Sea). *Crustaceana*, 71(5): 518-544.

2 - Papaconstantinou C. and Kapiris K., 2003. The biology of the giant red shrimp (*Aristaeomorpha foliacea*) on an unexploited fishing ground in the Greek Ionian Sea *Fish. Res.*, 62: 37-51.

3 - Lagardère J. P., 1972. Reserches sur l'alimentation des Crevettes de la Pente Continentale Marocaine. *Tethys* 3: 655-675.

4 - Cartes J. E., 1995. Diets of, trophic resources exploited by, bathyal Penaeoidean shrimps from the Western Mediterranean. *Mar. Freshwater Res.*, 46: 889-96.

PRELIMINARY RESULTS ON RELATIONSHIPS BETWEEN TAIL AREA AND TOTAL BODY LENGTH FOR FOUR FISH SPECIES

P. K. Karachle * and K. I. Stergiou

Aristotle University of Thessaloniki, School of Biology, Department of Zoology, Laboratory of Ichthyology, Thessaloniki, Greece - * pkarachl@bio.auth.gr

Abstract

We present tail area-length (TA-TL) relationships for four fish species. TA was linearly related to TL for *Uranoscopus scaber*, *Scomber japonicus* and *Scorpaena porcus* and was a power function of TL for *Arnoglossus laterna*, and positively ($p<0.05$) related with trophic level.

Keywords: Arnoglossus laterna, Scomber japonicus, Scorpaena porcus, Uranoscopus scaber, tail area-length relationships

Introduction

Relationships among various morphometric characteristics of fish have been the object of extended research, mainly focusing on relationships between different types of lengths and weight, with an increasing interest on other types of relationships (e.g., girth: 1; mouth dimensions: 2). In contrast, relationships involving tail characteristics (e.g., area, height, aspect ratio), despite their well documented importance (3; 4) have not been studied extensively.

In this study we present preliminary results on tail area-length relationships for four fishes, using data obtained within the framework of a research project on the trophic ecology and feeding habits of more than 40 fish species.

Materials and methods

Samples of *Arnoglossus laterna*, *Scomber japonicus, Scorpaena porcus,* and *Uranoscopus scaber* were collected from commercial fishing vessels (i.e. purse seiners, trawlers and small-scale gill-netters), in N-NW Aegean Sea, and preserved in 10% formalin solution. For all individuals, total length (TL) was measured to the nearest mm and tail area (TA) was calculated using UTHESCSA IMAGETOOL Ver. 3.0.

Results and discussion

The results of the statistical analysis are shown in Table 1. TA was a linear function of TL in all cases, except for *Arnoglossus laterna* for which it was a power function of TL (Table 1, Fig. 1). TA was positively related ($r=0.98$, $p<0.05$) with the log(trophic level, Troph) of the four species (Table 1). We point out that the shape of the TA-TL and TA-Troph relationships might change when more data and species will be added.

Calculating TA is important since it can be related to the estimation of food consumption rate (3; 4), the latter being essential for three main reasons (5): to assess the demand of fish from their food, to assess the effect of food availability on survival, growth and reproduction, and to estimate the energy available for maintenance, growth and reproduction.

Table 1. Relationships between tail area (TA, cm^2) and total length (TL, cm) for four fishes. N=number of individuals; Troph=fractional trophic level (data from 6); tail shape is given as 25% of natural tail size.

Species	Equation	N	R^2	Troph	Shape
Arnoglossus laterna	$TA=0.02TL^{2.15}$	37	0.97	3.6±0.54	TL=15.0 cm
Scomber japonicus	TA=0.33TL-2.28	51	0.88	3.1±0.43	TL=14.9 cm
Scorpaena porcus	TA=0.90TL-5.28	49	0.79	3.9±0.65	TL=15.2 cm
Uranoscopus scaber	TA=1.07TL-6.47	38	0.95	4.4±0.70	TL=15.0 cm

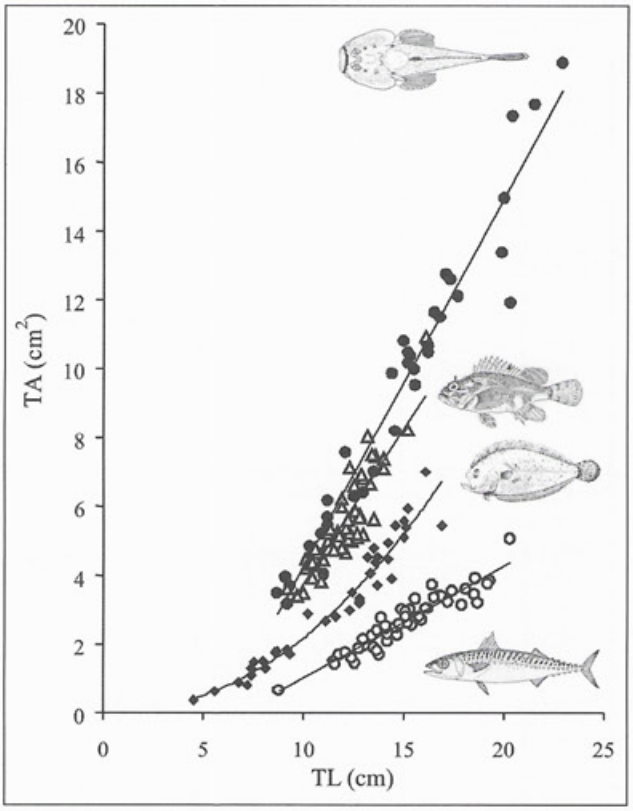

Fig. 1. Relationship between total length (TL) and tail area (TA) for *Arnoglossus laterna* (◆), *Scomber japonicus* (○), *Scorpaena porcus* (△) and *Uranoscopus scaber* (●).

References

1 - Stergiou K. I., and Karpouzi V. S., 2003. Length-girth relationships for several marine fishes. *Fish. Res.*, 60: 161-168.

2 - Karpouzi V. S., and Stergiou K. I., 2003. The relationships between mouth size and shape and body length for 18 species of marine fishes and their trophic implications. *J. Fish Biol.*, 62: 1353-1365.

3 - Palomares M. L., and Pauly D., 1989. A multiple regression model for predicting the food consumption of marine fish populations. *Aust. J. mar. Freshwat. Res.*, 40: 259-273.

4 - Pauly D., 1994. Why didn't I think of this? Pp. 74-77. *In*: Pitcher T. J. (ed.) On the sex of the fish and the gender of scientists. A collection of essays in fisheries science. Fish and Fisheries Series 14, Chapman & Hall, London.

5 - Wootton R. J., 1998. Ecology of teleost fishes. 2nd Edition. Kluwer Academic Publishers, Fish and Fisheries Series 24, London.

6 - Froese R., and Pauly D. (Eds), 2003. FishBase. World Wide Web electronic publication. URL: www.fishbase.org– http//:www.fishbase.org

MESOSCALE EFFECTS OF FISH FARMING ZONES ON MACROBENTHIC COMMUNITIES IN THE AEGEAN SEA

Karakassis I. [1] *, Papadopoulou K.N. [1], Apostolaki E. [1] and D. Koutsoubas [2]
[1] Inst. of Marine Biology of Crete, Heraklion, Hellas - * jkarak@imbc.gr
[2] Dept. Marine Sciences, University of the Aegean, Mytilene, Hellas

Abstract
The effect of fish farming zones on the marine benthic communities over mesoscales (1-10 km) was investigated in three coastal areas of the Aegean Sea. The results showed that there were no significant changes between sites close to and far from the fish farming zones in terms of abundance, biomass and diversity.

Key words: aquaculture, fish farming zones, benthos

Introduction

The benthic effects of fish farming in the vicinity of fish cages have been documented from several parts of the world including the Mediterranean [1,2]. However, the expansion of fish farming has resulted in the development of large zones with considerable production and therefore with significant release of nutrients. Although the dispersive character of the sites selected for fish farming induces rapid water renewal it could be expected that the amount of nutrients and fine particulate material released could directly or indirectly disturb marine biota over larger spatial scales. Even more so in the case of oligotrophic marine systems such as the Mediterranean where the signal of nutrient enrichment should be more readily detectable over larger spatial scales. The present study was designed to test the hypothesis that macrofaunal communities are influenced by fish farming zones at spatial scales of 1-10 km.

Materials and methods

Three areas in the Aegean Sea (Evoia, Chios and Lesvos islands) were sampled during September 2002, during the period of maximal feed supply. In each region, one sub-area near the zone of fish farming activity (thereafter referred to as "fish-farm site") as well as one sub-area far away from these zones (thereafter referred to as "reference site") were investigated. Reference sites had comparable topography, depth and an average distance of 20 nautical miles (nm) from the respective fish-farm sites. At each site 10 random replicates were taken by means of a 0.1 m^2 Smith-McIntyre grab. Specimens were sieved over a 0.5 mm sieve, fixed with formalin 10% and identified into species level. Sediment redox potential (Eh), total organic carbon and nitrogen (TOC, TON), chlorophyll a and phaeopigments were determined for each replicate. Diversity was determined by means of PRIMER software and comparisons between sites, sediment types and proximity to fish farming zones were performed by means of 3-way ANOVA.

Results and discussion

In the 60 samples analyzed, a total of 9077 individuals were found belonging to 334 species. The results of the 3-way ANOVA (Table 1) for abundance and biomass, showed no significant changes in biomass in respect of any of the variables examined, whereas abundance showed significant changes in response to sediment type and area but no significant differences in response to proximity to fish farming zones. All the measures of diversity employed (Table 2) namely Shannon index (H'), evenness (J) and number of species per sample (S) also showed significant changes among areas and types of sediments but again with no significant changes in response to proximity to fish farming zones. Our results indicate that fish farming zones examined under the present levels of production and at the present scheme of site selection procedures do not impose significant changes on macrofaunal community attributes. Although fish farming releases considerable amounts of nutrients in the water column [3] it seems that these do not affect the productivity in a way that could negatively affect the benthic environment beyond the zone at the immediate vicinity of the farms.

Table 1. ANOVA table for total macrofaunal biomass and abundance per area (E:Evia, L: Lesvos, C:Chios), aquaculture presence (Aqua) and substratum type (sed). F: value of F-test, p: the probability value (significant values in bold). Res: results (when significant differences only), N: Near, F: Far, Co: coarse, Fi: Fine sediments.

	Biomass			Abundance		
	F	p	Res	F	p	Res
Sept						
Area	0.02	0.9783		9.90	0.0002	L<E
Aqua	0.15	0.7030		1.74	0.1927	
Sed	0.20	0.6540		10.49	0.0021	F<Co

Table 2. ANOVA table for diversity indices (J, H, S) from abundance data per area (E:Evia, L: Lesvos, C:Chios), aquaculture presence (Aqua) and substratum type (sed). F: value of F-test, p: the probability value (significant values in bold). Res: results (when significant differences only), N: Near, F: Far, Co: coarse, Fi: Fine sediments.

	J			H			S		
	F	p	Res	F	p	Res	F	p	Res
Sept									
Area	16.73	0.0000	L>E,C	6.36	0.0033	L<C	9.24	0.0004	L<E
Aqua	1.41	0.2405		0.05	0.8311		0.13	0.7224	
Sed	3.35	0.0728		40.52	0.0000	F<Co	40.37	0.0000	F<Co

References

1 - Karakassis I., Tsapakis M., Hatziyanni E., Papadopoulou K.N. and Plaiti, W., 2000. Impact of cage farming of fish on the seabead in three Mediterranean coastal areas. *ICES J. Mar. Sci.* 57: 1462-1471.
2 - Fernandes T.F., Eleftheriou A., Ackefors H., Eleftheriou M., Ervik A., Sanchez-Mata A., Scanlon T., White P., Cochrane S., Pearson T.H. and Read P.A., 2001. The scientific principles underlying the monitoring of the environmental impacts of aquaculture. *J. Appl. Ichthyol.* 17: 181-193.
3 - Pitta P., Karakassis I., Tsapakis M. and Zivanovic S., 1999. Natural *vs* mariculture induced variability in nutrients and plankton in the Eastern Mediterranean. *Hydrobiologia* 391: 181-194.

THE STATUS OF THE DEMERSAL FISHERIES RESOURCES IN THE MARMARA SEA

F. Saadet Karakulak *, Bayram Öztürk, Bülent Topaloglu, Elif Özgür
Istanbul University, Faculty of Fisheries, Laleli, Istanbul, Turkey
Turkish Marine Research Foundation, Beykoz, Istanbul, Turkey
* karakul@istanbul.edu.tr, ozturkb@istanbul.edu.tr, topalbl@istanbul.edu.tr, eozgur@istanbul.edu.tr

Abstract
A bottom trawl survey was carried out in the Marmara Sea in summer 2001 in order to determine species composition and biomass of demersal fisheries resources. The average catch was 175.9±34.5 kg/hour (±se) and the average biomass 10,799.7±1,882.9 kg/nm^2 (±se).

Keywords: Bottom-trawl survey, catch composition, biomass, Marmara Sea

Introduction
The Marmara Sea, located between two different marine systems, the Mediterranean Sea and the Black Sea, is important as feeding and breeding habitat for commercial pelagic species (1). Few studies concerning the demersal stocks of the Marmara Sea are available (2, 3, 4). The present study evaluates the condition of the demersal fish stocks of the Marmara Sea and proposes advices for the sustainable fisheries management in the area.

Materials and Methods
This research was carried out in August 2001, in the Marmara Sea using a bottom trawl net. The head-rope length of the trawl net was 21.6 m and the cod-end mesh size 20 mm (knot to knot). The duration of each haul was 30 min at depths up to 200 m and 60 min at depths >200 m. The trawling speed was 2.2-2.6 nm/hour. Biomass was calculated based on the swept area method.

Results
A total of 12 hauls were carried out between 30-300 m. The average catch was 175.9±34.5 kg/hour (±se). The average biomass was 10,799.7±1,882.9 kg/nm^2 or 5,821.1±1,014.6 kg/Km^2.

From a total of 91 species identified, 34 were osteichthyes, 16 molluscs (4 bivalves, 3 gastropods, 9 cephalopods), 13 echinoderms, 12 crustaceans, 9 chondrichthyes, 6 cnidarians and 1 annelid. The commercial species comprised 78% of the total catch. Osteichthyes made up the greatest portion of the catch (by weight: 56.83%; by number: 34.92%) (Fig. 1).

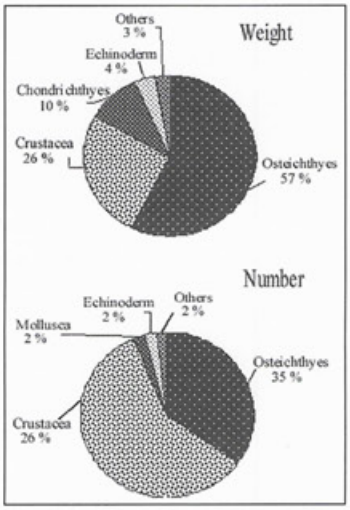

Fig. 1. Catch species composition by number (N) and weight (W).

Discussion
The Marmara Sea is a very productive fishing ground for pelagic fishes like anchovy, pilchard, bonito, etc. In the Turkish fisheries, the Marmara Sea ranks second after the Black Sea as far as total fish catch is concerned (5). After the 1980s, the population increase in the Marmara region was followed by a rapid urbanized and industrialized development so that the domestic and industrial wastewater and unfavourable habitat conditions affected fishing grounds negatively, especially so the water masses below the thermocline (5). Additionally, fishing pressure on demersal resources increased. For preserving demersal fishing resources, trawling has been prohibited since the early 1970s. In spite of this, due to the lack of any official control trawl fishing still continues illegally.

Despite a serious decrease in hake and whiting stocks in 1990-1994 (4), an increase in both stocks was found in this study. The total amount of whiting catch was 2047 t in 1990, 557 t in 1994 and 2455 t in 2000. The demersal resources of the Marmara Sea might have positively affected by some protecting measures taken, such as: (a) the prohibition of the hydraulic dredges used for *Chamelea gallina* fishing since 2000, (b) the prohibition of sand extractions and (c) the establishment of the sewage treatment systems.

The protection of biological diversity in the Marmara Sea and the sustainable fisheries development could be achieved by: (a) respecting the fishing prohibitions, especially for the protected species, (b) limiting fishing effort, (c) protecting shores and (d) using more selective nets.

Table 1. The frequency of occurrence and biomass (in kg/nm^2) indices (mean standard error, se) of species caught in the Marmara Sea. Species are listed alphabetically.

	Biomass index		Frequency of
SPECIES	kg/nm^2	Se	occurrence (%)
FISH			
Blennius ocellaris	5,2	1,87	50,00
Callionymus lyra	70	26,33	66,66
Callionymus risso	37,5	21,69	41,66
Cepola macrophthalma	18,6	9,26	50,00
Chelidonichthys gurnardus	57,2	23,69	58,33
Chelidonichthys lucernus	209	74,38	58,33
Citharus linguatula	63,3	25,58	50,00
Galeus melastomus	41,4	28,24	25,00
Gobius auratus	17,5	10,08	75,00
Gobius niger	102,4	35,93	66,66
Lepidotrigla cavillone	28,6	17,74	50,00
Lophius budegassa	43,1	38,96	25,00
Merlangius merlangus	2969,5	1267,01	75,00
Merluccius merluccius	976,6	217,32	100,00
Mullus barbatus	8,9	6,69	25,00
Mullus surmuletus	0,4	0,4	8,33
Mustelus mustelus	76,9	49,07	25,00
Raja clavata	867,8	500,79	58,33
Rostroraja alba	64,7	30,21	50,00
Scophthalmus maeoticus	4,8	3,38	16,66
Scophthalmus rhombus	10	7,22	16,66
Scyliorhinus canicula	71	44,94	41,66
Serranus hepatus	198,7	73,22	91,66
Solea solea	35,4	11,15	58,33
Sprattus sprattus	657,3	403,06	66,66
Trachurus trachurus	378,9	176,26	91,66
Trigla lyra	53	41,57	25,00
Other fishes	63,8	28,5	
CRUSTACEANS			
Parapenaeus longirostris	2063,4	578,91	83,00
Macropipus depurator	571,07	320,76	91,66
Plesionika heterocarpus	358,74	208,20	33,33
Other crustaceans	2,22	0,86	
CEPHALOPODS			
Loligo vulgaris	8,79	3,73	58,33
Sepia officinalis	22,02	11,51	16,66
Sepia orbignyana	29,22	15,81	50,00
Other cephalopods	6,06	2,91	
OTHER INVERTEBRATES	510,54	261,19	

References
1 - Kocatas, A., Koray, T., Kaya, M., Kara, O.F. 1990. Review of the fishery resources and their environment in the Marmara Sea. GFCM, 64, part 3, pp. 87-143, Rome.

2 - JICA, 1993. Report of demersal fisheries resource survey in the Republic of Turkey. JICA, AFF, JR.63, 579p, Ankara.

3 - Karakulak, F. S., Tarkan, A. N., Öztürk, B. 2000. Preliminary study on the demersal fish stocks in the northern Marmara Sea. The Symposium of Marmara Sea 2000, TUDAV Publications. No.5, pp. 500-512, Istanbul.

4 - Okus, E., Yüksek, A., Uysal, A., Orhon, V. 1994. Determination of the stocks of some commercial demersal fishes in the Marmara Sea project (1990-1994). Tübitak DEBAG-116/G, I.U. Institute Of Marine Sciences and Management and T.C. Ministry of Agriculture Rural Affairs.

5 - Zengin, M., Mutlu, A. 2000. The resent state of the fisheries and suggestions related to the future of the stocks at the Marmara Sea. "The Symposium of Marmara Sea 2000", TUDAV Publications. No.5, pp. 411-425, Istanbul.

SPATIOTEMPORAL DISTRIBUTION OF HAKE *(MERLUCCIUS MERLUCCIUS)* IN THE N. AEGEAN SEA USING GEOSTATISTICAL ANALYSIS

S. Kavadas [1] *, A. Siapatis [1], A. Kalianiotis [2], C. Papaconstantinou [1]
[1] National Centre for Marine Research, Athens, Greece - * stefanos@ncmr.gr
[2] Fisheries Research Institute, Kavala, Greece

Abstract
Geostatistical techniques were used to analyze the spatio-temporal distribution of hake in the N. Aegean Sea during 1996 to 2000, based on five experimental trawl surveys. Abundance varied significantly both spatially and temporally. Spatial heterogeneity was attributed to the biology of the species, the geomorphology and the environmental conditions prevailing in the study area.

Keywords: Geostatistics, spatial distribution, hake, North Aegean

Introduction

Demersal fish assemblages have been analyzed using conventional statistics, which are based on random, independent variables that assume zero continuity and allow no extension of each data value. This makes impossible to estimate points on a map, within an area as all of these points should be given the same overall mean value. Geostatistics (1, 2), assuming that adjoining points are correlated to each other spatially, is used in earth sciences to analyse, model, estimate and map the spatial distribution of natural resources through the analysis of their spatial autocorrelation (3).

In the present study an attempt was made to map the spatial and temporal distribution of hake abundance and to study the structure of the hake population in the North Aegean using geostatistics and based on five MEDITS surveys carried out during 1996-2000.

Material and methods

Surveys were carried out with a commercial trawler following MEDITS methodology. A stratified sampling scheme with simple random sampling within each stratum was used. The stratification criterion was depth: 10-50, 50-100, 100-200, 200-500 and 500-800 m. The sampling area was divided into six subareas (Fig. 1). Extended, narrow continental shelves, basins, peninsulas, river runoff and islands characterize this area. The sampling grid covered 63 stations per survey.

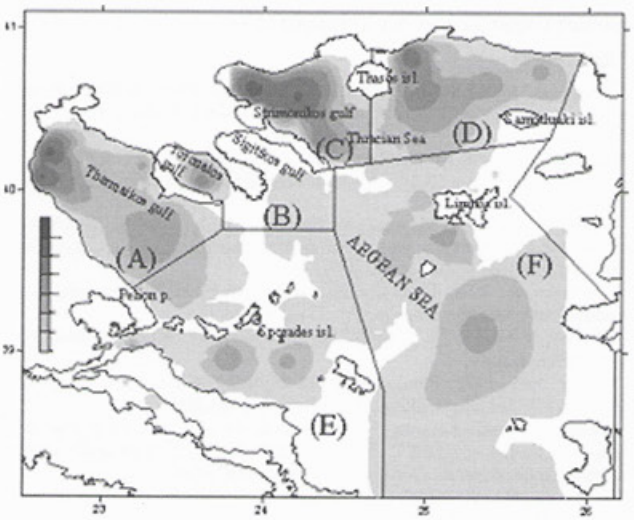

Fig. 1. Spatial distribution of hake in the N. Aegean Sea in 1999.

A geostatistical model was built to analyze hake abundance (N/km^2). We applied the spherical model that was adapted significantly to the form of the experimental semivariograms (1, 2) of our data. Point kriging was used to estimate the values of the sampling points over a polygon defined by depth contours (10-800 m).

Results and discussion

The results showed that the spatial distribution of hake in the North Aegean Sea extends to depths from 30 to 680 m.

The lowest values of hake abundance among the five surveys were observed in 1996. In this year, the highest values of hake were recorded at the subarea D (SE of Thasos Island) and at the subarea A (across the Pelion peninsula). At the 1997 survey the highest values of hake abundance were recorded at the subareas A (near the Aliakmonas river outfall), C (inner and outer part of the Strimonikos Gulf) and F (SW of Limnos island). During the 1998 survey the highest values were recorded in subareas D (SE of Thasos island), C (outer part of Strimonikos Gulf), E (southern part of Sporades islands) and B (Toronaios Gulf). In 1999 survey, the highest values of hake abundance were observed among the five surveys (Fig. 1). The highest values were recorded in subareas C (inner and outer part of the Strimonikos Gulf), D (near the Nestos river outfall), A (near the Aliakmonas river outfall) and B (Toronaios Gulf). Finally in 2000 survey the highest values of hake abundance were recorded in subareas A (near the Aliakmonas river outfall), D (between Thassos and Samothraki islands), B (Toronaios Gulf) and F (with 3 different peaks).

The North Aegean Sea is one of the most productive areas of hake fishery in Greece (4). Significant differences of the spatial and temporal patches of the population were detected during the five surveys. In particular, areas near estuaries (i.e., west Thermaikos, Strimonikos Gulf, NE of Thasos island) were characterised by the highest values of hake abundance especially during 1999 and 2000. The study of the length frequency distribution of hake indicated that these areas are characterized by the presence of high densities of juveniles. The heavy rainfalls during 1999-2000 can probably explain the high concentrations of juveniles at these locations. Toronaios Gulf was characterized by a presence of juveniles during all surveys. Although the west part of Thermaikos Gulf and Toronaios Gulf are generally considered as nursery grounds (5), our results showed that Strimonikos Gulf and the area NE of Thasos are characterized by the highest density of juveniles.

References

1 - Matheron, G., 1971. The theory of regionalized variables and its applications. *Cah. Center Morphol. Math. Fontainebleau,* 5.
2 - Journel, A.G., and Huijbrgets, C.J., 1978. Mining geostatistics. Academic.
3 - Maynou, F., Conan, G.Y., Cartes, J.E., Company J.B., and Sarda, F., 1996. Spatial structure and seasonality of decapod crustacean populations on the northwestern Mediterranean slope. *Limnol. Oceanogr.,* 41(1): 113-125.
4 - Stergiou, K.I., 1989. Multivariate analysis and trends of the Greek fishery. FISHBYTE, 7(2): 4-7.
5 - Papaconstantinou, C., 1993. Factors affecting the distribution of the nurseries ground of hake in the Greek seas E.30 (in abstract). Fisheries Society of the British Isles. Congress on factors affecting the distribution of fish. Conway, Wales. *J. Fish. Biol. Suppl. A,* 333 p.

COMPOSITION OF JUVENILE FISH POPULATIONS IN ERDEK BAY, SEA OF MARMARA

Cetin Keskin [1] *, Nuran Unsal [1], Muammer Oral [1], Ozgur Emek Inanmaz [2]

[1] Istanbul University, Fisheries Faculty, Laleli Istanbul, Turkey - * seahorse@istanbul.edu.tr

[2] Canakkale Onsekiz Mart University, Faculty of Fisheries, Terzioglu Campus, Canakkale, Turkey - emek1@turk.net

Abstract

In this study, community structure of the juvenile fish was qualitatively and quantitatively investigated at 12 stations in the Erdek Bay, between March and May 2000. Abundance and number of the individuals were determined; diversity, richness, evenness, and dominance indices were calculated. A total of 3661 juvenile individuals representing 41 species were collected. *Atherina hepsetus, Liza aurata* are the most presence species. The community was dominated numerically by a few species: *Atherina hepsetus* (28.3% of total number), *Liza aurata* (27.5%) and *Symphodus (Crenilabrus) ocellatus* (15.6%).

Key words: juvenile fish, abundance, diversity, Marmara Sea

Introduction

Marine coastal habitats have high species richness due to diversities in topography. They are important because of the influence they have on broader aspects of marine ecosystems (1, 2). The nutritional elements of coastal area are richer than open water. Particularly juvenile fishes live in those areas where there are rich nutrimental material and safe surrounding. The southern Marmara Sea has important bays having shallow waters and these areas are utilised as nursery area by juvenile fishes (3). The present study is aimed to provide information about species composition of the juvenile fish in Erdek Bay.

Material and methods

Erdek Bay is located in South of Marmara Sea (27°20'- 27°52' E Longitude and 40°18'- 40°28' N Latitude), and the length of the coastline is 130 km, and maximum depth is 55 m. The bottom in the sampling stations are characteristically covered by meadows (*Zostera marina*, *Cymodocea nodosa*), macroalgae (*Cystoseria* sp., *Lomentaria* sp., *Ceramium* sp., *Ulva* sp.), and sandy. Samples were collected at 12 stations using a 35 m long beach seine. Net depth at the beginning of wings was 40 cm and 250 cm at the central part together with the sac. The mesh size was 6 mm at the outer wing and 4 mm at the central sac. The hauls were carried out along the shore (50 m), and from offshore to the inner along the 50 m. Sampling stations depth ranged from 1 to 10 m. Both of samplings were pooled estimated for everyone stations. Community structure was specified by Shannon-Weaver diversity (H'), Pielou evenness (J'), Margalef species richness (D), and Simpson dominance (C) indices using formula proposed by (4, 5, 6).

Results

A total of 3661 individuals belonging to 41 juvenile fish species were collected and identified from the nearshore water in Erdek Bay. These species showed their monthly percentage of abundance in Table 1. The first three species were listed in respect to abundance as *Atherina hepsetus* (28.3%), *Liza aurata* (27.5%) and *Symphodus (Cr.) ocellatus* (15.6%) respectively. The highest collection was in May with 39 species, 1880 individuals. The lowest collection was in March with 22 species, 791 individuals. 30 species, 990 individuals were caught in April. Shannon-Weaver diversity indecies(H') were 1.93 in March, 2.58 in May and 2.98 in April. Pielou evenness index (J') were 0.43 in March, 0.48 in May and 0.60 in April. Margalef species richness (D) were 2.18 in March, 3.02 in April and 3.59 in May. Simpson dominance index (C) were 0.23 in April, 0.34 in May and 0.44 in March.

Table 1. Abundance of juvenile fish individuals in spring in Erdek Bay.

Species	March	April	May	Total	Ind.(%)
A. hepsetus	-	3	1032	1035	28,3
L. aurata	505	407	93	1005	27,5
S.(Cr) ocellatus	58	194	318	570	15,6
A. boyeri	128	67	54	249	6,8
S. sprattus	7	59	68	134	3,66
S. pilchardus	3	64	49	116	3,17
L. saliens	12	75	9	96	2,62
S. thphle	12	16	30	58	1,58
N. ophidion	27	7	15	49	1,34
S. abaster	9	15	23	47	1,28
G. bucchichi	7	7	32	46	1,26
P. marmoratus	-	3	42	45	1,23
D. Sargus	6	3	17	26	0,71
G. curientatuus	1	4	17	22	0,6
D. puntazzo	4	15	3	22	0,6
Others	12	51	78	141	3,85
Total	791	990	1880	3661	100

Discussion

In terms of families, the most dominants were *Atherinidae*and *Labridae* followed by *Mugilidae*. Guidetti & Bussotti (7) indicated that the Atherinids were the most dominant group in the western Mediterranean coastal zone. It was indicated by Francour (8) that *S(Cr.) ocellatus* was the abundant species in the seagrass beds of the Mediterranean Sea, and Costello (9) found out that the Labrids were present as abundant species in the algae regions and in 0-5 m depths in the northern European coastal zone. Total of 41 fish species included 8 pelagic and 33 demersal fish species.This result indicated that mostly demersal fish species inhabited in the Erdek Bay. Average H' value was above critical point. Margalef species richness (D) increased from March to May. This situation might be related with new juvenile fish species that appeared in spring associated with temperature, and they lived there until they join the main stock. According to the Shannon-Weaver diversity index, Pielou evenness index (J'), and Simpson dominance index (C), the juvenile fish community is most stable from point of numbers of species and individuals in April.

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References

1 - Biagi, F., Gambaccini S., and Zazzetta, M., 1998. Settlement and recruitment in fishes: The role of coastal areas. *Ital. J. Zool.*, 65, Suppl.: 269- 274.

2 - Mazzoldi, C. and De Girolamo, M., 1998. Littoral fish community of the Island Lampedusa (Italy): A visual census approach. *Ital. J. Zool.*, 65, Suppl.: 275-280.

3 - Arım, N., 1957-59. Marmara ve Karadeniz'de bazı kemikli baliklarin (teleost'ların) yumurta ve larvalarının morfolojisi ile ekolojisi. *Hidrobiyoloji Mecmuası*, A 4-5: 7-57.

4 - Margalef, R., 1978. Diversity, Phytoplankton Manual, Monographs on Oceanic Methodology. Unesco. Pp. 251-260.

5 - Pielou, E.C., 1975. Ecological Diversity. A Wiley-Interscience Publication, 4: 5-19.

6 - Odum, E.P., 1971. Fundamentals of Ecology. 4'rd edition, ISBN: 0-7219-6941-7, Saunder Colloge Publishing. Philadelphia.

7 - Guidetti, P. and Bussotti, S., 2000. Fish fauna of a mixed meadow composed by the seagrass *Cymodocea nodosa* and *Zostera noltii* in the Western Mediterranean. *Oceanologica Acta,* 40(7): 759-770.

8 - Francour, P., 1997. Fish assemblages of *Posidonia oceanica* beds at Port-Cros (France, NW Mediterranean): Assessment of composition and long-term fluctuations by visual census. *P.S.Z.N. I: Marine Ecology*, 18: 157-173.

9 - Costello, M. J., 1991. Review of the biology of wrasse (Labridae: Pisces) in Northern Europe. *Prog. Underwater Sci.*, 16: 29-51.

EARLY JUVENILE DEVELOPEMENT OF THE CUTTLEFISH (*SEPIA OFFICINALIS* L.) AND SQUID (*LOLIGO VULGARIS* L.)

V. Kožul *, P. Tutman, N. Glavić, B. Skaramuca and J. Bolotin

Institute of Oceanography and Fisheries, Laboratory Dubrovnik, Croatia - * kozul@labdu.izor.hr

Abstract

Juvenile cuttlefish hatched in the laboratory were reared for 15 days. Hatching was not simultaneous and was completed after 5 days. The cuttlefish were fed mysids. As with the cuttlefish, juvenile *Loligo* hatched in the laboratory. Newly hatched specimens were fed with *Brachionus plicatilis*.

Keywords: Early development, cuttlefish, squid

Introduction

Cephalopod research, especially cuttlefish *Sepia officinalis* has been carried out for many years (1-3). Due to fast growth rates, high food conversion (4, 5) high market price, and good adaptability to captive conditions, the cuttlefish is a very interesting species for mariculture and for biomedical research (6). In comparison with other cephalopods, cuttlefish eggs are relatively large and hatchlings are similar to adult specimens (1, 3). Another cephalopod that is interesting for mariculture and important for fishery resources is squid, *Loligo vulgaris*. Until recently, some research had been done on reproduction and rearing (7-14).

Materials and methods

Specimens of cuttlefish were captured in the Malostonski Bay, 70 km northwest of Dubrovnik. Cuttlefish for the broodstock (20 ind.) were collected throughout July 2002. The sex ratio was 1:1. Specimens weighed from 95-130 g, and the mantle length was 9-11.1 cm. The adaptation time was very short. During the first 6 hours, specimens separated into couples to different parts of the rearing tanks. Broodstock were cultured in ambiental conditions, with a temperature range of 23.3-27.6 °C, salinity 36.4-38.2 ‰ and dissolved oxygen 6.5-6.7. The broodstock was feed with sardines. Adaptation to this food was fast. After a few days, females started to attach eggs onto a plastic net. Eggs were transferred for incubation in 100 l tanks. Small and damaged eggs were separated. Young cuttlefish were cultured in incubation tanks and measured until the 15th day of life. Hatchlings were feed with live mysid shrimp.

On April 30th, 2002, 22 strands with squid eggs were collected in the Malostonski Bay near Dubrovnik. Strands were placed in 300 l tanks with ambiental conditions. There was a constant flow of 50-70% seawater daily through a 0.5 mm mesh net, temperature ranged from 17.3-20.6 °C, salinity 36.2-37.9‰ and dissolved oxygen 6.7-6.9. The paralarvae were measured until the 8th day of life and were fed with *Brachionus plicatilis* and *Artemia salina.*

The cuttlefish and squid experiments were carried out under artificial photoperiods (12:12 h, 2000 lux). The water was gently aerated from the bottom of the tanks. The tanks were cleaned by siphoning once daily.

Results

The reproductive behavior of cuttlefish was more evident in males. They swam side-by-side near females with intense body colors. When male and female pairs formed, a head-to-head meeting was noted. Four groups of eggs were attached to different parts of the tanks. The average number of attached eggs in a single position was 150-250. Females attached eggs in the same place a few times during 2-3 days. Hatching started after 22 days of incubation and lasted 4 days. After hatching, young cuttlefish were on the bottom of tanks. The average mantle length was 5.44±0.75 mm. After 15 days of rearing, the mean mantle length was 7.11±0.62 mm. In each of the three rearing tanks, there were 300 hatched cuttlefish. The first day after hatching, 2000-3000 mysids were added to each tank and feeding started at once. Cuttlefish selected prey up to 10 cm visual distance. The rest of the uneaten food was rejected.

The incubation period of squid eggs lasted 22 days. After the first day of hatching, 15% of paralarvaes hatched. The largest number of hatched paralarvaes was on the 3rd day (50%). After four days, all the paralarvaes hatched. The mean dorsal mantle length was 2.95±0.33 mm. The mean mantle length was 3.46±0.28 mm eight days after hatching. Paralarvaes chose prey up to 10-15 mm in front of the visible area around the head.

Discussion

Since 40% of the cuttlefish in the broodstock spawned and attached eggs in tanks, it may be concluded that *S. officinalis* adapt easily to captive conditions. In good rearing conditions, it is possible to get two cultures per year, during the summer and winter seasons. Cuttlefish eggs are relatively large. Newly hatched cuttlefish are similar to adult specimens (1). In comparison to squid paralarvae, they are much larger and need larger prey that can be located at greater visual distances. When they don't hunt mysids, juvenile cuttlefish are on the bottom, while squid paralarvae prefer the water column. During the rearing period of 15 and 7 days, neither species showed marked growth, but the first live food was very easily accepted.

S. officinalis and *L. vulgaris* are excellent candidates for aquaculture in Croatia. They are a targeted fishing species of cephalopodes due to good prices. Both species grow fast, reaching adult size and reproducing quickly. They adapt well to different diets and there is little difficulty in switching them from live to dead food.

References

1 - Wales, M.J. 1958. Factors affecting reaction to Mysis by newly hatched Sepia. *Behaviour*, 13: 96-111.

2 - Boletzky, S.v. and R.T.Hanlon. 1983. A review of the laboratory maintenance, rearing and culture of cephalopod molluscs. *Mem. Nat. Mus. Victoria*, 44: 147-187.

3 - Hanlon R.T. and J.B. Messeger. 1988. adaptive coloration in young cuttlefish (*Sepia officinalis* L.) the morphology and development of body patterns and their relation to behaviour. *Philos. Trans. R. Soc.* B320: 437-487.

4 - Forsythe, J.W. and W.F. Van Heukelem. 1987.Growth. In: Cephalopod Life Cicles. Vol 2. Ed. P.R. Boyle, pp. 135-155. Academic press. London.

5 - Lee, P.G.1994. Nutrition of cephalopods: fuelling the system. *Marine and Freshwater Behavior Physiology,* 25: 35-51.

6 - Forsythe, J.W., Hanlon R.T. and R. DeRusha. 1991. Pilot large-scale culture of sepia in biomedical research. Pp. 313-323. In.: The Cuttlefish, E. Boucaud-Camou (ed). Centre de Publication de l'Université de Caen, France.

7 - Hurley, A.C. 1976. Feeding behaveiour, food consumption, growth and respiration of the squid Loligo opalescens raised in the laboratory. *Fish. Bull.,* 74(1): 176-182.

8 - Turk, P.E., Hanlon, R.T., Bradford, L.A. and W.T. Yang. 1986. Aspects of feeding, growth and survival of the European squid *Loligo vulgaris* Lamarck, 1798, reared through the early growth stages. *Vie et Milleu*, 36(1): 9-13.

9 - Young, R.E. and R.F. Herman. 1988. "Larva", "paralarva" and "subadult" in cephalopod terminology. *Malacology*, 29: 201-208.

10 - Rocha F. and A. Guerra. 1996. Sings of an extended and intermittent terminal spawning in the squids *Loligo vulgaris* Lamarck and *Loligo forbesi* Steenstrup (Cephalopoda: Loliginidae). J. *Mar. Biol. Ass. U.K.* 207(1-2): 177-189.

11 - Lopes SS. Coelho ML. and J. P. Andrade. 1997. Analysis of oocyte development and potential fecundity of the squid *Loligo vulgaris* from the waters of southern Portugal. *J. Mar. Biol. Ass. U.K.*, 77(3): 903-906.

12 - Hanlon R.T. 1998.Mating systems and sexual selection in the squid Loligo: How might commercial fishing on spawning squids affect them? *Cal. CoFi. Rep.,* 39: 92-100.

13 - Raya C.P. Balguerias E. Fernandez-Nunez M.M. and G.J. Pierce. 1999. On reproduction and age of the squid *Loligo vulgaris* from the Saharan Bank (north-west African coast). *J. Mar. Biol. Ass. U.K.,* 79(1): 111-120.

14 - Mladineo, I., Valić, D. and M. Jozić. 2003. Spawning and early development of *Loligo vulgaris* Lamarck, 1798, under experimental conditions. *Acta Adriat.*, 44(1): 77-83.

SKELETONEMA COSTATUM (GREV.) CLEVE IN THE NORTHERN ADRIATIC (JUNE 1999 - JULY 2002)

Romina Kraus *, Tamara Djakovac and Tomislav Radic

Centre for Marine Research, Rudjer Boskovic Institute, Rovinj, Croatia - kraus@cim.irb.hr

Abstract

Abundance and apparent frequency of the diatom *Skeletonema costatum* were investigated for three years (June 1999 - July 2002), at seven stations, representing the western (eutrophic) and eastern (oligotrophic) northern Adriatic Sea. The relation of *S. costatum* with transparent exopolymer particles (TEP), a possible precursor of macroaggregation, recurrent in the northern Adriatic Sea, was analysed as well.

Keywords: Skeletonema costatum, Adriatic, nutrients, TEP

Introduction

The microphytoplankton of the northern Adriatic Sea is greatly influenced by the nutrients brought with the Po River (1, 2), which are particularly high in spring (May and June) and recently, even higher in the autumn, mostly in October (3). The abundance and apparent frequency of *Skeletonema costatum*, one of the prominent blooming diatoms in the eutrophic areas of the northern Adriatic Sea, increased markedly in the 80's and 90's (4). High stickiness properties (5) and the association of this diatom with mucus macroaggregates (6) were the reasons to investigate the possible connection of the *S. costatum* with TEP.

Materials and methods

Samples were collected monthly from June 1999 to July 2002 at seven stations along a profile from the Po River Delta, Italy, to Rovinj, Croatia, at six depths (surface, 5, 10, 20, 30 m and bottom). Samples for phytoplankton analysis were preserved with Lugol's solution, buffered with sodium acetate, and counted using a Zeiss inverted microscope, with the Utermöhl settling technique. TEP concentrations were measured by the Alcian blue colorimetric method, using Xanthan Gum as an equivalent (7).

Nutrients analysis was performed with spectrophotometric methods widely used in oceanography. Salinity was measured with a Yeo-Kal MKII high precision salinometer (8).

Results and discussion

During the research period, the abundance of *S. costatum* varied from $3{,}7 \cdot 10^2$ to $2{,}4 \cdot 10^7$ cells L^{-1} (mean $2{,}5 \cdot 10^5$ cells L^{-1}, median $8{,}88 \cdot 10^6$ cells L^{-1}). Generally, the highest values and frequencies of *S. costatum* were measured in the upper layer (0-10m), at the western (eutrophic) and decreased horizontally towards eastern (oligotrophic) region and vertically with depth (Fig. 1.).

Highly significant positive correlations between the diatom and nutrients, and negative with salinity (Table 1), confirm the influence of the Po River on the dynamics of the *S. costatum*.

Significant positive correlation between the *S. costatum* and TEP, in the upper layer of the western region, was determined during the whole period. Moreover, in about 40% of cases, when the concentrations of TEP were the highest, the dominance and high abundances of *S. costatum* were marked as well. Although it was established that *S. costatum* is not a high producer of exopolysaccharide material (9), which results in the formation of TEP, our data indicates that this diatom should be investigated further in this context.

Table 1. Pearson correlations of log abundances of *S. costatum* cells with temperature, salinity, nutrients and log/c(TEP).

Region	Western					Eastern				
Depth/m	(0m, 5m and 10m)			(20m, 30m and bottom)		(0m, 5m and 10m)			(20m, 30m and bottom)	
Period/ month	X-II	III-V	VI-IX	X-II	III-V	X-II	III-V	VI-IX	X-II	III-V
Temperat.	-0.448 **	0.149	0.376	-0.388	-0.338	0.119	0.227	0.597	-0.124	-0.094
Salinity	-0.415 *	-0.655 **	-0.602 **	-0.028	0.380	-0.356	-0.517	0.023	-0.000	-0.539
Oxygen saturation	0.468 **	0.488 *	0.720 **	0.526	0.107	0.484 *	0.723 **	0.075	0.062	0.453
Phosphate	0.336 *	0.627 **	0.633 **	-0.562 *	0.229	0.415 *	0.678 **	0.697	0.798 *	-0.176
Silica	0.384 *	0.480 *	0.402	-0.537	-0.138	-0.393	-0.380	0.048	-0.112	0.312
Total inorganic N	0.439 **	0.638 **	0.341	-0.272	0.013	-0.036	0.372	0.100	-0.041	-0.123
TEP	0.405 *	0.513 **	0.711 **	0.488	0.101	0.059	0.697 **	0.408	0.435	-0.117

*(p<0,05), **(p<0,01). Correlations for lower layer, in the period VI-IX were impossible to obtain due to scarce appearance of *S. costatum*.

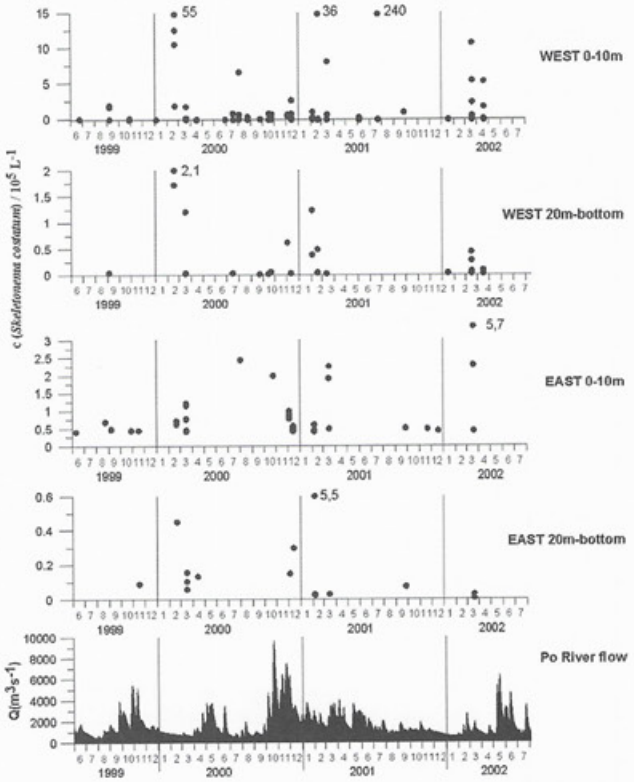

Fig. 1. Abundance of *S. costatum* (c/$10^5 L^{-1}$) during the analysed period (June 1999-July 2002) in the northern Adriatic, with the Po River flow.

References

1 - Revelante N., and Gilmartin M., 1976. The effect of Po river discharge on phytoplankton dynamics in the Northern Adriatic Sea. *Mar. Biol.*, 34: 259-271.

2 - Degobbis D., Precali R., Ivančić I., Smodlaka N., Fuks D., and Kveder S., 2000. Long-term changes in the northern Adriatic ecosystem related to anthropogenic eutrophication. *Int. J. Environment and Pollution.*, 13: 495-533.

3 - Precali R., Djakovac T., Smodlaka N., and Ivancic I., 2001. Long-term changes of nutrient concentrations and phytoplankton biomass in the northern Adriatic Sea. *Rapp. Comm. int. Mer Médit.*, 36: 156.

4 - Revelante N., and Gilmartin M., 1985. Possible phytoplankton species as indicators of eutrophication in the northern Adriatic Sea. *Rapp. Comm. Int. Mer Médit.*, 29: 89-91.

5 - Kiørboe T., Anderson K.P., and Dam H.G., 1990. Coagulation efficiency and aggregate formation in marine phytoplankton. *Marine Biology* 107: 235-245.

6 - Thornton D.C.O., Santillo D., and Thake B., 1999. Prediction of sporadic mucilaginous algal blooms in the northern Adriatic Sea. *Marine Pollution Bull.*, 38: 891-898.

7 - Passow U., and Alldredge A., 1995. A dye-binding assay for the spectrophotometric measurement of transparent exopolymer particles (TEP). *Limnol Oceanogr.*, 40(7): 1326-1335.

8 - Parsons T.R., Maita Y., Lalli C.M., 1985. A manual of chemical and biological methods for seawater analysis. Pergamon Press. Oxford, New York, Toronto, Sydney, Frankfurt.

9 - Kiørboe T., and Hansen J.L.S., 1993. Phytoplankton aggregate formation: observations of patterns and mechanisms of cell sticking and the significance of exopolymeric material. *J. Plankton Res.*, 15: 993-1018.

CYCLE SEXUEL ET PÉRIODES DE PONTE CHEZ DEUX ESPÈCES DE POISSONS EXOTIQUES: *SIGANUS LURIDUS* (FORSSKÅL) ET *S. RIVULATUS* (RÜPPELL) (SIGANIDAE) DANS LES EAUX CÔTIÈRES SYRO-LIBANAISES (BASSIN LEVANTIN)

S. Lakkis [1] *, A. Saad [2], W. Sabour [3] et R. Zeidane [4]

[1] Laboratoire d'Océanographie, Faculté des Sciences, Université Libanaise, Beyrouth, Liban - * slakkis@ul.edu.lb
[2] Faculté d'Agronomie, Université de Techrine, Lattakié, Syria
[3] Département de Biologie, Faculté des Sciences, Université de Techrine, Lattakié, Syria
[4] Laboratoire du Plancton et d' Écologie Marine, CNSM/ CNRSL, Batroun, Liban

Abstract

Siganus rivulatus and *S.luridus*, two exotic lessepsian species have settled dense populations in the Levantine coast. Reproduction, sexual maturity and spawning period of these species were studied in Syro-Lebanese waters.

Key words: Siganidae, Reproduction, Sex-ratio, Spawning period, Levantine Basin

Introduction

Parmi les 27 espèces de *Siganidae* réparties dans les mers chaudes de l'océan mondial, deux espèces d'origine Indo-Pacifique: *Siganus rivulatus* (Ruppell, 1829) et *S. luridus.* (Forsskål, 1775) introduites dans le Bassin levantin par le canal de Suez, forment des populations importantes sur les côtes levantines de la Méditerranée (1, 2, 3). Ces deux espèces exotiques lessepsiennes se sont bien adaptées aux conditions hydrologiques des côtes levantines qui sont assez proches de celles régnant dans la mer Rouge, notamment la température et la salinité élevées. Elles se sont bien développées pour former des populations importantes.

Les *Siganidae* des côtes syro-libanaises ont fait l'objet de quelques études préliminaires (4, 5, 6), alors que l'ichtyoplancton des eaux libanaises, y compris les œufs et larves de Siganidae ont fait l'objet d'études antérieures (7). Dans le but d'aménager la pêche des *Siganidae*, on a trouvé nécessaire d'étudier et d'estimer le stock de ces deux espèces qui forment une fraction importante dans la pêche côtière.

Matériel et méthodes

Les échantillons des poissons adultes ont été pris mensuellement sur des bateaux de pêche, parfois toutes les semaines, dans trois régions de la côte syrienne: Lattakia, Tartous et Banias, en 2000-2001. Parallèlement, des pêches planctoniques de 300-500µ de vide de maille des filets ont été effectuées au large de Tripoli (nord Liban) pour l'étude des œufs et larves des poissons, y compris les Siganidae. Les poissons adultes ont fait l'objet des mesures de la taille, du poids, du calcul du sex ratio (%M/F) et du Rapport Gonado-Somatique (% RGS). Les œufs et les larves de Siganidae ont été triés et examinés au stéréoscope, pour l'identification et le comptage en vue de connaître l'abondance et la période de ponte.

Résultats

Le sex-ratio (% M/F) chez les deux espèces est très proche, avec une petite difference dans le «timing» et la densité des individus pêchés et traités, *S. rivulatus* étant plus abondants. Les variations mensuelles du sex-ratio des deux espèces sont présentées à la Fig. 1.

Le Rapport Gonado-Somatique R.G.S. chez *S. rivulatus* and *S. luridus*, avait le même profil, avec toutefois quelques petites différences temporelles dans la maturité sexuelle; la première étant plus précoce de quelques semaines. Le R.G.S chez les mâles variait entre 0, 9% ± 0.03 en mars et 11.17% ± 3.52 en mai, lorsqu'ils atteignent le maximum de maturité. La fertilité décroît tout de suite après pour descendre au niveau le plus bas en juillet (R.G.S.=1.2%) lorsque les gonades cessent de produire des spermatozoides. Chez les femelles le développement des ovaires commence en février (R.G.S = 0.69% ± 0.22) et atteint le maximum de la maturité en mai (R.G.S = 12.63 ± 6.28). Il décline après pour chuter au niveau le plus faible en juillet (R.G.S. = 0.47 ± 0.14), lorsque les ovaires cessent de produire des ovocytes.

La période de ponte chez *S. rivulatus* et *S. luridus* s'étend entre juin et août, lorsque la température de l'eau est maximale (T = 28-30°C) et la salinité la plus élevée de l'année (S = 39.50-40‰). Un certain décalage temporel est toutefois noté entre les deux espèces, *S. rivulatus* commence à émettre les œufs quelques semaines avant *S. luridus* (Fig. 2). La ponte se fait par plusieurs cohortes successives, comprenant chacune plusieurs centaines d'œufs. Les œufs fertilisés montrent des embryons qui, après écolsion se transforment en larves nageantes dans le plancton, qui après quelques semaines deviennent des poissons juvéniles.

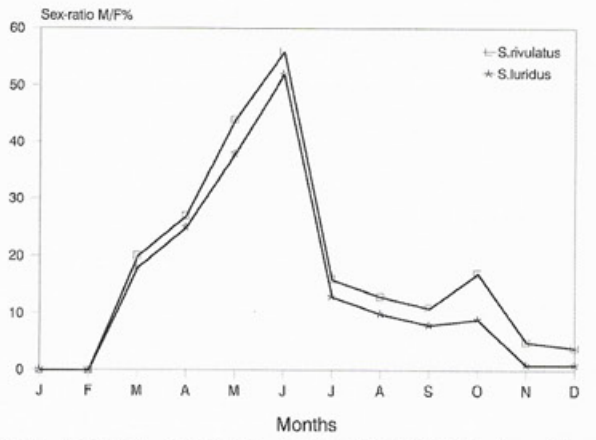

Fig. 1. Variations mensuelles du Sex-ratio (% M/F) chez *Siganus rivulatus* et *S. luridus* durant 2000.

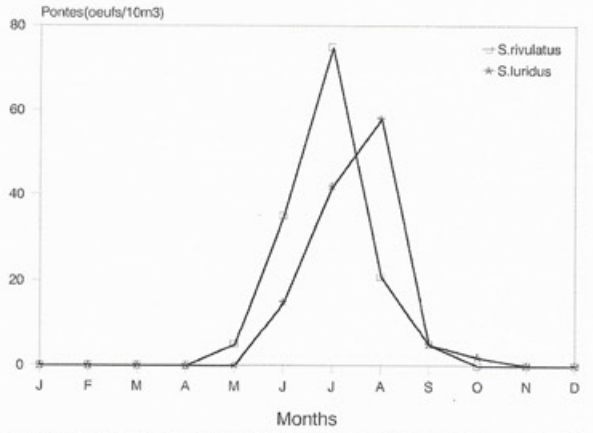

Fig. 2. Abondance des œufs et période de ponte chez *Siganus rivulatus* et *S. luridus* au cours de l'année 2000 sur les côtes syro-libanaises.

Références

1 - Mouneimne N., 1978. Poissons des côtes du Liban (Méditerranée Orientale), biologie et pêche. *Thèse de Doctorat, Université Paris VI,* 490 p.
2 - Golani D., 1993. Trophic adaptation of the Red Sea fishes to the eastern Mediterranean environment-review and new data. *Israel Journal of Zoology*, 39: 391-402.
3 - Ben-Tuvia A., 1964. Two siganid fishes of the Red Sea origin in the eastern Mediterranean. *Bulletin of the Sea Fisheries Research Station*, Haifa, 37:3-9.
4 - Bariche M., 2002. Biologie et Ecologie de deux espèces lessepsiennes (*Siganus rivulatus* et *Siganus luridus*, Teleosteens *Siganidae*) sur les côtes du Liban. Thèse Doctorat, Univ. d'Aix Marseille, 233 p.
5 - Saad A., et Sabour W., 2001. Données préliminaires sur la reproduction de *Siganus rivulatus* (Forskal, 1777, Pisces, Siganidae), dans les eaux côtières de Syrie. *Rapp. Comm. int. Mer Médit.*, 36: 319.
6 - Sabour W., Saad A., et Abou-Kaif N., 2002. Période de reproduction et relations taille-poids Téléostéens des eaux néritiques libanaises chez *Siganus luridus* (Siganidae) dans les eaux côtières syriennes (en arabe, sous-presse).
7 - Lakkis S., et Zeidane R., 1995. Périodes de ponte des principales espèces de Téléostéens des eaux Néritiques Libanaises. *Lebanese Science Bull.*, 8(1): 27-50.

EXOTIC SPECIES AND LESSEPSIAN MIGRATION OF PLANKTON IN LEBANESE WATERS, LEVANTINE BASIN, EASTERN MEDITERRANEAN

Sami Lakkis [1] * and Raymonde Zeidane [2]

[1] Section of Oceanography, Faculty of Sciences, Lebanese University, Beirut, Lebanon
* slakkis@inco.com.lb ; slakkis@ul.edu.lb ; www.ul.edu.lb
[2] Laboratory of Plankton and Marine Ecology, NCMS / LNCSR, Batroun, Lebanon

Abstract

The plankton community in the Levantine Basin is relatively poor in biomass and high in diversity. 35% of the local species are found in the Red Sea, and 65% are present in the western Mediterranean. The majority of the exotic species encountered off Lebanon are Lessepsian migrants of Indo-Pacific and Erythrean origin. However, several species that inhabit either in the Mediterranean and the Red Sea before the opening of the Suez Canal have their geological history back to the Miocene era and Tethys Sea. The Aswan High Dam and deepening of Suez Canal have enhanced hydrological changes in the entire Levantine Sea and induce a continuous migration process. This phenomenon leading to the "Tropicalization" of the Levantine Basin is an index of certain global climate change.

Keywords : Exotic species, Levantine Basin, endemism

Introduction

The Eastern Mediterranean, and in particular the Levantine Basin, are highly oligotrophic water bodies. Furthermore, their temperature and salinity are the highest in the entire Mediterranean. These hydrological characteristics are similar to those of the Red Sea. The opening of the Suez Canal enhance the migration process between the two marine environments, particularly from the Red Sea into the Mediterranean. An estimated 400-500 marine species were introduced into the Levantine Basin (1) and many planktonic species established permanent populations along the Levantine coast (2,3). Some other exotic species may reach the area, not only through the Canal pathway, but through human activity, namely with ballast water. The fauna and flora of the Eastern Mediterranean, belong to the Atlanto-Mediterranean type, with certain tropical and subtropical affinities. Studies of the Levantine plankton before the opening of the Suez Canal in 1869 were scarce and poorly known. Considering this gap of knowledge, it is difficult, even impossible, to ascertain whether species occurring both in the Levant and in the Red Sea may be considered exotic. However, we concur (1,4) that several Mediterranean endemic species inhabited the Tethys Ocean.

In this paper we try to define the exotic species found in the Lebanese waters, from Indo-Pacific origin and from other remote seas.

Methods and Material

Qualitative and quantitative series of samples for both phytoplankton and zooplankton were taken monthly or seasonally, from 1970 up to 2002, at several inshore and offshore stations along the coast of Lebanon between 33°52 N-35°29 N and 34°30 N-35°50 E. Major hydrological profiles were collected simultaneously with vertical and surface plankton net hauls. Taxa were identified to species. Long-time series of plankton and hydrological data were published in previous works (5,6).

Results

Several exotic species of Indo-Pacific and Erythrean origin have been introduced into Levantine Basin through the Suez Canal. Several other species were introduced by ballast water of vessels coming from remote seas. Possibly, up to 50% of these species adapted themselves to the new environment where they established permanent populations. We estimate that 35% of the species recorded in the Lebanese waters are also present in the Red Sea (7, 2) (Table 1).

Table 1. Number of plankton species commonly found in Lebanese waters and Red Sea.

GROUPS	Nb.Species Lebanon	Nb.Species common with Red Sea
Diatomae	175	40
Dinoflagellata	230	70
Tintinnidae	141	40
Radiolaria	25	?
Hydromedusae	74	?
Scyphomedusae	8	3
Siphonophorae	28	18
Pteropoda	8	4
Heteropoda	4	?
Cladocera	6	2
Amphipoda	25	7
Copepoda	175	50
Decapod larvae	109	?
Chaetognatha	10	5
Thaliacea	6	4
Appendicularia	15	8
Ichtyoplankton (eggs & fish larvae)	95	15

Some Indo-Pacific species in the Levantine Basin have been mentioned or recorded in the western Basin ; these exotic species have been probably introduced through the Gibraltar strait rather than the Suez Canal pathway.

The complete list of the exotic species found in Lebanese waters was given in a previous work (3). Some of these introduced species may develop and overcome other species to became an invasive species. This is the case of the scyphomedusa *Rhopilema nomadica*, which appeared in the late 1980s and replaced the previously common *Rhizostoma pulmo*. This stinging species injures swimmers and damages fishingnets. The main exotic species are given in Table 2.

Table 2. Major exotic species found in Lebanese waters during the last decades.

Diatoms	*Chaetoceros coarctatus*
Dinoflagellates	*Ceratium egyptiacum,C.breve, Dinophysis spp., Oxytoxum spp*
Tiuntinnids	*Tintinnopsis, Epiplocylis, Favella spp. Coxliella spp.*
Hydromeduasea	*Bougainvillia platygaster,Nubiella mitra, Paracytaeis octana, Cytaeis vulgaris, Aequorea conica*
Scyphomedusae	*Cassiopea andromeda , Rhopilema nomadica*
Copepods	*Paracalanus crassirostris, Calanopia elliptica, C.media, Pontellidae sp., Labodocera pavo, L.madurae, Centropages furcatus, Acartia fossae, Corycaeus speciosus, Oncaea rufa*
Decapod larvae	*Peneus spp.,Leucifer hanseni, Leptochela sp.Hipolytidae spp., Paguridae sp.,Alphaeidae sp. , Periclimenes, Paguridae sp., Neptunus pelagicus, Leucosiidae sp.*
Ichtyoplankton *(eggs & fish larvae)*	*Siganus rivulatus, S.luridus.,Selar djeddaba, Cynoglossus Cinusarabici, Sargocentrum rubrum,Stephanolepis dispros*

Conclusion

Lessepsian migration is a continuous phenomenon. Most of the exotic species establish permanent populations, some became invasive. Most of them remain confined to the Levantine Basin ; few reach the Aegean Sea, Ionian and Adriatic. Fewer still reach the western Basin. The increasing number of exotic species is due to the hydrological changes taking place in the Levantine Basin, namely, the rise of temperature and salinity, and also due to the global climatic change.

References

1 - Por F.D., 1979. Lessepsian migration. The influx of Red Sea Biota into the Mediterranean by the way of Suez Canal. Ecological studies. Spring Verlag, Berlin, 228 p.

2 - Lakkis, 1980. A comparative study of the plankton in the Red Sea and Lebanese waters. Proc. Symp. Coast. Mar. Env. Red Sea, Gulf of Aden and Tropical West. Indian Ocean (Khartoum). Vol. 2: 541-559. UNESCO-ALECSO.

3 - Lakkis S., Bitar, G., Novel-Lakkis, V. and R. Zeidane, 1996. Etude de la diversité biologique du Liban. Flore et Faune Marines. PNUE et Ministère de l'Agriculture Beyrouth, Liban, Publ. No 6 : 123 p.

4 - Goy J., Lakkis S., et Zeidane R., 1991. Les méduses (Cnidaria) des eaux libanaises. *Ann. Inst. Océanogr.*, Paris, 67, 2: 99-128. "Medusae from Lebanon".

5 - Lakkis S., 1997. Long-Time Series of Hydrological and Plankton Data from Lebanese waters (the Eastern Mediterranean). *NOAA Washington, D.C. Technical Report NESDIS* 87: 185-203.

6 - Lakkis S., 2002. Archiving and Rescue of oceanographic data in Eastern Mediterranean. *MEDAR/MEDATLAS II EC Project, Brussels and IFREMER, France, 4 CD Rom.*

7 - Halim Y., 1969. Plankton of the Red Sea. Oceanogr. *Mar. biol. Ann. Rev.*, 7 : 231-275.

ANTIOXIDANT DEFENCES IN COASTAL AND DEEP-SEA FISH: A COMPARATIVE STUDY

Ramón Lavado *, Luz M. García de la Parra, Estefanía Escartín, Cinta Porte
Environmental Chemistry Dept. IIQAB-CSIC, Barcelona, Spain - * rlpqam@cid.csic.es

Abstract
Rather low levels of oxidative stress are expected in deep-sea organisms due to both, their reduced metabolic rate and the physicochemical conditions of a dark, poorly oxygenated environment However, when antioxidant defences of coastal and deep-sea species collected from the NW Mediterranean were compared, only the activity of glutathione peroxidase was observed to decrease with depth; catalase and superoxide dismutate remained unchanged. Thus, dangers associated to reactive oxygen species (ROS) exposure did not appear to decrease in deep-sea areas, and other factors (presence of swim bladder, diet, pollutant exposure) can significantly enhance the endogenous production of ROS in deep-sea organisms.

Keywords: deep-sea fish, catalase, superoxide dismutase, glutathione peroxidase

Several reports suggest that marine organisms are exposed to high environmental concentrations of potentially deleterious oxygen derivatives, viz. superoxide anion, hydrogen peroxide. These reactive oxygen species (ROS) are abundant in the upper layers of the oceans, but their concentrations decreases with increasing depth. In deeper regions, the exposure to oxidative stress is considerable lower because of reduced light irradiance, lower oxygen levels; and reduced metabolic activity. ROS can oxidize most cellular constituents, such as DNA, proteins, and lipids, and markedly affect the physiology of the cell, leading to the initiation of cancer and cellular death (1). Consequently, organisms have developed defence systems against oxidative damage, consisting of antioxidant scavengers (glutathione, vitamin C, vitamin E, carotenoid pigments), and specific antioxidant enzymes: catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GPX).

This work was designed as a comparative study on the presence of antioxidant enzymes in coastal (30-50 m) and deep-sea fish (1500-1800 m depth) from the NW Mediterranean. Special attention was paid to the distribution of antioxidant enzyme systems in deep-sea fish species, and whether the reduced danger linked to oxygen toxicity could have lead to a reduction of their biochemical defences against oxidative damage. To test this hypothesis we investigated the activity of the antioxidant enzymes (CAT, SOD, GPX) in the liver of 10 fish species selected on the basis of their abundance, commercial interest and habitat. *Mullus barbatus*, *Serranus cabrilla*, *Serranus hepatus*, *Sparus aurata*, *Diplodus annularis*, *Scorpaena porcus*, and *Solea vulgaris* were collected at 30-50 m depth; *Lepidion lepidion*, *Coryphaenoides guentheri* and *Bathypterois mediterraneus* at 1500-1800 m. The number of individuals analyzed varied between 10 and 70, depending on the species. The methods used for the determination of antioxidant enzymes are described in Porte *et al.* (2).

No significant differences (Anova test, Tukey-Karamer multiple comparisons test, $P>0.05$) between coastal and deep-sea species were observed in terms of SOD activity; the highest activity detected in *S. hepatus* (18.4 ± 2.2 units/mg protein), and the lowest in *S. aurata* (5.4 ± 0.6 units/mg protein). Intermediate values were recorded for deep-sea species (8-14 units/mg protein). SOD converts $O_2^{\cdot-}$ into H_2O_2, which can in turn be detoxified into water and oxygen by either CAT or GPX, which utilizes glutathione as an electron donor. There was a significant correlation ($r=0.85$; $P<0.05$) between the activities of SOD and CAT in the studied species. CAT, which detoxifies H_2O_2 into water and oxygen, was determined in liver cytosol (broken peroxisomes) or in peroxisomes + cytosol (total activity), but no relationship with depth was observed. In agreement with other studies (3), the most active species, from both coastal (*S. aurata*) and deep-sea areas (*L. lepidion, C. guentheri*), showed higher CAT activities than the less active ones, with reduced motility (*S. cabrilla*, *S. porcus*, *B. mediterraneus*).

In contrast, the activity of GPX using H_2O_2 as a substrate decreased with depth. In shallow species, GPX ranged from 74 to 110 nmol/min/mg protein, with the exception of *S. hepatus*, that had an activity of 340 nmol/min/mg protein. Lower activities were recorded in deep-sea specimens (22-40 nmol/min/mg protein) (Fig. 1). The reason for this apparent preference for CAT in deep-sea species might be related to the limited resources available in the deep-sea, and to the fact that CAT requires neither cofactors nor energy to detoxify H_2O_2, while GPX consumes glutathione, which is oxidized and must then be recycled by a NADPH-consuming enzyme (glutathione reductase).

Despite of the reduced metabolic requirements of deep-sea fish species, this study shows that the dangers associated to ROS exposure do not decrease with increasing depth. Other factors, such as habitat, diet, exposure to pollutants, and the presence of swim bladder, can significantly increase the endogenous levels of ROS deep-sea organisms are exposed to (3). Hence, *B. mediterraneus*, a sedentary fish, well adapted to the oligotrophic deep environment, exhibited low activities of both catalase and GPX (both detoxify H_2O_2) in comparison with the other species, and this may be related to the absence of a swim bladder. It is reported that with increasing depth and increasing hydrostatic pressure, most species maintain swim bladder volume constant by increasing mainly its oxygen content that may make up to 90% of the gas mixture in deep-sea fish. Thus, the gas gland tissue operates under conditions of hyperoxia, and this enhances oxyradical production (4).

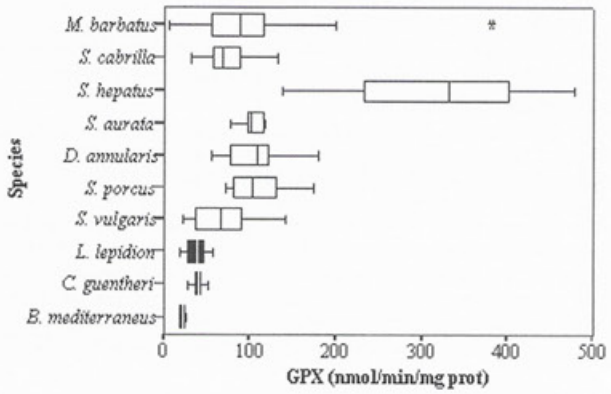

Fig. 1. Box plot of glutathione peroxidase (GPX) activity determined in liver cytosol of different fish species sampled in the NW Mediterranean. Black boxes indicate deep-sea fish species.

References

1 - Cadenas, E., 1995. Mechanisms of oxygen activation and reactive oxygen species detoxification. Pp. 1-61. *In*: Ahmad S. (ed.), Oxidative-Induced Stress and Antioxidant Defences in Biological Systems. Chapman & Hall, NY.

2 - Porte C., Escartín E., García L.M., Solé M., Albaigés J., 2000. Xenobiotic metabolising enzymes and antioxidant defences in deep-sea fish: Relationship with contaminant body burden. *Mar. Ecol. Prog. Ser.*, 192: 259-266.

3 - Wilhelm Filho D., Giulivi C., and Boveris A., 1993. Antioxidant defences in marine fish- I. Teleosts. *Comp. Biochem. Physiol.*, 106C: 409-413.

4 - Jones, D.P., 1985. The role of oxygen concentration in oxidative stress: hypoxic and hyperoxic stress. Pp. 151-195. *In*: Sies H. (ed.), Oxidative Stress. Academic Press, NY.

FIRST RECORD OF *BATHYPOLYPOUS SPONSALIS* (CEPHALOPODA: OCTOPODIDAE) IN THE IONIAN SEA

E. Lefkaditou *, A. Siapatis, A. Chilari, G. Christidis and G. Petrakis

National Centre for Marine Research, Aghios Kosmas, Helliniko, Athens, Greece - * teuthis@ncmr.gr

Abstract

The occurrence of *Bathypolypous sponsalis* (P. Fischer & H. Fischer, 1892) off the western coast of Peloponnesos is reported. Four specimens were collected in September 2003 during experimental trawl fishing at 546-655 m of depth. This is the first record of the species in the Ionian Sea, extending its northern latitudinal distribution in the central Mediterranean.

Key-words : Cephalopods, Ionian Sea

Introduction

Bathypolypous sponsalis is the only species of the subfamily Bathypolypodinae in the Mediterranean Sea, first recorded by Wirtz in 1954 (1). Its origin is considered Lusitanian (2) and further records in the Mediterranean Sea have been reported mainly for the western part (3-11) up to the strait of Sicily (12,13). In the eastern Mediterranean *B. sponsalis* has been reported only from the Aegean Sea (14, 15, 16). The species has not been cited previously either in the Ionian or in the Adriatic Sea.

Materials and methods

The present specimens were collected during a mission carried out in September 2003 in the southeastern Ionian Sea, for a study of trawl selectivity in the framework of the project "Development of an Integrated Management System to support the sustainability of Greek Fisheries resources (IMAS-Fish)". Two professional trawlers equipped with bottom trawl-nets with cod ends of 20 and 40 mm stretched mesh size, were used. Hauls lasting from 60 to 180 minutes were performed at a total of 39 sampling stations and depth ranging from 31 to 650 m. The species was identified following the keys in Mangold and Boletzky (17). The ventral mantle length (VML) and the total weight (TW) of individuals per haul were recorded on board.

Results and discussion

B. sponsalis was caught during three hauls carried out at depths between 546 and 655 m (Fig. 1). Four specimens were collected, two (46 and 55 mm VML, 45 and 35 g TW) by 20 mm and two (42-50 mm VML, 85 g TW) by 40 mm cod end mesh size. This is the first finding of the species in the Ionian Sea although several trawl surveys have been conducted on the slope of the eastern and western Ionian Sea during the last years (18,19). The closest areas where the species has been recorded are the Strait of Sicily and the slope off the eastern coasts of Peloponnesos. *B. sponsalis* is considered a bathy-benthic species of eastern Atlantic affinity, extending from 120 m11 to 1835 m of depth but relatively more common between 400-700 m. The large size of female's oocytes indicate birth of rather large benthic hatchlings and the lack of any pelagic phase in its life-cycle which is limiting factor for the species dispersal. Thus, the present finding could be most probably due to the species migration from the southern Aegean slope around Peloponnesos coastline than to eastward migration from the slope off southern Sicily. Deep-water mass circulation due to the gyre activity in this region (20) could probably favor the suspected migration pattern by creating suitable temperature conditions, which are generally regulating cephalopod species distribution.

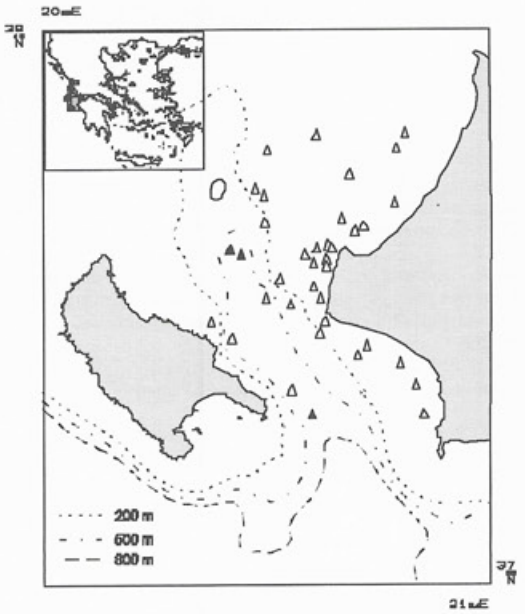

Fig. 1. Map of the southeastern Ionian Sea showing the locations of the hauls performed (white triangles), as well as, of the hauls where *B. ponsalis* was caught.

References

1 - Wirtz K.,1954. *Bathypolypous sponsalis* (P. et H. Fischer), Céphalopode nouveau pour la Méditerranée. *Vie Milieu*, suppl., 3: 139-154.

2 - Bello G., 1996. Biodiversity of Mediterranean benthic cephalopods. *Biol. Mar. Medit.*, 3(1): 88-93.

3 - Mangold-Wirtz K., 1973. Les Céphalopodes récoltés en Méditerranée par le "Jean-Charcot" campagnes Polymede I et II. *Rev. Trav. Inst. Peches marit.*, 37 (3): 391-395.

4 - Mangold-Wirtz K., 1963. Biologie des Céphalopodes benthiques et nectoniques de la Mer Catalane. *Vie Milieu*, Supl. 13 : 285 p.

5 - Sanchez P., 1986. Distribución batimétrica y abundancia de algunos cefalopódos del mar Catalán. *Invest. Pesq.*, 50(2): 237-246.

6 - Villanueva, R., 1992. Deep-sea cephalopods of the north-western Mediterranean: inclination of up-slope ontogenetic migration in two bathybenthic species. *J. Zool. Lond.*, 227: 267-276.

7 - Quetglas A., Carbonell A., Sanchez P., 2000. Demersal Continental Shelf and Upper Slope Cephalopod Assemblages from the Balearic Sea (North-Western Mediterranean). Biological Aspects of Some Deep-Sea Species. *Estuar. Coast. Shelf Sci*,. 50 (6): 739-749.

8 - Rossi L., 1958. Contributo allo studio della fauna di profondità vivente presso la Riviera Ligure di Levante. *Doriana. Ann. Mus. Civ. Storia Nat. Genova*, suppl., 2(92): 1-13.

9 - Tortonese E., 1962. Recenti ricerche sul benthos in ambienti litorali del mar Ligure. *Publ. Staz. Zool. Napoli suppl.*, 32: 99-115.

10 - Lumare F., 1970. Nota sulla distribuzione di alcuni cefalopodi del Mar Tirreno. *Boll. Pesca Piscic. Idrobiol.*, 25 (2): 313-344.

11 - Mannini P., Volpi C., 1989. Nota sulla presenza e distribuzione di alcuni Cefalopodi del Tirreno Settentrionale. *Oebalia*, XV-2: 693-701.

12 - Jereb P., Baino R., Ragonese S., Mannini P., 1989. *Bathypolylous sponsalis* (P. et H. Fischer, 1892). *Nova Thalassia*, 10, suppl. I: 513.

13 - Jereb P., Ragonese S., 1994. The Mediterranean teuthofauna: Towards a biogeographical coverage by regional census. II: Strait of Sicily. *Boll. Malacol.*, 30 (5-9): 161-172.

14 - D'Onghia G., Matarrese A., Tursi A., Maiorano P., 1996. Cephalopods collected by bottom trawling in the North Aegean Sea. *Oebalia*, 22: 33-46.

15 - Salman A., Katagan T., Benli, H.A., 1997. Bottom trawl teuthofauna of the Aegean Sea. *Arch. Fish. Mar. Res.*, 45(2): 183-196.

16 - Lefkaditou E., Peristeraki P., Bekas P., Tserpes G., Politou C.-Y., G. Petrakis, in press. Cephalopods distribution in the southern Aegean Sea. *Mediterranean Marine Science*.

17 - Mangold K., Boletzky S. V.,1987. Céphalopodes. Pp. 633-714. In: Fischer W., Bauchot M.L., Schneider M.(eds), Fiches d' identification des espèces pour les besoins de la pêche. (Revision 1) Méditerranée et mer Noire. Vol. I. FAO, Rome,

18 - Maiorano P., Mastrototaro F. Casamassima F., Panetta P.,1999. Comparative analysis of teurthofauna caught b two different trawl nets. *Biol. Mar. Medit.*, 6(1): 579-583.

19 - Lefkaditou E., Maiorano P., D' Onghia G., Mytilineou Ch., in press. Cephalopod species captured by deep-water exploratory trawling in the north-eastern Ionian Sea. *J. Northw. Atl. Fish. Sci.*

20 - Theocharis A., Georgopoulos D., Lascaratos A., Nittis K., 1993. Water masses and circulation in the central region of the Eastern Mediterranean. *Deep-Sea Res.II*, 40(6): 1121-1142.

PRELIMINARY OBSERVATIONS ON THE RELATIVE AND ABSOLUTE GROWTH OF THE SMOOTH CLAM, *CALLISTA CHIONE* (L, 1758) (BIVALVIA: VENERIDAE) FROM THE THRACIAN SEA, NE MEDITERRANEAN

P.K. Leontarakis [1] * and C.A. Richardson [2]

[1] Fisheries Research Institute, N.AG.RE.F., Nea Peramos, Kavala, Greece - * fri@otenet.gr
[2] School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, LL59 5AB, Anglesey, U.K - c.a.richardson@bangor.ac.uk

Abstract

The relative and absolute growth of the smooth clam, *Callista chione* (L, 1758) from the Thracian Sea was determined at two sites. The relationships amongst several size variables of the flesh and shell showed clearly that growth was allometric. Age determination was carried out from rings on the external shell surface and acetate peel replicas of shell sections. Von Bertalanffy growth parameters were estimated. *C. chione* is a slow-growing bivalve, attaining a size of 70-75 mm and an age of 11 to 16 yr.

Keywords: Callista chione; Bivalvia; Allometric relationships; Age; Growth

Introduction

The smooth clam, *Callista chione* (L, 1758), is a shallow-burrowing filter feeder, inhabiting sandy sediments mainly in Mediterranean Sea, from just offshore to a depth of about 130 m [1]. Despite its economical importance, available information on its biology and ecology is limited. The present work is the first attempt to study various aspects (e.g. relationships between several shell and flesh size variables, age, growth) of its biology in the Thracian Sea.

Materials and methods

During December 2001 to June 2002, smooth clams were collected from two sites off Thassos Island, at depths between 1 and 3 m at a 0.5 m interval, using a metal box quadrat (100X100X10 cm). Shell length, height, width (as defined in [2]; to the nearest 0.1 mm), shell weight, wet flesh weight and dry flesh weight (to the nearest 0.0001 g) were measured in the pooled sample (shell length: 16-72mm). Linear regressions were fitted to the $\log_{10}$-transformed data, while *t*-test [2] was used to identify allometry. Rings on the external shell surface and characteristic microgrowth patters apparent on acetate peel replicas of shell sections [3], were used for age determination. The von Bertalanffy equation [4] was fitted to the size-at-age data.

Results and discussion

The relationships (Table 1) between shell size variables reflect changes in the shell shape with increasing body size. The shell of *C. chione* tends to become proportionally higher, wider and heavier with increasing size, possibly providing better anchorage in the mobile sediment for larger animals. The flesh grew relatively faster than shell length, while the water content was reduced as the clams grew. It is known that bivalve shell growth and shape depend on both environmental (e.g. latitude, depth, currents, type of substrate) and ontogenetic factors (e.g. burrowing behaviour), so differences in morphometric relationships may indicate distinct environmental conditions occurred between the different geographical areas. However, results of the present study, concerning the relationships of shell height and width against length, are surprisingly similar to those reported from southern Portuguese waters [2]. The von Bertalanffy growth curves (Fig. 1), fitted to mean observed size-at-ages, in the two areas indicate a slow-growing species, as is also the case from northern Adriatic [5, 6, 7]. *C. chione* attained a size of 70-75 mm and a lifespan of 11-16 yr in the study area. Records from Plymouth waters [8] indicate slower growth rate (K=0.021 1/yr), possibly due to different environmental conditions prevailing in the two areas.

Table 1. Morphometric relationship parameters for *Callista chione* from Thassos Island, NE Mediterranean (SH=shell height, SL=shell length, SW= shell width, SWt= shell weight, WFWt=wet flesh weight, DFW=dry flesh weight, SE_b= standard error of slope; 60 individuals were measured; all regressions significant at P<0.001).

Morphometric relationship	Equation	r^2	SE_b
SH / SL	LogSH= -0.18+1.03.LogSL	0.96	0.006
SW / SL	LogSW= -0.56+1.12.LogSL	0.95	0.012
SWt / SL	LogSWt= -4.06+3.08.LogSL	0.94	0.033
WFWt / SL	LogWFWt= -4.81+3.30.LogSL	0.86	0.043
DFWt / SL	LogDFWt= -5.94+3.49.LogSL	0.83	0.051
WFWt / DFWt	LogWFWt=0.81+0.93.LogDFWt	0.82	0.016

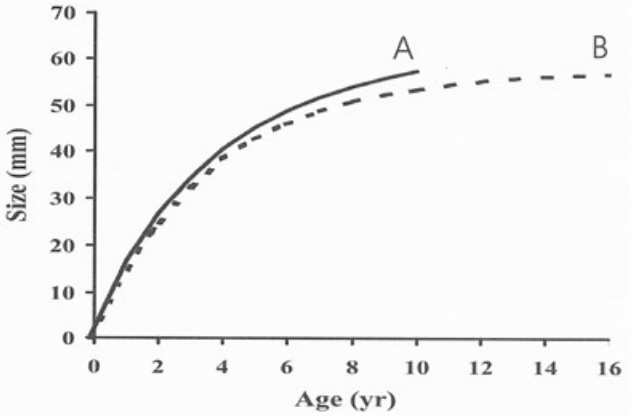

Fig. 1. Von Bertalanffy growth curves for *Callista chione* at two sites off Thassos Island, NE Mediterranean. A: L_t= 62.70 (1-$e^{-0.24\ (t+0.32)}$), SE_{L_∞}= 2.03, SE_K= 0.02; B: L_t = 57.83 (1-$e^{-0.26\ (t+0.15)}$), SE_{L_∞}= 1.47, SE_K= 0.03.

References

1 - Tebble N., 1966. British bivalve seashells: a handbook for identification. Trustees of the British Museum (Natural History), London.
2 - Gaspar M.B., Santos M.N., Vasconcelos P., Monteiro C., 2002. Shell morphometric relationships of the most common bivalve species (Mollusca: Bivalvia) of the Algarve coast (Southern Portugal). *Hydrobiologia,* 477: 73-80.
3 - Richardson C.A., Crisp D. J., Runham N.W., 1979. Tidally deposited growth bands in the shell of the common cockle *Cerastoderma edule* (L.). *Malacologia*, 18: 277-290.
4 - von Bertalanffy L., 1938. A quantitative theory of organic growth (inquiries on growth laws II). *Hum. Biol.,* 10: 181-213.
5 - Hall Jr. C.A., Dollase W.A., Corbató C.E., 1974. Shell growth in *Tivela stultorum* (Mawe, 1823) and *Callista chione* (Linnaeus, 1758) (Bivalvia): annual periodicity, latitudinal differences and diminution with age. *Palaeogeog., Palaeocl, Palaeoec.*, 15: 33-61.
6 - Strada R., Zocco M., 1985. Dati preliminary sull' accrescimento di *Callista chione* in Adriatico settentrionale. *Oebalia,* X(1-3): 829-831.
7 - Keller N., Del Piero D., Longinelli A., 2002. Isotopic composition, growth rates and biological behaviour of *Chamelea gallina* and *Callista chione* from the Gulf of Trieste (Italy). *Mar Biol,* 140: 9-15.
8 - Forster C.R., 1981. The age and growth of *Callista chione*. *J. Mar. Biol. Assoc. UK*, 61: 881-883.

ENQUÊTES HISTORIQUES (1900-1966) SUR LES ÉCHOUAGES DE *ZIPHIUS CAVIROSTRIS* G. CUVIER, EN MER LIGURE

Littardi V., Rosso M., Würtz M. *

Dipartimento di Biologia Sperimentale, Ambientale e Applicata (DIBISAA)
Università di Genova, Genova, Italia - * wurtz-ge@unige.it

Résumé

Ces dernières années, de nombreuses enquêtes ont été réalisées sur la présence et sur les échouages de *Ziphius cavirostris,* en Mer Ligure. La cause des échouages, dans la période 1900-1966, n'a pas été élucidée. Ce présent travail tente de combler cette lacune. Huit nouveaux échouages, avec au minimum 24 spécimens, ont été mis à jour. L'ensemble des échouages indiquent une distribution spatiale homogène ainsi qu'une présence constante tout au long de l'année, en Mer Ligure. Pour cinq de ces échouages, incluant au moins 35 animaux, une corrélation avec la présence de navires militaires a pu être établie.

Mots-clés: cétacés, ziphius, Mer Ligure, échouages

Ces dernières années, de nombreux échouages en masse se sont déroulés dans le monde. La famille des Ziphiidae est particulièrement touchée et plus spécifiquement l'espèce *Z. cavirostris*. De tels phénomènes se sont également déroulés sur la côte ligure, avec entre autres, le fameux cas du 11 mai 1963 (1), considéré comme un des premiers échouages en masse reportés dans la littérature. Cet événement fit comprendre que cette espèce n'était pas qu'un habitant occasionnel de la Mer Ligure. De récentes enquêtes, menées sur la présence et sur les échouages des *Ziphius* en Méditerranée, plus précisément dans le bassin liguro-provençal (2, 3) présentent une synthèse et une révision des données disponibles dans la littérature. La cause des échouages de 1900 à 1960 n'a pas été élucidée. Ce présent travail tente de combler cette lacune.

Pour déterminer les causes probables de ces échouages, tous les articles sur les *Ziphius*, dans des journaux scientifiques ou dans des quotidiens ont été rassemblées. Ceci a permis de mettre à jour une importante documentation photographique jusqu'ici inexploitée. Tous ces articles et ces photos, transférés sur support numérique, sont conservés au laboratoire DIBISAA.

Cette enquête a permis de ré-incrémenter une grande quantité d'informations relatives à la présence de *Z. cavirostris* en Mer Ligure; que ce soit des données chiffrées ou iconographiques concernant des échouages jusqu'alors oubliés. Dans le Tab. 1, huit cas, absents des récentes reviews, ont été retrouvés, ajoutant ainsi au moins 24 organismes à la liste des animaux échoués. Au total, 18 échouages ont eu lieu entre 1900 et 1966, ce qui globaliserait au moins 48 *Ziphius*.

Plusieurs déductions peuvent être établies en fonction des données rassemblées. En premier lieu, les échouages n'interviennent pas pendant seulement une saison; au contraire, des animaux morts peuvent être retrouvés toute l'année. Cette constatation confirme la présence de cette espèce en Mer Ligure pendant les quatre saisons. Deuxièmement, les échouages indiquent une répartition homogène dans le secteur du bassin liguro-provençal, à l'exception de la partie la plus occidentale. En réalité, dans cette zone, l'absence de données concernant la répartition des animaux est surtout liée à la difficulté de rassembler des données historiques éparpillées. En dernier lieu, cette étude met en évidence qu'au moins 5 cas d'échouage (06/01/1963, 13/01/1963, 11/05/1963, 09/11/1963 et 15/11/1966), incluant au moins 35 animaux, peuvent être correlés à la présence de navires militaires américains ou anglais dans la même zone (*Turner*, *Myles*, *C. Fox*, *Saratoga*, *Lowestoft*, *Independence*). En effet, beaucoup d'animaux retrouvés échoués présentaient des blessures par balles (Figs. 1 et 2). Ces derniers mourants étaient suivis par d'autres, apparemment en bonne santé, mais fortement désorientés.

Tab. 1. Liste des échouages de 1900-1966. Les échouages inédits sont indiqués par le symbole *.

Date	Localité	Nombre
24/09/1900	Varazze (Sv)	1
13/11/1925	Albisola (Sv)	1
11/12/1934	Sori (Ge)	1
1930 -1940 *	**Cogoleto(Ge)**	**1**
28/12/1956	Diano Marina (Im)	1
29/12/1956 *	**Imperia**	**1**
09/02/1957	San Giuliano (Ge)	1
1958 *	**Foce (Ge)**	**1**
01/04/1961	Zinola (Sv)	1
03/04/1961	Quinto (Ge)	1
05/01/1963 *	**Chiavari (Sp)**	**1**
13/01/1963 *	**Sestri L. (Sp)**	**1**
11/05/1963	tra Savona e Genova	>15
09/11/1963 *	**Celle e Varazze (Sv), Rapallo e Bogliasco (Ge)**	**>15**
20/04/1964	Genova Prà	1
1964	Genova	1
1964-65 *	**Celle (Sv)**	**1**
15/11/1966 *	**Cogoleto (Ge)**	**3**



Fig. 1. Quelques spécimens de *Z. cavirostris* échoués à Celle en 1963.

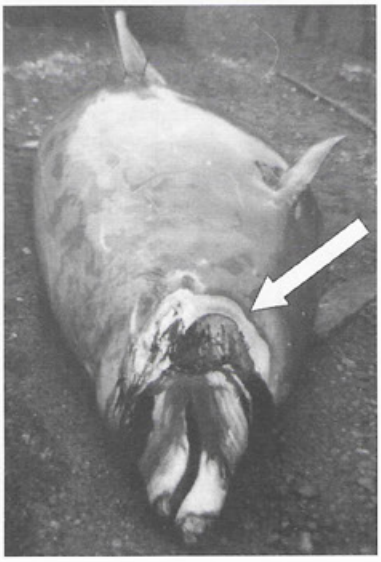

Fig. 2. Spécimen de *Z. cavirostris* échoué à Celle Ligure (Sv) en 1963. La flèche indique une blessure par balle.

Références

1 - Tortonese, E., 1963. Insolita comparsa di Cetacei (*Ziphius cavirostris* G. Cuv.) nel golfo di Genova. *Natura*, 54, 3: 120-122.

2 - Azzellino, A., *et al.*, 2003. Couvier's beaked whale (*Ziphius cavirostris*) habitat use and distribution in the Genoa canyon area (Sirena'02). 17th Conference of the European Cetacean Society, Conference Guide and Abstract, 193 p.

3 - Podestà, M., *et al.*, 2003. A review of *Ziphius cavirostris* strandings in the Mediterranean Sea. 17th Conference of the European Cetacean Society, Conference Guide and Abstract, 209 p.

HABITAT EFFECTS ON TOTAL LIPIDS OF EXPLOITED FISH IN THE NW MEDITERRANEAN

Josep Lloret

EPHE-CNRS, Campus Universitat de Perpinyà, Perpignan, France
(Present address: CMIMA-CSIC, Barcelona, Spain) - lloret@icm.csic.es

Abstract

The lipid content in the muscle of two exploited fish off NW Mediterranean was studied in relation to habitat. Results showed that the lipid content of *Pagellus acarne was* higher in the northern than in the southern parts of the study area. Furthermore, there was a significant ($P<0.05$) effect of depth on lipid content, with fish characterized by the highest lipid levels inhabiting the shallowest parts. The results also revealed differences in the condition of *Diplodus sargus* between protected and unprotected habitats, with condition being highest within the protected ones.

Keywords: Fish condition, Ecophysiology, Habitat, Marine Protected Areas

Introduction

Despite evidence on the importance of fish condition and the function of habitat for marine fish production, condition has seldom been used to assess habitat quality in marine ecosystems, where most research on essential fish habitats deals with differences in abundance and biomass between habitats (1). The condition of a fish is affected by interactions among habitat characteristics and the physiology of the fish and can have major consequences for the health of individual fish and influence survival and population success (2). This study aims to study the habitat effects on fish condition in the NW Mediterranean.

Materials and Methods

Individuals of *Pagellus acarne* were obtained at different depths from two areas of the continental shelf in the NW Mediterranean: the southern Gulf of Lions and the southern Catalan Sea. Samples were derived from EU "MEDITS" groundfish surveys, experimental trawls and from commercial trawl and gill-netters, between June and August 2001.

At a small scale, individuals of *Diplodus sargus* were collected from the rocky protected bottoms of the Natural Park of Cape Creus, and from the adjacent rocky unprotected bottoms, by spear fishing at night at several sites, from 0 to 10 m depth. Determination of total lipid (% dry weight) was carried out in the laboratory from muscle samples. Total lipids were determined spectrophotometrically with the sulphophosphovanillin method (3).

Results

Individuals of *P. acarne* from the Gulf of Lions showed a significant (ANOVA, $p<0.05$) higher percentage of lipid in the muscle (mean=2.38, SE=0.20, n=230) compared to individuals from the Catalan Sea (mean=0.94, SE=0.49, n=38). There is a significant (linear regression, $p<0.05$) effect of depth on the lipid content: the lipid content in the muscle decreased with depth (Fig. 1). Significantly (ANOVA, $p<0.05$) higher lipid levels in muscle of *D. sargus* spawners were detected in the rocky protected areas of Cape Creus (mean=0.75, SE=0.06, n=32) compared to the rocky unprotected areas (mean=0.49, SE=0.06, n=43).

Discussion

The results showed that there are significant spatial and bathymetric differences in the condition of fish species inhabiting the NW Mediterranean. The Gulf of Lions/northern Catalan Sea might provide good food supply for some species as a result of river runoff and wind mixing. The negative relationship between condition and depth suggests that the deeper areas of distribution of a given species represent a marginal habitat in terms of food resources. Results from the present study also indicate a possible reserve effect on the condition of *D. sargus*.

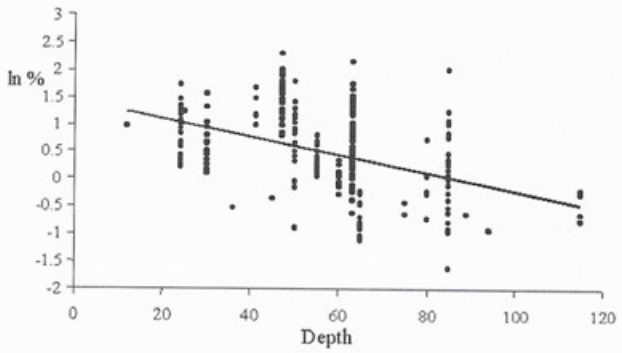

Fig. 1. Relationship between muscle lipid content (ln % lipid dry weight) and depth for individuals of *Pagellus acarne*.

References

1 - Benaka L. R, 1999. Summary of panel discussions and steps toward an agenda for habitat policy and science. Pp. 455-459. *In*: L. R. Benaka (Ed), Essential fish habitat and rehabilitation. American Fisheries Society, Bethesda.

2 - Shulman G. E., Love R. M., 1999. The biochemical ecology of marine fishes. *In*: A. J. Southward, P. A. Tayler, and C. M. Young (Eds.). Advances in marine ecology, vol 36. Academic Press, London.

3 - Barnes H,. Blackstock J., 1973. Estimation of lipids in marine animals and tissues: detailed investigation of the sulphophosphovanillin method for total lipids. *Journal Experimental Marine Biology Ecology,* 12:103-118.

RECYCLING OF PARTICULATE NITROGEN WASTE FROM THE FISH FARMS: EFFICIENCY OF HARD SUBSTRATE DEPLOYMENTS

S. Lojen [1] *, D. Angel [2], T. Katz [2], E. Spanier [3], M. Tsapakis [4], I. Karakassis [4]
N. Kovač [5], A. Malej [5], E.Cook [6], K. Black [6]

[1] J. Stefan Institute, Ljubljana, Slovenia - * sonja.lojen@ijs.si
[2] National Centre for Mariculture, Eilat, Israel
[3] The Leon Recanati Centre for Maritime Studies, University of Haifa, Israel
[4] Institute of Marine Biology of Crete, Heraklion, Greece
[5] Marine Biology Station, National Institute of Biology, Piran, Slovenia
[6] Scottish Association for Marine Science, Dunstaffnage Marine Laboratory, Oban, Argyll, U.K.

Abstract

The methodology for evaluation of hard substrate deployments for removal of particulate nitrogen waste deriving from aquaculture based upon $^{15}N/^{14}N$ ratios of colonising organisms was developed and tested at four fish farms in N Atlantic, N Adriatic, E Mediterranean and in the Red Sea. The hard substrates were proven efficient in oligotrophic environments, while in turbulent mesotrophic environments with multiple nitrogen sources the effect of farm-derived particulate nitrogen on the fouling organisms could not be traced by environmental isotopes.

Key words: fish farm, nitrogen, stable isotopes, suspension feeders

Introduction

Fish farms release large amounts of soluble inorganic and particulate organic matter (POM) into the environment. In order to capture effluents released from the fish farms, removable hard substrates were deployed in the immediate surroundings of the fish cages, so that these would be colonised by filtering organisms.

The aim of the present study was to examine whether the hard substrate deployment can efficiently reduce the environmental impact of particulate waste deriving from aquaculture. The flow of particulate organic nitrogen from fish farms to the local food web was traced using stable nitrogen isotopes. Nitrogen stable isotope compositions of POM and fouling communities colonising hard substrates (hereafter referred to as biofilters) adjacent to the fish farms and at non-polluted reference locations were determined. Based on differences in $^{15}N/^{14}N$ ratios in POM and organisms at both sites, the contribution of cage-derived particulate nitrogen to the organisms' diet and thus the efficiency of filtering organisms in removing the particulate nitrogen waste were estimated.

Experimental

At four fish farms in Oban (Scotland, N Atlantic), Piran (Slovenia, N Adriatic), Crete (Greece, W Mediterranean) and Eilat (Israel, Red Sea), biofiltering units consisting of several floating arrays of hard substrates were installed in June 2001. Each array was a set of plastic net cylinders (50 cm high, 25 cm in diameter) secured on horizontal frames at 8 m depth. The biofilter arrays were oriented perpendicular to the predominant current direction so as to maximise their exposure to effluents released from the cages. The same structures were installed at reference locations.

Samples of particulate organic matter (POM) and fouling organisms colonising the biofilters at the cages and at reference locations were taken seasonally from July 2001 to May 2003. Individual species and entire fouling communities from randomly selected biofilters were analysed. Faecal material was analysed, too. Stable isotope compositions of nitrogen were determined using a continuous-flow isotope ratio mass spectrometer (Europa 20-20 with ANCA-SL preparation module) and expressed as relative deviation in permil from the $^{15}N/^{14}N$ ratio of atmospheric nitrogen ($\delta^{15}N$). Assuming that the isotope separation between food (i.e. POM) and organisms was the same for the same species at the cages and at the reference locations (1), the fraction of organisms' diet deriving from the farm-derived waste was estimated using a simple mixing equation. As end-members, $\delta^{15}N$ values of POM at reference locations and fish faeces as farm-derived particulate waste were considered (2). Remains of food pellets were considered as negligible since the food conversion ratios have been reduced to ~1.

Results and discussion

In most of the cases, a systematic enrichment in ^{15}N was observed in samples collected at the cages compared to those from reference locations (Table 1). In Oban, $d^{15}N$ of POM and fouling organisms were almost the same at both locations due to the dispersion and mixing in the turbulent environment. In Piran, POM was enriched in ^{15}N at the cages compared to the reference location; however, the organisms at reference location were enriched in ^{15}N compared to the biofilters at the cages. The farm-derived POM was obviously not the only factor affecting the $\delta^{15}N$ of the fouling communities at both sites. The influence of cage-derived POM on the $\delta^{15}N$ of fouling organisms in Crete and in Eilat was detected as an enrichment of fouling organisms at the cages in ^{15}N compared to those at reference locations by about 2‰. Lower $\delta^{15}N$ of the fouling organisms compared to the POM in Crete are due to the taxonomic composition of the fouling community, where bryozoans – relying predominantly on phytoplankton as a food source – prevailed. It was estimated that at the same taxonomic composition of fouling communities colonising the biofilters at the cages and at reference locations, about 76% and 65% of nitrogen consumed by fouling communities on biofilters at the farms in Crete and Eilat, respectively, derived from the fish cages. A big discrepancy in efficiency of removing particulate waste between entire communities and individual species was observed. The most efficient in removing particulate waste from fish farms are annelids (33-48% of recycled N derived from the cages), followed by ascideans (27%), sponge (21%) and bivalves (19%). A mass calculation of N consumption was made for the fish farm in Eilat and Crete. Considering the dry masses of fouling communities (116-575 g/m^2 in Eilat, 106 – 370 g/m^2 in Crete) and concentrations of N in organisms (2.2 and 1% dry weight in Eilat and Crete, respectively), 1.6-7.5 g N from fish cages per m^2 of biofilter was retained in Eilat and 0.8-2.8 g/m^2 in Crete.

Table 1. Nitrogen stable isotope compositions ($\delta^{15}N$) of particulate organic nitrogen and organisms at four selected fish farms and reference locations

	CRETE $\delta^{15}N$ [‰]	EILAT $\delta^{15}N$ [‰]	OBAN $\delta^{15}N$ [‰]	PIRAN $\delta^{15}N$ [‰]
Faeces	9.5 ± 1.2*	7.0 ± 0.3*	4.8 ± 0.9**	6.5±0.3**
POM				
Fish farm	8.0 ± 2.3	4.2 ± 1.0	6.1 ± 2.9	6.0 ± 1.3
Reference	6.6 ± 2.2	3.6 ± 0.8	6.2 ± 1.8	4.6 + 2.4
Fouling communities+				
Fish farm	6.3 ± 0.9	5.6 ± 1.8	10.0 ± 2.0	6.3 ± 1.7
Reference	4.4 ± 0.3	3.5 ± 1.4	9.9 ± 1.4	6.8 ± 0.4

*stripped from fish
** sampled in traps directly under the cages
+homogenised samples of entire communities

Acknowledgement. This study was financed by the EU programme "Quality of Life and Management of Living Resources", Contract No. Q5RS-2000-30305.

References

1 - Minagawa M., and Wada E., 1984. Stepwise enrichment of ^{15}N along food chains: Further evidence and the relation between $\delta^{15}N$ and animal age. *Geochim. Cosmochim. Acta*, 48: 1135-1140.

2 - McGhie T.K., Crawford C.M., Mitchell I.M., and O'Brien D., 2000. The degradation of fish-cage waste during fallowing. *Aquaculture*, 187: 351-366.

L'USAGE DE L'ANALYSE DE LA FORME AVEC DES POINTS HOMOLOGUES (LANDMARKS) POUR DETERMINER LE MORPHO-ESPACE DE DEUX COMMUNAUTES LITTORALES

A. Lombarte * et L. Recasens

Institut de Ciències del Mar (CMIMA-CSIC), Barcelona, Catalonia, Spain - * toni@icm.csic.es

Résumé

Nous avons étudié deux communautés littorales de poissons du point de vue de l'analyse de la forme : 26 espèces d'une communauté rocheuse et 28 d'un récif artificiel placés à la même zone et la même profondeur. La distribution des espèces dans les deux milieux est très similaire. Les analyses séparent dans un bout du plan les poissons plats, dans l'autre les espèces épibentoniques et au milieu les espèces nageuses épibentoniques ou pélagiques.

Mots clés: écomorphologie, analyse de la forme, Teléosteéns, communauté littorale

Introduction

La répartition des ressources dans une communauté peut se déterminer à partir de l'analyse des caractéristiques morphologiques (1). Un des problèmes des analyses morphologiques est la quantification de la forme. On a utilisé traditionnellement des mesures linéaires du corps d'identification facile ou de codifications numériques de la forme (1). Ces mesures expriment les differences de taille mais non celles de la forme. L'analyse des points homologues (landmarks) a des avantages puisqu'elle quantifie correctement les différences de forme et permet d'interpréter facilement la variabilité morphologique (2).

Materiel et méthodes

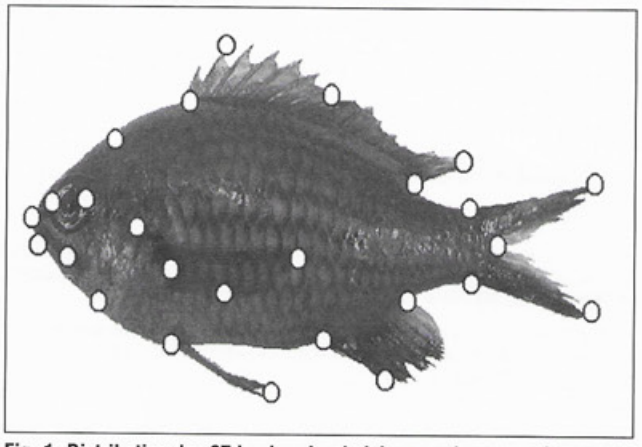

Fig. 1. Distribution des 27 landmarks choisis pour chaque espèce analysée.

On a choisi deux subcommunautés littorales de poissons Teléostéens: l'une appartient à une zone de roches placées autour d'un fond de sable vaseux et l'autre est une zone de récifs artificiels placés entre 18 et 25 m de profondeur. On a analysé 28 espèces pour la subcommunauté du récif artificiel et 26 pour la communauté de roches. On a pris de photographies digitales du coté gauche de tous les spécimens (au moins 3 photographies par espèce). On a calculé l'abondance moyenne (numéro d'individus par pêche) et le poids moyen pour chaque espèce. À partir des images digitales on a calculé 27 landmarks (Fig. 1) et on a obtenu les warps relatives avec les TpsDig v. 1 et TpsRelw 1.24 software (2).

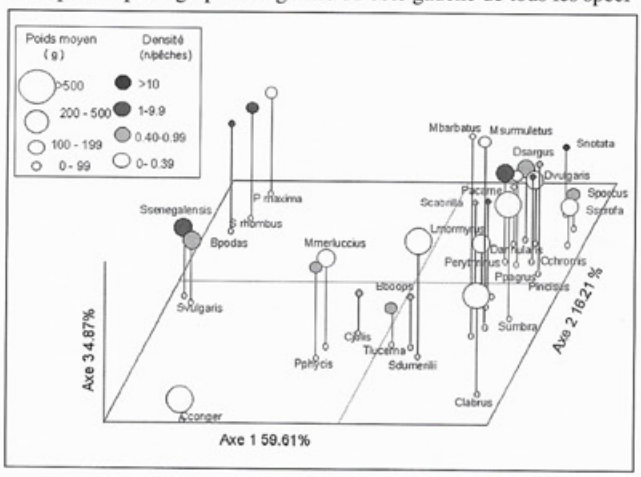

Fig. 2. Représentation des 3 premiers axes de l'analyse des composants principaux à partir des warps des 28 espèces du récif artificiel.

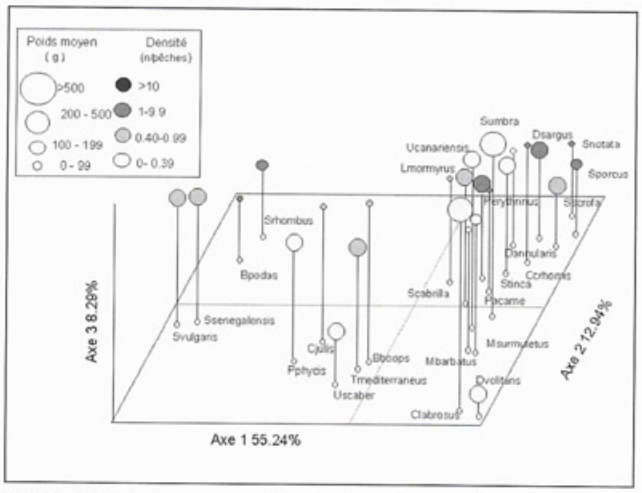

Fig. 3. Analyse des composants principaux à partir des warps des 26 espèces d'une zone de roches.

Résultats et conclusions

Chaque espèce est représentée pour la moyenne des points x, y et z des trois premiers axes, le grandeur du point et la couleur expriment respectivement la taille du poisson (en poids moyen) et l'abondance. L'analyse des composants principals de la subcommunauté du récif artificiel (Fig. 2) accumule 80,69% du total de la variabilité morphologique dans les trois premiers axes et l'analyse de la subcommunauté de roches (Fig. 3) 76,47% de la variabilité. Les résultats sont comparables et montrent une distribution des espèces très similaire. Dans un bout du plan on situe des espèces de poissons plats de sables vaseuses, et à l'autre bout on situe des espèces épibentoniques qui vivent autour des récifs ou des roches. Enfin, dans la zone intermédiare on trouve des espèces nageures épibentoniques ou pélagiques.

L'analyse de warps apparait comme un outil approprié pour décrire et interpréter l'espace morphologique d'une communauté. Il exprime à la fois le phénomène de ségrégation de la forme, la taille et la densité dans une communauté, donc des espèces similaires en forme ont des tailles et/ou abondances différentes en faisant minime la concurrence.

Remerciements. Ce travail a été subventionné par la Direction Générale des Pêches et Affaires Maritimes de la Generalitat de Catalogne.

Bibliographie

1 - Motta, P. J., Clifton, K. B., Hernandez, P., Eggold, B. T., 1995. Ecomorphological correlates in ten species of subtropical seagrass fishes: diet and microhabitat utilization. *Env. Biol. of Fishes,* 44: 37-60.

2 - Rholf, F. J., 2001. TPS Dig 1.31 and TPS relative warps Software, State University of New York at Stony Brook.

APPENDICULARIANS OF THE NORTHERN ADRIATIC SEA

Davor Lučić [1] *, Jakica Njire [1], Robert Precali [2], Dragica Fuks [2] and Jadranka Krstulović [2]

[1] Institute of Oceanography and Fisheries, Laboratory Dubrovnik, Croatia
[2] Center for Marine Research, Rudjer Bošković Institute, Rovinj, Croatia

Abstract

Appendicularians were collected monthly from 1999-2002 at three northern Adriatic stations with different productivity regimes. High abundance, especially of juveniles, was found. Particularly large variations in Chl-*a*, picoplankton, and appendicularians may be responsible for the failure to identify statistically significant correlations among these factors.

Keywords: juvenile/adult appendicularians, northern Adriatic

Intoduction

The ability of appendicularians to retain suspended particles down to the sub-micron range (1) makes them an important step in the microbial food web that links picoplankton with larval fish. The present study focuses on the density and distribution of appendicularians in the northern Adriatic, a productive ecosystem particularly influenced by industrial and municipal discharge of the Po River (2).

Materials and methods

Samples were taken monthly (February 1999-August 2002) at three stations between the Po River delta and Rovinj (Croatia): SJ101, near the delta; SJ105, in the central part; ZI032, near Rovinj. Water was collected with a 5-l Niskin bottle at 0.3, 5, 10, 20, and 30 m (near bottom). Temperature was measured with a reversing thermometer and salinity with a Yeo-Kal MkII salinometer. Epifluorescence microscopy was used to count picoplankton (DAPI-stained bacteria and coccoid cyanobacteria). Chlorophyll *a* (Chl *a*) was analyzed fluorometrically. Juvenile appendicularians were sedimented for 72 h, until the original volume (5 l) was reduced to 3 ml. Adults were collected with vertical tows of a standard WP2 plankton net.

Results and discussion

Temperature (Table 1) fluctuations were typical for a neritic area, with stratification beginning as early as May and a sharp thermocline forming by early summer. Salinity oscillations were more pronounced in spring and fall.

Picoplankton occurred in particularly high numbers during spring and summer at SJ101, and throughout the summer at others stations. The highest Chl-*a* was found in spring and fall, while high abundance of picoplankton was noted in summer and fall. There was a significant horizontal gradient in picoplankton abundance and Chl-*a* concentration (Kendall's coefficient of concordance; $p<0.001$; sequence of abundance = SJ10>SJ105>ZI032). Significantly higher values were noted in the surface layer (0.3 m and 10 m) at SJ101 and SJ105 (Mann-Whitney Test; $p<0.001$).

Juveniles were most numerous in spring (Fig. 1), with a maximum at all stations in June: 24 ind.l^{-1} at SJ101; 20 ind.l^{-1} at SJ105; 12 ind.l^{-1}. Higher juvenile abundances were found in January at SJ101, during fall at SJ105, and in summer at ZI032. No significant difference in abundance was found between surface and bottom layers. Comparison of the mean number of juveniles and adults showed a positive correlation at SJ101 ($n=46$, $r=56$, $p<0.001$).

Table 1. Minimum, maximum, and mean hydrographic and biotic parameters in the northern Adriatic Sea during 1999-2002.

SJ101	Minimum	Maximum	Mean
Temperature (°C)	7.87	29.15	16.11±5.58
Salinity	14.92	38.47	36.89±2.32
Picoplankton (x10^6 l^{-1})	334	5938	1340±819
Chl-*a* (mg m^{-3})	0.1	13.19	1.51±1.82
SJ105	**Minimum**	**Maximum**	**Mean**
Temperature (°C)	7.36	28.22	16.12±5.41
Salinity	31.25	38.54	37.48±1.12
Picoplankton (x10^6 l^{-1})	321	4267	1135±662
Chl-*a* (mg m^{-3})	0.06	12.81	1.07±1.50
ZI032	**Minimum**	**Maximum**	**Mean**
Temperature (°C)	8.85	27.06	17.62±5.41
Salinity	33.87	38.54	37.69±0.83
Picoplankton (x10^6 l^{-1})	241	3315	891±480
Chl-*a* (mg m^{-3})	0.03	3.32	0.45±0.44

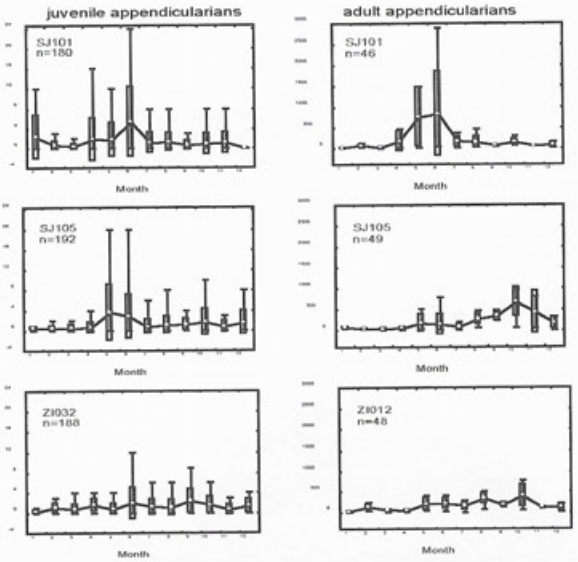

Fig. 1. Box plot of numerical abundance of appendicularians in the northern Adriatic Sea during 1999-2002. *Middle tiny squares* and line indicate means; *boxes*, standard deviations; *whiskers*, min-max values.

A pronounced maximum of adults, 2899 ind.m^{-3}, was noted in June at SJ101. Highest values at other stations were lower and occurred in fall (Fig. 1). The most numerous species at SJ101, *Oikopleura dioica*, made up 50% of total appendicularians. Other stations were dominated by *O. longicauda* (50%). *O. fusiformis* was the third most important species. Regarding other species, peaks were found for *Fritillaria borealis* in October 2000 (452 ind.m^{-3}) and *F.pellucida* in November 2001(632 ind.m^{-3}) at SJ105; and for *F. haplostoma* in October 1999 at ZI032 (307 ind.m^{-3}). *Kowalewskia tenuis* was present sporadically from May to July, and *O. graciloides* in winter at ZI032. Both in terms of quality and quantity, these samples were similar to those found in earlier investigations (3).

No difference in the abundance of juveniles and adults was found between stations. Appendicularian growth and abundance are mostly affected by temperature and food availability (2, 4). Temperature and salinity clearly influenced seasonal succession, especially at those stations distant from the Po. Large variations both in picoplankton and Chl a, as well as complex predator-prey relations along a trophic gradient, might be responsible for the lack of correlations among these factors and appendicularian abundance. Part of the variability also might be owed to mucilage events that occurred during the research period. High picoplankton and Chl-*a* observed during this study suggest appendicularians were not food-limited in the study area.

References

1 - Gorsky G., Chrétiennot-Dinet M.J., Blanchot J., and Palazzoli I., 1999. Picoplankton and nanoplankton aggregation by appendicularians: Fecal pellet contents of *Megalocercus huxleyi* in the equatorial Pacific, *J. Geophysical Res.*, 104: 3381-3390.

2 - Degobbis D., Precali R., Ivancic I., Smodlaka N., Fuks D., and Kveder S., 2000. Long-term changes in the northern Adriatic ecosystem related to anthropogenic eutrophication. *Int. J. Environ. Pollut.*, 13: 495-553.

3 - Skaramuca B., 1983. Quantitative and qualitative distribution of appendicularians population in the open waters of the Adriatic Sea. *Acta Adriat.*, 24: 133-177.

4 - Acuña J.L and Anadón R., 1992. Appendicularian assemblages in a shelf area and their relationship with temperature. *J. Plankton Res.*, 14: 1233-1250.

ACOUSTIC SEABED CLASSIFICATION AND MAPPING OF SEAGRASS *POSIDONIA OCEANICA* (L.) DEL. MEADOW

Vesna Macic [1] *, Claudio Badin [2], Zoran Kljajic [1], Sreten Mandic [1]
[1] Institute of marine biology, Kotor, Serbia and Montenegro, * marikultura@cg.yu
[2] F.A.R.O., Pordenone, Italy

Abstract

The purpose of our work was to using echo-sounders and acoustic seabed classification identify and map *Posidonia* meadows on the south-west part of St. Nicola island (Montenegrian coast). We used the QTC VIEW system to capture the full waveform acoustic data and than using software QTC IMPACT we identified the best features combinations to distinguish groups of echoes representing different seabed (*Posidonia* meadow, send, rock etc.). For each recorded echo we tagged coordinates from GPS so we have necessary information's for positioning of classified seabed.

Keywords: Posidonia, echo-sounders, mapping, Adriatic sea

Introduction

The seagrass *Posidonia oceanica* (L.) Del. is considered to play the most important role in the coastal Mediterranean region. Unfortunatly because of many natural and human-induced events world-wide decline in seagrasses has been reported. The purpose of our work was to identifay and map *P. oceanica* meadows using digital seabed classification on the sout-west part of St. Nicola island (Montenegrian coast) in order to with periodic mapping and monitoring, protect and preserve these important marine resources.

Material and methods

It is well known that the seabed echoes contain much more information than necessary for simply determining depth. The signal, an acoustic reflection which includes backscatter, bottom reverberation and spectral returns has a direct relationship with and is a function of the character of the seabed. So acoustic seabed classification is the organization of the sea floor and direct subsurface into seabed types or classes, based on characteristics of an acoustic response (1). For this purpose we used the QTC VIEW system and than using software QTC IMPACT we indetified groups of echoes representing different seabed types (*P. oceanica* meadow, send, rock, etc.).

The QTC VIEW instrument interfaces directly to conventional echo sounders. The system is connected, in parallel, between the sounder and monitors the transmitted pulse and the seabed acoustic returns in a manner which not interfere with the normal operation of the echo sonder (2). The QTC View than digitizes and pre-processes the echo after which the resultant data are analyzed by multiple algorithms. A 3-D clustering process generates discrete classes representing the acoustic diversity of the data (3). Similar echoes are grouped into classes and user relates the acoustic class to the physical characteristics of the seabed through the calibration process that is diving in this case. For each recorded echo we tagged coordinates from GPS so we have necessary informations for positioning of classified seabed.

After survey and processing with software on display we have clusters containing similar acoustic signatures in Q-space, than a track plot showing locations of the six classes that we determined, a bathymetry plot showing how the classes are distribuited by depth and statistical confidence of the class assignments.

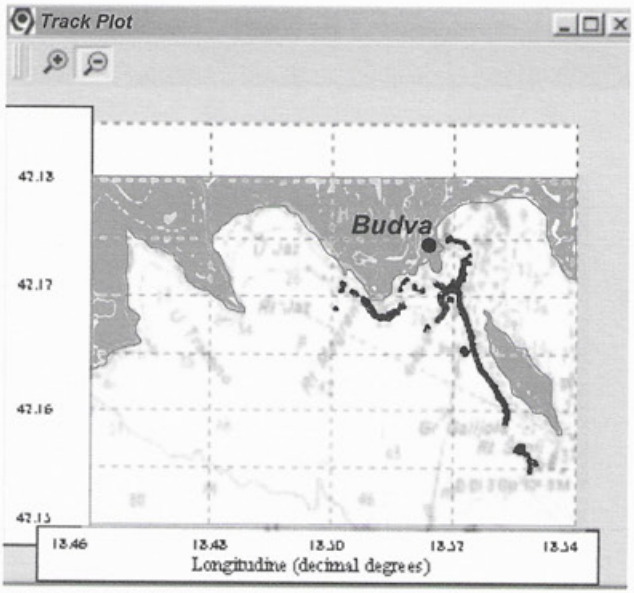

Fig. 1. Track Plot showing only positions of *Posidonia* meadows.

Conclusion

In purpose of mapping *P. oceanica* meadows, with QTC acoustic system we located *P. oceanica* meadows so that divers easely can find positions of interest for furder investigation (Fig. 1). These are first maps of seagrass meadows in this area so they will be of grate inportance for further monitoring.

When compared with traditional seabed geological mapping techniques, acoustic seabed classification QTC is capable of providing accurate, repeatable and nondestructive seabed classification information. Although aerial photographs represent one of the most efficient methods in terms of its cost, rapidity and reliability, the image processing technique have been used only for the surface layer (from 0 to 20m) (4.), so quality of QTC classification technique is that we can use it in the whole area of the Posidonia meadows.

References

1 - Collins, B. and Rhynas, K., 1998. Acoustic seabed classification using echo sounders: Operational considerations and strategies. Proceedings of the Canadian Hydrographyc Conference. Pp. 384-390. Victoria BC, Canada.

2 - Quester Tangent Corporation. 2002. QTC IMPACT User Manual, DMN-MIMP-0001-R03B(2002). Quester Tangent Corporation, Sidney, B.C. Canada.

3 - Collins, W.T., Gregory, R.S., and Anderson, J.T., 1996. A digital approach to seabed classification. *Sea Technology*, Vol.37., No. 8: 83-87.

4 - Pasqualini, V., Pergent-Martini, C., and Pergent, G. 1999. Environmental impact identification along Corsican coast (Mediterranean sea) using image processing. *Aquatic Botany*, 65: 311-320.

EVALUATION OF THE PURPLE DYE MUREX *BOLINUS BRANDARIS* (MOLLUSCA: GASTROPODA) POPULATION AS A NEW FISHERY RESOURCE IN THE GULF OF ROSES (CATALAN COAST, NW MEDITERRANEAN)

Sandra Mallol [1] *, Marta Muñoz [2], Mª Rosa Hernández [2] and Margarida Casadevall [2]

[1] IEO-Centre Oceanogràfic Balears, Palma de Mallorca, Spain - * sandra@ba.ieo.es
[2] Àrea de Zoologia, Universitat de Girona, Campus Montilivi, Girona, Catalonia, Spain

Abstract

Length frequency distribution, sex ratio and catch per hour (CPUE) of *Bolinus brandaris* sampled with a new gear design called the sweep bottom turning gear in the Gulf of Roses (NW Mediterranean) were analysed. A total of 3754 specimens (shell length = 22.66-119.40 mm, sex-ratio = 1:1.1 in favour of females, CPUE = 1.22-30.70 kg h^{-1}) were measured from 36 experimental hauls.

Keywords: Bolinus brandaris, population, fisheries, north-western Mediterranean

Introduction

The purple dye murex, *Bolinus brandaris*, constitutes a resource of local importance in different Mediterranean areas. Off the Catalan coast (NW Mediterranean) this species can only be fished in the two southernmost regions of Barcelona and Tarragona, using a type of dragged gear. During recent years, incidental catches of *B. brandaris* have been increasing in the Gulf of Roses (northern region of Catalan coast) although there is no fishery targeting on this species. The local fisher's association requested permission from the authorities to exploit this resource with a new gear design called the sweep bottom turning gear or "radasses". The aim of this study was to evaluate the local *B. brandaris* population in view of its future exploitation.

Material and methods

Data were collected by onboard sampling during March-April 2001 in the Gulf of Roses. Thirty-six experimental hauls were performed by commercial fishing vessels at a depth range of 9 to 50 m. The gear used was the sweep bottom turning gear that consists of a trammel net of 150 m long and 2 m high in which both the lower and upper lines carry weights. In other words, the net has two lead lines that hold it flat on the bottom. The stretched mesh size was 50 and 240 mm for the inner and outer panels of the net respectively. The net was towed from 1 to 3 hours and the towing speed was between 1 and 2 knots. A representative sample of the catch was taken from each haul. The shell length (SL, mm) and shell width (SW, mm) of every individual were measured, with a precision of 0.1 mm, using an automatic vernier caliper. Also the sex ratio of the sample and the total weight of the catch of each haul were recorded. Available data on total monthly landings of *B. brandaris* from the fishing port of Roses were used to infer the evolution of the abundance during the last years.

Results and discussion

A total of 45896 individuals of *B. brandaris* weighting 754.44 kg were caught. The CPUE (kg per hour) ranged between 1.22 and 30.70 kg h^{-1}. A subsample of 3754 specimens was measured. The size of the specimens ranged from 22.66 to 119.40 mm SL (mean ± S.E. = 70.80 ± 11.80 mm) (Fig. 1) and from 10.01 to 57.46 mm SW (mean ± S.E. = 32.60 ± 5.92 mm) respectively. The SL of females (N = 719) ranged from 28.05 to 105.05 mm (mean ± S.E. = 70.79 ± 11.47 mm) and that of males (N = 647) ranged from 32.55 to 119.40 mm (mean ± S.E. = 70.84 ± 10.62 mm). The sex was determined in 1366 specimens and females comprised 52.64% of the sampled population. The SL range and the mean SL reported here are higher than those reported for the exploited population of Sant Carles de la Ràpita (SL range between 16 and 90 mm, mean SL = 52 mm) (as in 1).

The landings of *B. brandaris* showed a pronounced seasonality. The maximum landings during the year in Roses occurred in late spring and early summer (May, June and July; 1000 kg/month) coinciding with the ripening of the gonads and the spawning aggregations. Due to the seasonal rotation of the artisanal fishery, the lowest landings occurred in autumn coinciding with the resting phase of reproductive cycle (September, October and November; 200-300 kg/month). This contradicts a previous study that reported maximum landings in late autumn and winter and minimum landings in summer (as in 1). Commercial landings (landed catch per vessel, CPUE) exhibited an increasing trend from 1994 to 2002 suggesting that the fishery has not attained the maximum sustainable yield.

Our results showed a well structured length frequency distribution of *B. brandaris* from Roses with specimens that surpassed the 100 mm of shell length, an exceptional length for this species, result of a non-exploited population.

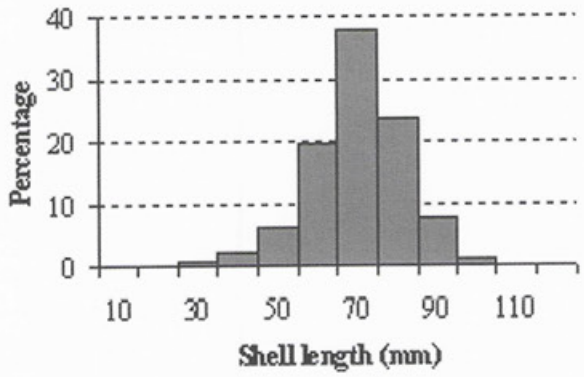

Fig. 1. Shell length frequency distributions of *Bolinus brandaris* from Gulf of Roses.

References

1 - Martín P., Sánchez P., and Ramón M., 1995. Population structure and exploitation of *Bolinus brandaris* (Mollusca: Gasteropoda) off the Catalan coast (north-western Mediterranean). *Fish. Res.*, 23: 319-331.

TOXICITY OF 2-PHENOXYETHANOL AND PROPISCIN AS A NEW ANESTHETIC FOR LARVAL SEA BASS *DICENTRARCHUS LABRAX, L.*

Jasna Maršić-Lučić

Institute of oceanography and fisheries, Split, Croatia - jmarsic@izor.hr

Abstract

Toxicity of two anesthetics, 2- phenoxyethanol and Propiscin, was examined on the larval sea bass (*Dicentrarchus labrax, L.*). Both anesthetics showed low toxicity, Propiscin exhibited much lower LT_{50} than 2-phenoxyethanol. Mortalities after 96 h were induced with Propiscin at lower concentrations than for 2-phenoxyethanol. It can be concluded that 2-phenoxyethanol is a better choice for anesthesia of larval sea bass.

Keywords: larval sea bass, 2-phenoxyethanol, Propiscin, toxicity

Introduction

The studies of anesthetic efficacy have been conducted mostly on juvenile and adult freshwater fish, and little is known about the toxicity concentrations for earlier life stages of fish, especially marine ones (1). The goal of this study was to establish the toxicity concentration of 2-phenoxyethanol and Propiscin when used for anesthesia on larval sea bass, *Dicentrarchus labrax.*

Materials and Methods

Groups of 10 sea bass larvae were randomly put in glass aquarium and the rest of 30 larvae were put in the control tank with aeration and photoperiod of 12 h. Temperature, pH and salinity were measured daily. A short-term bioassay was performed according to (2, 3). The median survival time (LT_{50}) was determined for each concentration of test substance according (2,3). Differencies between mean survival time (LT_{50}) at the same concentrations were tested by ANOVA.

Larvae were exposed to 7 different concentrations (two replicates per concentration) of Propiscin (0.2% stabilized solution of etomidate) on logarithmic scale: 0.032, 0.056, 0.01, 0.18, 0.32, 0.56 and 1.00 ml/l, and to 5 different concentrations (two replicates per concentration) of 2- phenoxyethanol on logarithmic scale: 0.18, 0.24, 0.28, 0.32, 0.56 and 1.00 ml/l.

Results

The average temperature, salinity and pH in vessels with 2-phenoxyethanol was 18.5°C, 36.6 ‰ and 8.12. Fish weighted 0.39 ± 0,10 g. No mortalities were observed in both control tanks. At 0.032 and 0.056 mg/l concentrations no mortality was observed up to 96 h. At 0.1 mg/l, 10% mortality occurred after 48 h, being zero for longer time preiods. At 0.18 mg/l, mortality started after 36 h. At concentrations higher than 0.32 mg/l, the mortality was 100% in the first hour of the experiment. Because of the evident difference between the mortalities related to the 0.18 and 0.32 mg/l concentrations, two additional concentrations were tested, 0.24 and 0.28 mg/l (Fig. 1). The latter lead to 80% mortality in 96 h.

In tanks with Propiscin, the average temperature, salinity and pH were 18.42 °C, 37,08 ‰ and 8.10. Fish weighted 0.33 ± 0.09 g. Propiscin induced mortalities at all concentrations. In first 1 h, mortalities were observed for 1 and 0.56 ml/l. After 12 h, all fish died at 0.32 ml/l (Fig. 2). In all cases, mortality was observed at times < 96 h.

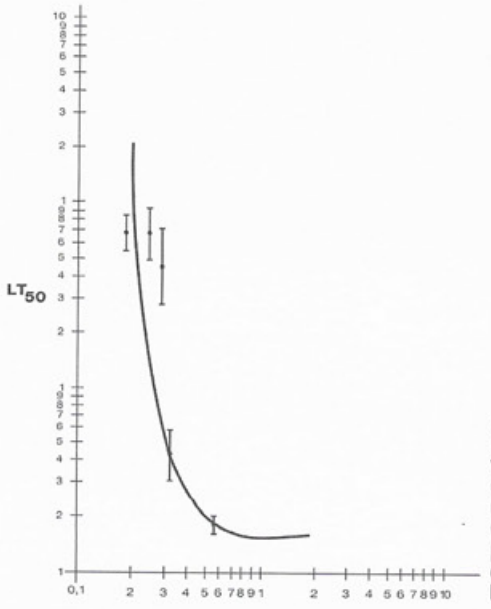

Fig.1. Medial survival time (LT_{50}) at different concentration (ml/l) of 2-phenoxyethanol on larval sea bass.

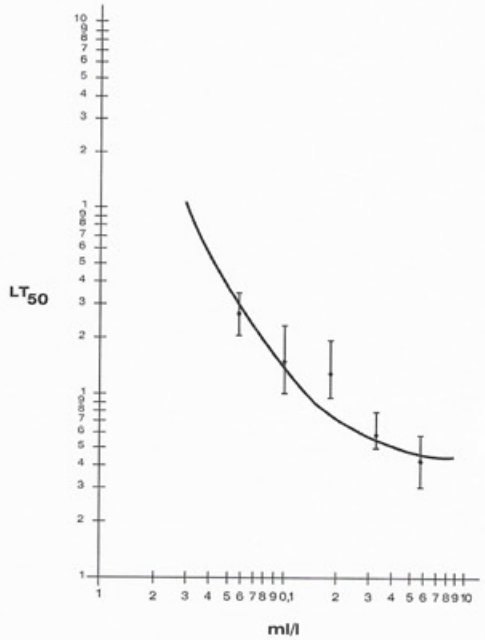

Fig. 2. Medial survival time (LT_{50}) at different concentration (ml/l) of Propiscin on larval sea bass.

Discussion

Propiscin induced mortalities after 96 h at concentrations that were non-toxic when fish were treated with 2-phenoxyethanol. The median survival time at same concentrations of both anesthetics also differed (F=0.775, d.f.1, P=0.389) with Propiscin having much lower LT_{50} than 2-henoxyethanol pointing to its elevated toxicity for larval sea bass.

Evaluated concentrations of etomidate for four different freshwater fish show almost the same concentration range suitable for anesthesia (4). For safe fish anesthesia, 2-phenoxyethanol is mainly used at concentrations of 0.3-0.4 ml/l (5). Our results showed that the concentration most suitable for anesthesia was 0.56 ml/l for Propiscin and the most safe concentration of 2-phenoxyethanol was 0.32 ml/l. The results showed that 2-phenoxyethanol was more suitable as an anesthetic for larval sea bass than Propiscin.

References

1 - Massee K.C., Rust M.B., Hardy R.W., Stickney R.R., 1995. The effeciveness of triciane, quinaldine sulfate and metomidate as anaesthetics for larval fish. *Aquacult.*, 134: 351-359.

2 - UNEP Manual, 1989. Test of the acute lethal toxicity of pollutants to marine fish and invertebrates. Reference methods for marine pollution studies, Monaco. No. 43, 27 p.

3 - Reish D.J., Oshida P.S., 1986. Manual of methods in aquatic environment research, Part 10 – Short-time static bioassays. FAO Fish. Tech. Pap. Rome, FAO., 247, 62 p.

4 - Plumb J.A., Schwedler T.E., Limsuwan C., 1983. Experimental anaesthesia of three species of freshwater fish with etomidae. *Prog. Fish-Cult.*, 45(1): 30-33.

5 - Woynarowich T., Horváth L., 1980. The artificial propagation of warmwater finfish. A manual for extension. *FAO Fish. Tech. Paper.*, 201: 138-147.

INCREASING ABUNDANCE OF THE ROUND SARDINELLA, *SARDINELLA AURITA*, RELATED TO THE WARMING TREND IN THE NW MEDITERRANEAN

P. Martín * and A. Sabatés
ICM-CSIC, Barcelona, Spain - * paloma@icm.csic.es

Abstract
In the last decade a marked increase in the abundance of the warm water pelagic species *Sardinella aurita* has been observed, following the warming of the NW Mediterranean waters. From the distribution of commercial landings along a latitudinal gradient, the possible replacement of *Sardina pilchardus* by *Sardinella aurita* is brought up.

Key words: Sardinella aurita, stock fluctuations, temperature, NW Mediterranean

Introduction

In the NW Mediterranean, an increase in the annual mean sea temperature has been recorded. This increase has been, during the last 25 years, of 0,7 °C at surface, and of 0,4 °C at 80 m depth (1); and, between 1959 and 1989, of 0,12°C at >400 m depth (2). Furthermore, the distribution range of fishes and benthic organisms characteristic of warm waters has expanded (e.g. 3), and their presence is more and more frequent in the northern part of the sea. Conversely, the abundance of boreal species has dramatically decreased since the 1980's (4), suggesting a process of tropicalization of NW Mediterranean. At a large scale, variations in the geographic limits of the distribution are the most immediate effect of the global warming on the icthyofauna, resulting to both local extinctions and invasions by allochthonous species from warmer or tropical environments. This effect is likely to be observed on those populations located at the boundaries of the species geographical distribution. Round sardinella, *Sardinella aurita,* is a thermophilous small pelagic species, having a tropical to subtropical distribution in the Mediterranean and Eastern Atlantic coasts, particularly sensitive to temperature changes (5). *S. aurita* was known to complete its full biological cycle off the Catalan coast at least since the early 1980's (6).

Results

Sardine (*Sardina pilchardus*) and anchovy (*Engraulis encrasicolus*), are the main target species for the purse seine fleet, accounting for the highest catches off the Catalan coast. However, *S.aurita* landings have increased in the last decade, implying that the species is more abundant in the area (Fig. 1). It is worth mentioning that in coincidence with the *S. aurita* abundance increase, a decreasing trend in the landings of *S. pilchardus* and *E. encrasicolus* has been observed, especially for sardine. In the case of anchovy, the most intensively exploited small pelagic species off the Catalan coast, this trend ended by 1999, probably explained by varying fishing pressure.

S. aurita is particularly abundant in the southern Mediterranean, its abundance gradually decreasing northwards. The differences in species abundance are linked to the latitudinal pattern of the sea surface temperature (7). Along a latitudinal gradient in the Spanish Mediterranean coast, the proportion of this species in the 2001 purse seining landings was much higher in the southern ports, where sardine presence was lower, decreasing northwards (Fig. 2). Altogether seems to indicate that a replacement of sardine by round sardinella would be taking place in the NW Mediterranean. At present, there is no evidence for competition between these two species in the study area.

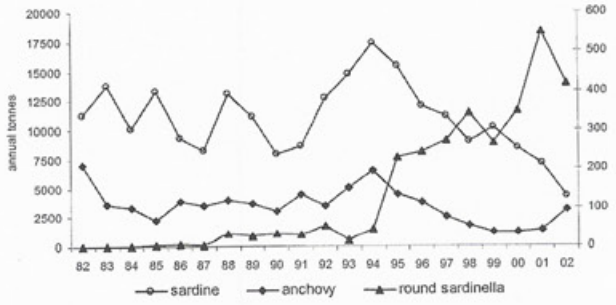

Fig. 1. Annual landings from five fishing ports along the Catalan coast (data from the fishermen's associations and the autonomous government statistics; sardine and anchovy left axis, round sardinella right axis).

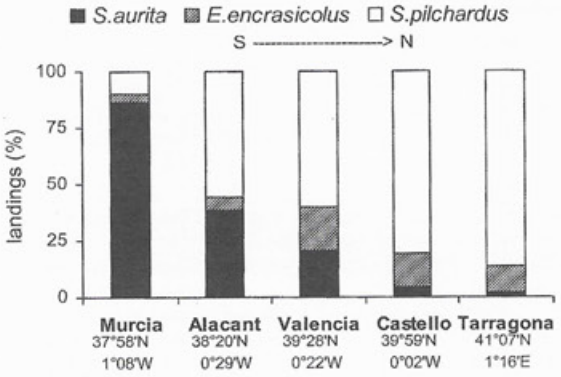

Fig. 2. Small pelagics landings along the Spanish Mediterranean coast (in percentage of the 2001 landings; data from different autonomous government's statistics).

Our results show that *S. aurita* gradually spreads northwards. The observed changes in the geographical distribution and abundance of *S. aurita* in the last years suggest a trend in the long term, consequence of global warming, and would not be only a response to interannual variability.

References

1 - Salat J., and Pascual, J., 2002. The oceanographic and meteorological station at l'Estartit (NW Mediterranean). Tracking longt-erm hidrological change in the Mediterranean Sea. *CIESM Workshop. Series*, 16: 29-32.
2 - Bethoux J.P., Gentili B, Raunet J., and Tailliez D., 1990. Warming trend in the western Mediterranean deep water. *Nature,* 347:660-662.
3 - Francour P., Boudouresque C.F., Harmelin J.G., Harmelin-Vivien M., and Quignard J.P., 1994. Are the Mediterranean waters becoming warmer ? Information from biological indicators. *Mar. Poll. Bull.*, 28: 523-626.
4 - Quignard J.P., Raibaut A., 1993. Ichthyofaune de la côte languedocienne (Golfe du Lion). Modifications faunistiques et démographiques. *Vie et Milieu,* 43:191-195.
5 - Guidetti P., Boero F., and Dulcic J., 2002. Mass mortality of gilt sardine, *Sardinella aurita* (Clupeidae), in the Adriatic and Ionian Seas. *Cybium,* 26: 317-319.
6 - Palomera I., and Sabatés A., 1990. Co-occurrence of *Engraulis encrasicolus* and *Sardinella aurita* eggs and larvae in the Northwestern Mediterranean. *Sci. Mar.,* 54: 63-69.
7 - Climatological Atlas of the Mediterranean Sea. Scientific Report of the MAST-MOBD initiative for ocean data and information management. Contract number MAS2.0093.0075.BE (http://modb.oce.ulg.ac.be/atlas/atlas.html).

YIELDS, BYCATCH AND DISCARDS IN THE *MULLUS SURMULETUS* GILLNET FISHERY OFF SOUTHEASTERN MALLORCA (WESTERN MEDITERRANEAN)

Xavier Mas *, Raquel Goñi and José Luis Fernández

IEO-Centre Oceanogràfic Balears, Palma de Mallorca, Spain - * javier.mas@ba.ieo.es

Summary

This is the first of a series of studies of the artisanal fisheries of the Balearic Islands (Western Mediterranean) that aim to evaluate their efficiency, yields and ecosystem impacts. Here we present results of the striped red mullet (*Mullus surmuletus)* gillnet fishery carried out during 1999-2001 off Southeastern Mallorca Island. The efficiency of the fishery was high with commercialised species making up 99% of the total catch in number. However, the selectivity of the fishery was low and over 40 bycatch species of fishes and molluscs were subject to unaccounted fishing mortality.

Key words: Bycatch, discards, gillnet, fishing impacts, Mullus surmuletus

Introduction

One of the ecological costs of fishing is the incidental catch of organisms which are not target of the fisheries (1,2). Many current fishing methods are highly indiscriminate and result in the catch of non-target species or of undesirable sizes of target species which are then discarded back to the water. Knowledge of bycatch and discard practices in large-scale fisheries has grown in parallel with this awareness (2,3) and in the Western Mediterranean studies have focused on bottom trawl fisheries (4). Artisanal fisheries are generally perceived as low impact, highly efficient fisheries that generate few if any discards. The prevalence of artisanal fisheries in the Western Mediterranean, and in the Balearic Islands in particular, has prompted a series of studies aimed at assessing their efficiency and ecosystem impacts by investigating the relationship of the yield of target and non target organisms as well as the bycatch and discard practices. Here we present the results of the first study conducted on the striped red mullet (*Mullus surmuletus)* gillnet fishery off Southeastern Mallorca Island (Western Mediterranean).

Material and methods

Data were collected on board artisanal vessels participating in the autumn *M. surmuletus* gillnet fishery. The fishery takes place at sunset and at sunrise when gillnets are set over *Posidonia*/sand substrates for periods of 2-3 hours. The stretched mesh size of the netting is 35-40mm and gillnets are 500-1000m long.

Data from 48 valid fishing operations sampled randomly during the 1999-2001 seasons were used in the study. Information was collected on fishing effort (length of net, fishing time) and on the retained and discarded catch. For each species we calculated the yield (expressed as the number of individuals caught in 500m) in the retained and discarded fractions, and their percentage contribution to the catch. To assess the fishery and ecological efficiency of the fishery, for each fishing set the following indices were calculated: a) target species index= number of retained *M. surmuletus*/total number of specimens caught; b) fishery index= number of specimens retained/total number of specimens caught; c) bycatch index= number of bycatch specimens/number of *M. surmuletus* caught; and d) discard index= number of discarded specimens/number of *M. surmuletus* caught.

Results and discussion

Forty-two species were caught (39 fishes and 3 molluscs), 40 of which were retained in at least one occasion (commercial bycatch). *M. surmuletus* made up 47.7% of the catch in number and the mean yield was 38.0 (±5.2 SE). The commercial bycatch made up 50.9% of the catch in number and the mean yield was 44.6 (±7.9 SE). The main bycatch species were the fishes *Diplodus annularis*, *Spicara maena*, *Diplodus vulgaris*, and *Serranus scriba*, all of commercial value.

Twelve species were discarded at least in one occasion, and the discarded fraction was 1.4% in number. *M. surmuletus* were discarded in 19% of the fishing sets and made up the largest fraction of the discards (42.8% in number). Reasons for discarding were: damages caused by bites of dolphins or other organisms (e.g. *M. surmuletus, Pagrus pagrus, Symphodus tinca, Scorpaena notata*), low or nil market value (e.g. *Synodus saurus, Sarpa salpa, Chromis chromis)* and size below the legal limit (*Epinephelus costae* and *Scorpaena scrofa*).

The target species index was 0.46 (± 0.03 SE), indicating a relatively high efficiency of the fishery for *M. surmuletus* when compared with other artisanal fisheries, such as cuttlefish trammel net fishery off Greece where cuttlefish made up 31% of the catch (5). The fishery index was 0.99 (± 0.003 SE) and shows that overall the fishery is highly efficient and produces low waste. The estimated bycatch (2.3±0.5 SE) and discard (0.03±0.01 SE) indices illustrate that on average for every *M. surmuletus* caught 2.3 non-target organisms must be fished of which 0.03 are discarded. Both in absolute terms and when compared with discard rates of 25% in bottom-trawl fisheries in the Western Mediterranean (4), or of 15-25% in gillnet and longline fisheries in the Northeast Atlantic (6), these values appear very low.

The good outlook of this fishery in terms of its low discard rates should not hide the fact that its species selectivity is low as the fishery impacts 41 bycatch species of fishes and molluscs. These species are subject to unknown and unaccounted levels of fishing mortality while little to nothing is known about the status of their populations. Further assessments of the efficiency and ecological impacts of artisanal fisheries will consider the resilience of the bycatch species and strive to incorporate the impacts on taxonomic groups that have no market value and are generally not considered in these studies.

References

1 - Hall, S.J. 1999. The effects of fishing on marine ecosystems and communities. Fish Biology and Aquatic Resources Series I. Blackwell Science. 274 p.

2 - Goñi, R. 1998. Ecosystem effects of marine fisheries: An overview. *Ocean & Coastal Management*, Vol. 40: 37-64.

3 - Alverson, D.L., Freeberg, M.H., Murawski, S.A., Pope, J.G. 1994. A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper 339. 235 p. Roma.

4 - Carbonell, A., Martin, P., de Ranieri, S. and WEDIS team. 1998. Discards of the Western Mediterranean trawl fleets. *Rapp. Comm. Int. Mer Médit.*, 35: 392-393.

5 - Petrakis, G. and Politou, C. Y. 2001. Cuttlefish trammel net "metier" in Greece. *Rapp. Comm. Int. Mer Médit.*, 36: 309.

6 - Pérez, P., Pereda, P., Uriarte, A., Trujillo, V., Olaso, Y., Lens, S. 1995. Discards of the Spanish fleet in ICES Divisions. Study contract EU-DG XIV. Ref. No. PEM/93/005.

OCCURRENCE OF *TREMOCTOPUS VIOLACEUS* DELLE CHIAJE, 1830 (CEPHALOPODA–TREMOCTOPODIDAE) IN THE STRAIT OF SICILY (MEDITERRANEAN)

D. Massi *, G.B. Giusto and C. Badalucco

MaLiRA-Group - Istituto di Ricerche sulle Risorse Marine e l'Ambiente, sez. di IAMC-CNR, Mazara del Vallo, Italy - * giusto@irma.pa.cnr.it

Abstract

The occurrence of blanket octopus *Tremoctopus violaceus* Delle Chiaje, 1830 is reported for the first time in the Strait of Sicily. The specimen was collected by trawling on January 2003, about 50 nm southward Lampedusa Island on 265 m depth bottoms. The individual was a maturing female of 133 mm dorsal mantle length and 342 g total weight. Ovary appeared whitish, weighed 4.30 g, with up to six clusters of oocytes whose size ranged between 0.1 and 2.4 mm.

Keywords: Tremoctopus violaceus, fecundity, Strait of Sicily

Introduction

Tremoctopus violaceus Delle Chiaje, 1830 is an epipelagic octopus distributed in Atlantic Ocean, Caribbean and Mediterranean seas [1,2,3]. Although the species was considered as "rare", its presence is well documented along the Italian coasts. In the last decades, stranded individuals were reported in the Strait of Messina [4]. A particularly abundant catch was reported by purse-seine in the Northern Tyrrhenian Sea, along the coast of Piombino (Leghorn) [5]. The same authors reported the occurrence of other individuals in the waters around the Tuscan island of Giglio and Sardinian coast, off Olbia. The species presence in Italian waters is indirectly documented from a study of swordfish stomach contents caught in the Southern Adriatic Sea [6]. Recently, a live, mature female, brooding egg masses at the base of the first arms, was photographed in the superficial water off the island of Ponza (Central Tyrrhenian Sea) [7]. The species has not been previously reported from the Strait of Sicily [8], though an interesting study about reproductive aspects of *T. violaceus* was recently conducted in Aegean Sea [9].

Material and methods

The specimen was collected by the trawler M/P *Salvatore Caterina* of Mazara del Vallo fleet, trawling a deep water pink shrimp fishing ground (265 m depth), at about 34°45'00 N and 12°57'00 E. The specimen was preserved in formol 4% and the main morphological features were measured [10]. The sex was determined, the reproductive system removed, and the ovary weighed (0.01 g) to estimate the potential fecundity (the oocyte number in the ovary). In particular, three oocyte samples of 0.050 g were taken from three different parts of the gonad (upper, central and lower) in order to have a better representation of the whole ovary. Then, in each ovarial sample, all the oocytes were measured by stereo-microscope under 16x magnification (longest diameter, μ) and counted to provide the oocyte size distribution.

Results

The external morphology and the colour pattern of this individual agree with the description of literature [2] and the main morphological data are reported in Table 1. The individual, weighting 342 g, was a maturing female without ripe eggs in the oviduct. The ovary weighted 4.30 g, representing the1.3% of the body weight. The estimated number of oocytes was 125,500 with a predominant group of tiny oocytes (No = 66,500, 53% of the total oocyte stock) ranging between 0.1 and 0.6 mm (modal size: 0.4 mm). Five consecutive clusters of maturing oocytes were present. Their numbers were estimated as 23,150 (modal size: 0.7 mm), 12,150 (1.0 mm), 14,000 (1.3 mm) 6,500 (1.6 mm) and 3,200 (1.9 mm) (Fig. 1).

Discussion

The estimated potential fecundity of the specimen collected falls within the range of values reported in literature [9] (100,000-300,000 eggs depending on female size). The longest egg size resulted very close to that found in the eastern Mediterranean [9] (2.4 mm in the Strait of Sicily, 2.2 mm in Aegean sea) and larger than those reported for the western basin [11] (up to 1.5 mm).

Previous reports documented maturing specimens in May-August, but the present female was caught in January. Furthermore, the presence of several batches of maturing oocytes agreed with the reproductive pattern of the species, classified as "intermittent and terminal spawning" [12].

Table 1. Main morphological features of the female of *Tremoctopus violaceus* caught in the Strait of Sicily (lengths in mm).

Dorsal mantle length	133	Arm length III	98
Mantel width	88	Arm length IV	135
Head length	40	Funnel length	20
Head width	70	Funnel width	23
Eye diameter	12	Gill length	33
Arm length I	155	Gill lamellae number	13
Arm length II	250		

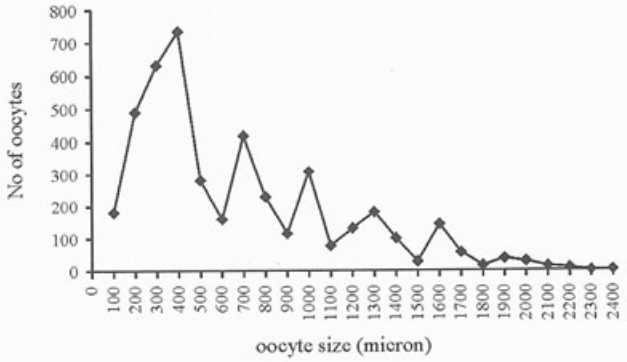

Fig. 1. *Tremoctopus violaceus*- Oocytes size distribution.

Acknowledgements. Many thanks to the captain of trawler *Salvatore Caterina*, Ingargiola Francesco, who kindly gave us the specimen and the site data.

References

1 - Thomas R.F., 1977. Systematics, distribution and biology of Cephalopods of the genus *Tremoctopus* (Octopoda: Tremoctopodidae). *Bull. Mar. Sci.*, 27 (3): 353-392.

2 - Nesis K., 1987. Cephalopods of the world. Neptune City, TFH Publications, 351 p.

3 - Mangold K.M., Vecchione M., and Young R., 1996. Tremoctopodidae. *In*: Tree of Life. Web Project. www.tolweb.org/tree.

4 - Berdar A., and Cavallaro G., 1975. Ulteriore contributo alla conoscenza dei Cefalopodi spiaggiati lungo la costa siciliana dello Stretto di Messina. *Mem. Biol. Mar. Oceanogr.*, 5 (5): 121-138.

5 - Biagi V., and Bertozzi A., 1992. Presenza stagionale di *Tremoctopus violaceus* Delle Chiaje, 1830 (Cephalopoda-Octopoda) nel mare di Piombino (Li). *Boll. Malacol.*, 28 (1-4): 47-54.

6 - Bello G.B., 1993. *Tremoctopus violaceus* (Cephalopoda: Tremoctopodidae) in the stomach content of a swordfish from the Adriatic Sea. *Boll. Malacol.*, 29 (1-4): 45-48.

7 - Belluscio A., Ardizzone G.D., Conticelli M., and Pellicciari C., 2003. Prima documentazione fotografica di *Tremoctopus violaceus* (Octopoda, Tremoctopodidae) nel Mediterraneo. Presented at XXXIV Congresso S.I.B.M., Sousse 1-7 giugno 2003.

8 - Jereb P., and Ragonese S., 1994. The Mediterranean Teuthofauna: towards a biogeographical coverage by regional census. II: Strait of Sicily. *Boll. Malacol.*, 30 (5-9): 161-172.

9 - Laptikhovsky V., and Salman A., 2003. On reproductive strategies of the epipelagic octopods of the superfamily Argonautidea (Cephalopoda: Octopoda). *Marine Biology*, 142: 321-326.

10 - Roper C.F.E., and Voss G.L., 1963. Guidelines for taxonomic descriptions of cephalopod species. *Mem. Nat. Mus. Victoria*, 44: 49-63.

11 - Naef A., 1928. Die Cephalopoden, Embryologie. *Fauna Flora Golf Neapel*, 35: 357 p.

12 - Rocha F., Guerra A., and Gonzales A.F., 2001. A review of reproductive strategies in Cephalopods. *Biol. Rev.*, 76: 291-304.

POPULATION STRUCTURE OF ANNULAR SEA BREAM, *DIPLODUS ANNULARIS* L., IN THE EASTERN ADRIATIC SEA

S. Matic-Skoko *, M. Kraljevic and J. Dulcic
Institute of Oceanography and Fisheries, Split, Croatia - * sanja@izor.hr

Abstract
The total length of 1872 individuals of *Diplodus annularis* ranged from 3.3 to 20.0 cm. Maximum age was 13 yr and the 5-yr old individuals dominated the catches (24.75%). The parameters of the von Bertalanffy growth equation were: L_∞= 22.6 cm, K=0.173 yr^{-1}and t_0=-1.460 yr. The overall male: female ratio was 1:1.12.

Keywords: Diplodus annularis, growth, Adriatic

Introduction

Annular sea bream *Diplodus annularis* is a demersal marine fish found in groups in sandy bottoms and seagrass bed habitats, at depths ranging from 0 to 50 m. It is distributed from the Gulf of Biscay to Gibraltar, around Madeira and Canary Islands, as well as in the Mediterranean, Black and Adriatic Seas (1). Although, it is common in the Adriatic Sea, there is a lack of data on its biology and ecology in this area.

Material and methods

Samples were collected on monthly basis (2000-2002), in the eastern Adriatic Sea, from commercial catches (trawl: 20 mm mesh size, knot-to-knot; beach seines: 6 mm mesh size). Overall 1874 specimens were collected of which 1694 (90.0%) were mature. Age was determined by reading scales from 699 individuals caught in May (91 juveniles and 608 adults). The non-linear least square regression procedure was used to estimate the growth parameters L_∞, K and t_0 of the von Bertalanffy equation (2).

Results and discussion

A total of 1872 specimens were analyzed, ranging in size from 3.3 to 20.0 cm total length TL (mean 12.38 ± 2.532 cm), of which 799 (42.68%) were males and 895 (47.81%) females. Males ranged in size from 8.7 to 20.0 cm TL (mean 13.11 ± 1.744 cm) and females from 7.5 to 19.6 cm TL (mean 12.75 ± 1.943 cm). The TL frequency distribution exhibited a mode at 12-14 cm. An increase in TL from NW to SE, and from the coastal zone to the open sea was observed. There is no previous data on the length structure of *D. annularis* population in the study area.

Maximum age was 13 yr (for a female individual). The oldest male was 11 yr old. The estimated von Bertalanffy growth parameters were: L_∞= 22.6 cm (SE = 0.054), K=0.173 yr^{-1} (SE = 0.003) and t_0=-1.460 yr (SE = 0.015) (R^2=0.890) (Fig. 1). Overall, the 5-yr old individuals, with lengths 11.3-17.8 cm TL, dominated (24.75%) the catches. Our results differ from those from Canary Islands (3), due to faster growth and shorter life cycle of *D. annularis* in that area (maximum age of 6 yr, L_∞= 24.85 cm, K = 0.259 yr^{-1} and t_0 = -0.871 yr).

In the eastern Adriatic Sea the overall male (799) to female (894) ratio of *D. annularis* was 1:1.12 and changed according to length classes (Fig. 2). This species is a rudimentary hermaphrodite (4) and observed sex ratio is a consequence of this fact. It is evident that in length range from 10.0 to 16.0 cm TL, males and females had similar distributions. Predominance of males in lower length classes (< 9.0 cm) is mainly determined by nature of the sexual change, namely protandric hermaphroditism, as it was reported for *D. annularis* from Canary Islands (5).

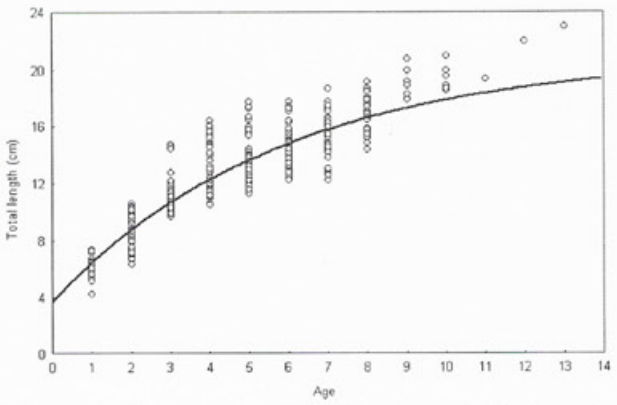

Fig. 1. von Bertalanffy growth curve of *Diplodus annularis* in the eastern Adriatic Sea.

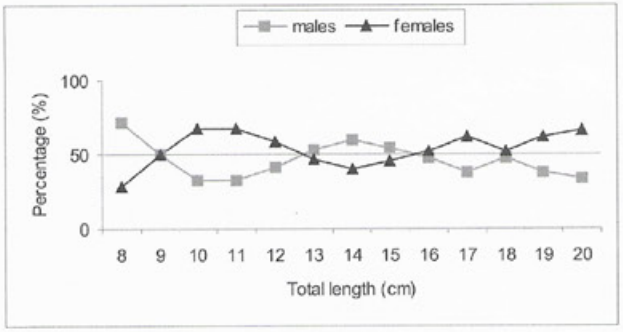

Fig. 2. Sex ratio of *Diplodus annularis* in the eastern Adriatic Sea.

References

1 - Jardas I., 1996. Sparidae. Pp. 265-285. *In*: Matekalo Draganović J. (ed.), Jadranska ihtiofauna. Školska knjiga, Zagreb.
2 - Ricker W.E., 1975. Computation and Interpretation of Biological Statistics of Fish Populations. *Bull. Fish. Res. Board Can.*, 191: 382 p.
3 - Pajuelo J.G., Lorenzo J.M., 2002. Age and growth of the annular seabream, *Diplodus annularis* (Pisces: Sparidae), from the Canarian archipelago (central-east Atlantic). *Sci. Mar.*, 28: 1-11.
4 - Matić-Skoko S., 2003. Fishery-biological and ecological characteristics of annular sea bream (*Diplodus annularis* L.) in the eastern Adriatic Sea. PhD Thesis, University Zagreb, 165.
5 - Pajuelo J.G., Lorenzo J.M., 2001. Biology of the annular seabream, *Diplodus annularis* (Sparidae), in coastal waters of the Canary Islands. *J. Appl. Icht.*, 17: 121-125.

GEOGRAPHICAL AND VERTICAL DISTRIBUTION OF EUPHAUSIACEA (MALACOSTRACA, CRUSTACEA) IN THE AEGEAN SEA.

Mavidis M. [1] *, M.-S. Kitsos [1], M. Aplikioti [1], Ch. Arvanitidis [2], I. Leonardos [3] and A. Koukouras [1]

[1] Department of Zoology, School of Biology, Aristoteleio University, Thessaloniki, Greece
[2] Institute of Marine Biology of Crete, Iraklio, Crete, Greece
[3] Department of Biodiversity and Ecology, School of Biological Applications and Technology, University of Ioannina, Greece

Abstract

The study of quantitative and qualitative samples, taken at various depths in the north Aegean Sea, revealed the presence of 8 species of Euphausiacea: *Euphausia krohnii* (Brandt, 1851), *Meganyctiphanes norvegica* (M. Sars, 1857), *Nematoscelis atlantica* Hansen, 1910, *N. megalops* G.O. Sars, 1883, *Stylocheiron abbreviatum* G.O. Sars, 1883, *S. maximum* Hansen, 1908 and *S. suhmii* G.O. Sars, 1883. The analysis of the collected data gave information on the vertical distribution of these species. A checklist of the Mediterranean species is given, along with their geographical distribution in the Aegean Sea and the Mediterranean.

Keywords: Euphausiacea, vertical distribution, Aegean Sea, Mediterranean

Introduction

A review of the literature revealed the presence of 13 Euphausiacea species in the Mediterranean Sea (Table 1). Twelve species are known from the Aegean Sea, but the information stems mainly from the south Aegean (1, 2), while in the north Aegean only 7 species are known (1, 3). Information on the vertical distribution of the Mediterranean species was also given (1, 4). The present study aims to add information on the geographical and vertical distribution of Euphausiacea from semi-quantitative sampling in the north Aegean Sea.

Table 1. Geographical and vertical distribution of the known Euphausiacea species from the Mediterranean, based on the relevant literature and the results of the present study. WM= Western Mediterranean, CM= Central Mediterranean, AD= Adriatic Sea, AS= Aegean Sea (including the Sea of Marmara and the Gulf of Korinthos), LS= Levant Sea, A= Atlantic Ocean, IP= Indo-Pacific Ocean.

Species	Aegean Sea (present study)		Mediterranean Sea (literature)		General distribution	
	Stations	Depth range (m)	Area	Depth range (m)	Oceans	Depth range (m)
Euphausia brevis Hansen, 1905	-	-	WM, CM, AD, AS, LS	0-2000	A, IP	0-3000
Euphausia hemigiba Hansen, 1910	-	-	WM, CM, AD, AS, LS	0-2000	A, IP	0-2000
Euphausia krohnii (Brandt, 1851)	1-9	250-1000	WM, CM, AD, AS, LS	0-1750	A	0-2200
Meganyctiphanes norvegica (M. Sars, 1857)	1-4, 6-11	10-1000	WM, CM, AD, AS	0-1000	A	0-2175
Nematoscelis atlantica Hansen, 1910	12	400	WM, CM, AD, AS, LS	5-2000	A, IP	0-2000
Nematoscelis megalops G.O. Sars, 1883	1-9	250-1000	WM, CM, AD, AS, LS	0-1750	A, IP	0-2175
Nyctiphanes couchii (Bell, 1853)	-	-	WM, CM, AD, AS, LS	12-500	A	0-800
Stylocheiron abbreviatum G.O. Sars, 1883	1-9	250-1000	WM, CM, AD, AS, LS	0-2000	A, IP	0-2000
Stylocheiron longicorne G.O. Sars, 1883	1-9	250-1000	WM, CM, AD, AS, LS	0-2000	A, IP	0-2000
Stylocheiron maximum Hansen, 1908	1-9	250-1000	WM, CM, AD, AS, LS	12-2000	A, IP	12-2000
Stylocheiron suchmii G.O. Sars, 1883	8	250	WM, CM, AD, AS, LS	0-2000	A, IP	0-2000
Thysanoëssa gregaria G.O. Sars, 1883	-	-	WM, CM	5-1000	A, IP	0-1000
Thysanopoda aequalis Hansen, 1905	-	-	WM, CM, AD, AS, LS	0-2000	A, IP	0-2000

Materials and methods

During the summer of 1993 an expedition to study the pelagic fauna of the north Aegean Sea was carried out. For this purpose a network of 9 stations was designed (Fig. 1, 1-9). In each station routine diurnal semi-quantitative samples were taken, from 250, 500, 750 and 1000 m depth, with a METHOT mid-water trawl.

Samples collected previously from the north Evoikos Gulf (station 10), the Chalkidiki peninsula, off Agia Paraskeui (station 11) and Porto Koufo (station 11) were also examined.

Results and discussion

A checklist of the Mediterranean species of Euphausiacea, with their geographical and vertical distribution (from the literature and our data), is given (table 1). Ten of the thirteen species are cosmopolitan, and the remaining 3 have an Atlanto-Mediterranean distribution. No species is endemic probably because they are pelagic organisms.

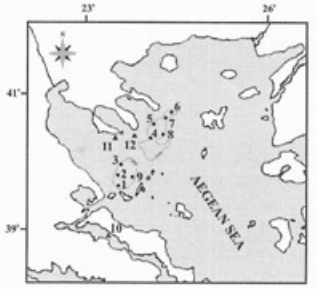

Fig. 1. Map indicating the sampling stations in the north Aegean Sea.

From the 8 species identified in our samples *Nematoscelis atlantica* and *Stylocheiron maximum* are new records for the north Aegean Sea. The most abundant species is *Nematoscelis megalops*, followed by *Euphausia krohnii*, while *N. atlantica* and *S. suhmii* were represented by single specimens.

The vertical distribution and the mean abundance at each depth are provided (Fig. 2). The abundance bulk of *Stylocheiron* species appeared at 250 m depth, while the other species were mainly found in greater depths. Our data agrees with the known diurnal vertical distribution of these species as it results from the literature (4).

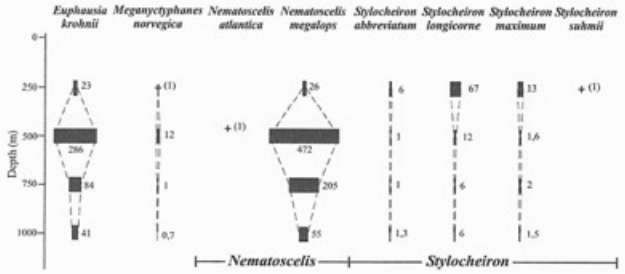

Fig. 2. The diurnal vertical distribution of the 8 Euphausiacea species found in the north Aegean Sea. Numbers show the total mean number of individuals for each depth, while numbers in parenthesis show the absolute number of individuals.

References

1 - Ruud, J.T., 1936. Euphausiacea. Rep. Dan. Oceanogr. Exped. 1908-10 to the Med. and Adj. Seas. D. 6 (2): 1-86.

2 - Bacescu, M., R. Mayer, 1961. Malacostracés (Mysidacea, Euphausiacea, Decapoda, Stomatopoda) du plancton diurne de la Méditerranée. Étude basée sur le matériel du Lamont Géological Observatory-Washington. *Rapports et Procès-Verbaux des Réunions. C.I.E.S.M. Monaco.* 16 (2): 183-202.

3 - Kiortsis, V., and Collaborators, 1969. Marine fauna of the Aegean Sea, Surface Zooplankton from the North Aegean Sea. Zoological Laboratory and Museum University of Athens Greece. Unpublished manuscript. 82 p.

4 - Mauchline, J., L. R. Fisher, 1969. The biology of euphausiids. *Advances in Marine Biology*, 7: 1-439.

INFLUENCE OF ENVIRONMENTAL FACTORS ON SWORDFISH CATCH RATES IN THE EASTERN MEDITERRANEAN SEA

P. Megalofonou *, D. Tetorou, D. Damalas

Department of Biology, Section of Zoology-Marine Biology, University of Athens, Greece - * P.megalo@biol.uoa.gr

Abstract

The influence of environmental and operational parameters on swordfish longline catch rates in the Eastern Mediterranean Sea was investigated applying a generalized additive model. The model indicated seven factors (longitude, sea surface temperature, latitude, bathymetry, distance from coastline, fishing gear and month), which influence either swordfish relative abundance or vulnerability. Spatial and operational factors played predominant role in the model, while environmental features were subsequent constituents. Lunar index was excluded from the analysis as insignificant to the convergence of the model. Higher catch rates were observed in greater longitudes and lower latitudes and for SST from 16 to 21° C.

Keywords: swordfish, generalized additive models, long-line, catch rates, fisheries oceanography

Introduction

Broadbill swordfish, *Xiphias gladius*, is a large pelagic, oceanic species with worldwide distribution and high commercial value. Environmental influence on distribution and abundance of swordfish resources is an important factor that should be included in fisheries management models (1,2,3). In this study, we present a preliminary attempt to examine the relative influence of various environmental and operational factors on the swordfish longline catch rates in the Eastern Mediterranean Sea.

Materials and methods

During 1998-2001, catch and effort data from the Greek swordfish long-line fishery were collected by observers along with spatio-temporal, oceanographical and operational data. A stepwise fitted (in a forward and backward manner) generalized additive model (GAM) was applied to quantify the influence of the various factors on swordfish catch rates (2). Initially nine variables were included in the analysis: satellite-derived estimates of SST at the fishing location, a lunar index based on the illuminated percentage of the moon's face, the distance from coastline, the bathymetry at the fishing location, the latitude, longitude, month, fishing gear type (American or traditional swordfish longline) and sampling method (on-board or at landing). Catch-per-unit-effort (CPUE) was expressed in number of fish per 1000 hooks. Since the histogram of nominal CPUE values was not normal (n=15 zero data points), in our link function ($\log_e$), we assumed that the underlying probability distribution was a Poisson distribution. Spans of the locally weighted polynomial scatterplot smoothers (*loess*) were set to 0.25 (25% of surrounding data) in order to avoid rough and bumpy responses that became apparent when using a span of 0.1. The independent variables were incorporated in the model in the following form:

$\log_e$ (CPUE + 0.1) =
c + lo_1(longitude) + lo_2(SST) + lo_3(latitude) + lo_4(bathymetry) + lo_5(distance from coastline) + fishing gear type + lo_6(month) + lo_7(lunar index) + sampling (on-board, at landing) + e,

where c is a constant, lo_i(variable) is a *loess* smoother function of the i-studied variable and e is a random error term.

Results and discussion

A total of 594 observations of swordfish longline sets were roughly distributed from 19 to 34ºE and from 32 to 40ºN. GAM indicated that longitude had a profound effect on catches explaining more than 36% of the deviance in swordfish CPUE. Sea surface temperature (10.4%) and latitude (6.2%) were the next most influential parameters, while bathymetry (4.1%), distance from coastline (2.2%), fishing gear (1.3%) and month (1.0%) played a minor role. In total, the derived model explained more than 61% of the variance in swordfish CPUE. Lunar index and sampling were non-significant covariates. Similar results were obtained for the commercial swordfish longline fishery in the Atlantic Ocean (4).

Higher CPUE values in greater longitudes and lower latitudes (Fig. 1) corresponded to the Levantine region where exploitation rates for large pelagic fish were quite low compared to the rest of the Mediterranean till recently (5). Therefore, it was deduced that higher catch rates in this area might indicate higher swordfish abundance.

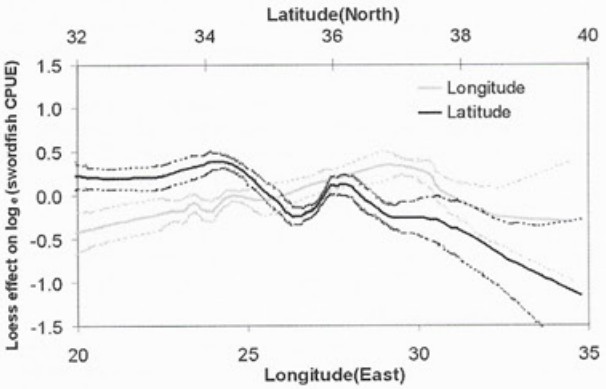

Fig. 1. GAM derived effect of Longitude and Latitude on swordfish nominal CPUE deviance (log transformed). Dashed lines: 95% confidence bands.

Abundance related to SST fluctuated through the temperature range studied, however higher CPUE values were observed in temperatures from 16 to 21ºC. Moreover, CPUE related to both distance from coastline and bathymetry displayed no noticeable trends. Monthly allocation of catch rates revealed that September is accompanied with increased abundance. Probably the recruitment of juveniles in the longline fishery affects the rising of CPUE values during September.

The effect of fishing gear alone on swordfish catch rates was low but significant. The use of fish attractant chemical light-sticks and thicker (more resilient) line are reasonable explanations for the increased catches of the "American type" swordfish longline when compared to the traditional one. We assumed that this variable reflects the catchability of the species rather than the abundance.

Given that our GAM analysis covers a few years and a small number of variables, it may be immature to draw strong inferences regarding environmental effects on swordfish distribution and abundance. Nevertheless, our preliminary results indicated that spatio-temporal and operational factors played the predominant role in the model (explaining more than 44% in total CPUE deviance), while the environmental features were subsequent constituents (17%).

References

1 - Carey, F., G., and Robinson, B., H., 1981. Daily patterns in the activity of swordfish, *Xiphias gladius,* observed by acoustic telemetry. *Fish. Bull.* 79(2): 277-292.

2 - Bigelow K.A., Boggs C.H., and He X., 1999. Environmental effects on swordfish and blue shark catch rates in the US North Pacific longline fishery. *Fish. Oceanogr.*, 8: 178-198.

3 - Draganik, B., and Cholyst, J., 1987. Temperature and moonlight as simulators for feeding activity by swordfish. *Reports of Sea Fisheries Institute*, vol. 22: 73-84.

4 - Moreno, S., Pol, J., and Munoz, L., 1991. Influencia de la luna en el abundancia del emperador. *Coll. Vol. Sci. Pap. ICCAT* vol. 35(2): 508-510.

5 - De Metrio, G., Deflorio, M., Marano, G., De Zio, V., de la Serna, J.M., Macias, D., Yannopoulos, C. and Megalofonou, P., 2001. Regulatory discard of Swordfish. Effectiveness of the EU Regulation regarding the catch minimum size of swordfish in the Mediterranean. EU Project 97/074 DG XIV/C1, 2001.

COMPARATIVE EFFECTIVENESS OF 2-PHENOXYETHANOL AND PROPISCIN AS ANESTHETICS FOR LARVAL SEA BASS *DICENTRARCHUS LABRAX* L.

Ivona Mladineo

Institute of Oceanography and Fisheries, Split, Croatia - mladineo@izor.hr

Abstract

The comparative effectiveness of 2-phenoxyethanol and Propiscin as anesthetic was studied for larval sea bass (*Dicentrarchus labrax* L.). Both anesthetics showed good hypnotic characteristics. However Propiscin induced slower anesthesia than of 2-phenoxyethanol at the same concentrations. The most suitable concentration for anesthesia was 0.56 ml/l for Propiscin and 0.32 ml/l for 2-phenoxyethanol. Based on the results of the experiments it can be concluded that the 2-phenoxyethanol is more suitable for larval sea bass anesthesia.

Keywords: Larval sea bass, 2-phenoxyethanol, Propiscin, anesthesia

Introduction

2-Phenoxyethanol or Ethylene Glycol Monophenyl Ether (EGPE) is used for anesthesia in freshwater fisheries for routine work, because of its fast effect, good and quick recovery time provided that the exposition to the drug is not very long (1, 2).

The other widely used and effective anesthetic in freshwater fish culture is Propiscin (IRS, Polland), containing 0.2% stabilized solution of etomidate, which is a non-barbiturate hypnotic. It is adequate, especially for freshwater fishes, because of its high solubility in water, effectiveness and safety (3, 4, 5).

The purpose of the study was to examine the effectiveness of mentioned anesthetics, which are widely and successfully used in freshwater culture, for possible applications in sea bass' rearing.

Materials and methods

Three hundred larval sea bass (*Dicentrarchus labrax* L.), weighting 0.39 ± 0.1 g, were collected from a nearby hatchery and left for an acclimatization period of 14 days in 500-l polyvinyl pots with a circulating system.

The onset of different phases of anesthetic and recovery was measured in seconds and minutes according to (6). Phase I is characterized by physiological position, increased activity, restlessness and irregular respiratory motion; phase IIa with decreased activity, tilting on the flank, slower and deeper respiratory motion; phase IIb with flank position, loss of motility and deep retarding respiration and phase III with flank position and blocked respiratory motions.

Results and discussion

Duration of specific anesthesia and recovery phases for different concentrations of 2-phenoxyethanol and Propiscin are shown in Tables 1 and 2. Both anesthetics showed good hypnotic characteristics. Propiscin did not show the same capacity to induce faster anesthesia with slower recovery period than 2-phenoxyethanol, as suggested in earlier experiments with freshwater fishes (6). Propiscin concentration most suitable for anesthesia was 0.56 ml/l. In the case of 2-phenoxyethanol, the concentration of 0.32 mg/l slowest induced the IIb phase of anesthesia, but the excitation stage was not sharp and fast. The recovery period at same concentration was the longest, but most safe and unstressful for the fish in means that awaking was smooth without erratic movements, thus pointing this concentration to be the safest for the larvae.

It can be concluded that the 2-phenoxyethanol is more suitable than Propiscin for larval sea bass anesthesia and appropriate anesthesia phases are achieved much faster than with Propiscin.

Table 1. Duration of anasthesia and recovery phases of 2-phenoxyethanol at different concentrations.

anasthesia	0.32 mg/l	0.56 mg/l	1 mg/l
I	10"	6"	3"
IIa	1'38"	47"	38"
IIb	9'40"	4'15"	2'50'
recovery			
IIb	1'09"	56"	1'
IIa	2'01"	1'30"	1'47"
I	2'33"	1'51"	2'51"

Table 2. Duration of anasthesia and recovery phases of Propiscin at different concentrations. The asterix (*) is for concentrations that had to long IIb phase of anaesthesia.

anasthesia	0.1mg/l	0.18 mg/l	0,32 mg/l	0.56 mg/l	1 mg/l
I	2'40"	30"	18"	13"	8"
IIa	4'26"	3'58"	2'30"	1'22"	1'10"
IIb	40'10"	>60'	26'03"	1'10"	6'40"
recovery					
IIb	*	*	1'48"	29"	1'35"
IIa	*	*	5'40"	1'18"	2'44"
I	*	*	7'51"	5'12"	8'51"

References

1 - Idler D.R., McBride J.R., Jonas R.E.E., and Tomlinson N., 1961. Olfactory perception in migrating salmon. *Cannadian J. Biochem. Physiol.*, 39: 1575-1584.

2 - Sehdev H.S., McBride J.R., and Fagerland U.H.M., 1963. 2-Phenoxyethanol as a general anaesthetic for sockeye salmon. *J. Fish. Res. Bd. Canada.*, 20(6): 1435-1440.

3 - Amend D.F., Goven B., and Elliot D.G., 1982. Etomidate: effective dosages for a new fish anaesthetic. Trans. *Am. Fish. Soc.*, 111: 337-341.

4 - Plumb J.A., Schwedler T.E., and Limsuwan C., 1983. Experimental anaesthesia of three species of freshwater fish with etomidae. *Prog. Fish-Cult.*, 45(1): 30-33.

5 - Kouřil J., Stupka Z., Hamáčková J., and Lepičková A., 2001. The Preliminary Results of Effect of Three Anaestetics on Various Fish Species (in Czech). Pp. 131-136. *In*: Kolářova J. *et al.* (ed.): Ochrana zdravi ryb. VÚRH JU Vodňany..

6 - Hamáčková J., Sedova M.A., Pjanova S.V., and Lepičová, A., 2001. The effect of 2-phenoxyethanol, clove oil and Propiscin anaesthetics on perch (*Perca fluviatilis*) in relation to water temperature. *Czech. J. Anim. Sci.*, 46: 469-473.

LARGE SCALE CLIMATE CONTROL ON OCEANOGRAPHIC AND ECOLOGICAL CHANGES IN THE LIGURIAN SEA, NORTHWESTERN MEDITERRANEAN

Molinero J.C. [1] *, Buecher E. [1], Ibanez F. [1], Nival P. [1] and Souissi S. [2]
[1] Laboratoire d'Océanographie de Villefranche (LOV), Villefranche-sur-mer, France - * molinero@obs-vlfr.fr
[2] Ecosystem Complexity Research Group, Station Marine, Université des Sciences et Technologies de Lille, CNRS-UMR 8013 ELICO, Wimereux, France

Abstract
A causal chain of meteorological, hydrological and ecological processes linked to the North Atlantic climate forcing and the Northern Hemisphere temperature have been pointed out in the Ligurian Sea, Northwestern Mediterranean.

Keywords: NAO, Northern Hemisphere temperature, Ligurian Sea, planktonic copepods, hydromedusae

Introduction

During the last decades, planktonic ecosystems have experience strong ecological changes (i.e. population explosions, strong decreases, ecosystem shifts) occurred with increasing frequency, intensity, variety and range (1). A causal link between these changes and the warming trend registered in the Northern Hemisphere has been suggested (2,3).

The western Mediterranean constitutes a sensible area to large scale climate forcing from subtropical and North Atlantic sectors (4,5,6) and to global climate warming (7). However, although such relationships have been identified, the ecological consequences in this area are poorly explored.

In this work we analyse long-term variability of two distinct trophic levels, planktonic copepods and gelatinous carnivores, during the period 1967-1993. We document the contribution of the North Atlantic climate forcing and the Northern Hemisphere temperature on the oceanographic and ecological changes in the Ligurian Sea.

Material and methods

The study site is located in the Ligurian Sea (NW Mediterranean), and precisely in the monitoring station of the Bay of Villefranche/mer (43° 41'N; 7° 19' E). We analysed physical (temperature and salinity) and biological data from the long term monitoring of pelagic populations carried out by the Observatory of Oceanography of Villefranche (OOV). We also used daily records of local meteorology (air temperature, atmospheric pressure, wind speed and precipitation).

Biological time series analysed correspond to zooplankton abundance of planktonic copepods (adult stages of three free-spawning, *Centropages typicus*, *Acartia clausi* and *Temora stylifera*, and two egg-carrying species, *Oithona spp* and *Oncaea spp*) and gelatinous carnivores (*Liriope tetraphylla*, *Solmundella bitentaculata* and *Rhopelonema velatum*).

Time series were analysed in their standardised and non-dimensional form (i.e. standard deviations from the mean of the time series). Principal Component Analysis and Pearson product-moment correlation were used to explore interannual variability on local hydroclimatic and biological changes and their possible relation with large scale climate processes.

Results and discussion

A significant link between the governing climate in the North Atlantic sector and the hydroclimatic conditions in the Ligurian Sea is pointed out. This relationship appears stronger during winter. Indeed, hydroclimatic interannual variability (PC1 38.3% of the total variance) was linked with the NAO ($r = 0.69$; $p<0.01$) and the Northern Hemisphere temperature ($r = 0.45$; $0.05<p<0.1$).

The local hydroclimatic variability driven by the climate forcing during winter and linked to the NAO state (i.e. changes in heat fluxes, precipitation, wind stress and mesoscale circulation) quite have an effect on the development and/or structure of phytoplankton composition leading to a shift in species dominance.

The main signal of the whole zooplankton populations, as indicated by the first eigenvector and principal component (PC 1 55% of the total variance), results showed a strongly link to the NAO variability ($r = 0.62$; $p<0.01$) and Northern Hemisphere temperature ($r=0.62$; $p<0.04$).

The long term trend observed in gelatinous carnivores has been related to a period characterized by an increase in temperature, salinity and dry conditions (8) particularly marked during mid-late 1980's. In this study we show that such period was linked ultimately to an exceptional high NAO and tightly coupled to the Northern Hemisphere Temperature trend.

Hydroclimatic modifications occurred during the last decades in the study area quite promoted increase in food availability for gelatinous carnivores (i.e. microzooplankton production related to the flagellate dominance on the microplankton community) and favour conditions for their development (i.e. high temperatures, low water column mixing). Owing to their important increase since mid-1980s, recurrent autumn peak and their feeding proprieties (i.e. they are no satiated and can feed on a larger range of particles than copepods), the higher abundance observed suggests a multiplicative and non-linear predation pressure over copepods. Indeed, a collapse in the summer-autumn blooming copepods occurred during late 1980's.

These results provide evidence for a significant link between local changes in the Ligurian Sea (i.e. meteorology, hydrology and plankton populations) and the governing atmospheric circulation in the North Atlantic. During this time, the influence of the North Atlantic climate appears as a key control on the dynamics of hydroclimatic conditions and long term variability of planktonic populations, as indicated by decadal changes documented in both physical and biological time series.

These results when considered in the context of long term changes in planktonic groups previously reported for the same study area (salps, doliolids and other gelatinous carnivores), suggest a shift in the Ligurian planktonic ecosystem which might be related to large scale climatic processes governing the North Atlantic.

There are several implications of this study which could be useful to understanding interannual and decadal abundance variability in the planktonic populations of the Northwestern Mediterranean. The first is that these results confirmed the sensitivity of the Western Mediterranean to large scale climate processes and showed a rapid response to the forcing from the North Atlantic sector. The second is that instead of approaching long term trends in marine ecosystems as determined by local events, efforts should be directed toward investigate connections across the atmospheric circulation and ranges of influence of large scale climate variability in order to forecast and mapping possible scenarios of ecological changes in the context of the global climate change.

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Bibliography

1 - Hayes, M, B.J., T. Mitchell, J. Prospero, E. Shin, F. Van Dolah, and Barber R., 2001. How are climate and marine biological outbreaks functionally linked? *Hydrobiologia*, 460: 213-220.

2 - Beaugrand G., P.C. Reid, F. Ibanez, J.A. Lindley, and Edwards M., 2002. Reorganization of North Atlantic Marine Copepod Biodiversity and Climate. *Science*, 296: 1692-1694.

3 - Beaugrand G., and Reid P.C., 2003. Long-term changes in phytoplankton, zooplankton and salmon related to climate. *Global Change Biology*, 9: 1-17.

4 - Reddaway J., and Bigg G., 1996. Climatic change over the Mediterranean and links to the more general atmospheric circulation. *International Journal of Climatology*, 16: 651-661.

5 - Raicich F, Pinardi N., and Navarra A., 2001 Teleconnections between Indian Monsoon and Sahel Rainfall and the Mediterranean, *Archo Oceanogr. Limnol.*, 22: 9-14.

6 - Molinero J.C. 2003. Abundance variability of planktonic copepods in the Mediterranean Sea. Mechanisms and characteristic scales : the *Centropages typicus* case study. Doctoral Thesis, Paris VI University, Paris, 171 p.

7 - Béthoux, J.P., and Gentili B., 1999. Functioning of the Mediterranean Sea: past and present changes related to freshwater input and climate changes. *Journal of Marine Systems*, 20: 33-48.

8 - Buecher E, 1999. Appearance of *Chelophyes appendiculata* and Abylopsis tetragona (Cnidaria, Siphonophora) in the Bay of Villefranche, northwestern Mediterranean. *Journal of Sea Research*, 41: 295-307.

CARACTÉRISTIQUES MORPHOMÉTRIQUES ET MÉRISTIQUES DE *DIPLODUS SARGUS* (LINNAEUS, 1758) DU GOLFE DE TUNIS

Mouine N., Chakroun-Marzouk N. *, Ktari M. H.

Laboratoire de Biologie animale, Faculté des Sciences de Tunis, Tunis El Manar, Tunisie - * knn.marzouk@gnet.tn

Résumé

Cette étude est consacrée à l'étude biométrique de la population de *Diplodus sargus* du golfe de Tunis. Les résultats obtenus révèlent des différences du mode de croissance et des indices moyens des proportions du corps en fonction du sexe et de la taille.

Mots clés: biométrie, Diplodus sargus, golfe de Tunis, Méditerranée

Les sargues du groupe *D. sargus* ont une distribution étendue et sont formés de plusieurs sous-espèces très proches les unes des autres; celle qui fréquente la Méditerranée est *D. sargus sargus* (1). L'objectif de ce travail est de caractériser la population tunisienne du golfe de Tunis et également d'apprécier s'il existe des différences morphométriques entre sexes ou tailles ainsi que des allométries de croissance.

Matériel et méthodes

Les échantillons, collectés de septembre 2002 à avril 2003, proviennent de la pêche commerciale dans le golfe de Tunis. Ils comprennent 113 poissons qui se répartissent en 49 immatures (I), 21 mâles (M), 43 femelles (F) de longueur totale respectivement comprise entre 11,4 et 19,3 cm, 15,8 et 30 cm, 15,5 et 34,2 cm. Sur chaque exemplaire, 21 mensurations sont effectuées: longueurs totale (LT), standard (LS) et à la fourche (LF); longueurs des nageoires dorsale (LD), pectorale (LP), ventrale (LV) et anale (LA); distances prédorsale (DpD), prépectorale (DpP), préventrale (DpV) et préanale (DpA); hauteurs du corps (HC) et du pédoncule caudal (HPC); diamètre oculaire (DO); longueur céphalique (LCé); longueur du maxillaire (LM); distances préorbitaire (DpO), postorbitaire (DptO), sous-orbitaire (DsO), interorbitaire (DiO) et enfin épaisseur du corps (EC). Par ailleurs, 6 caractères méristiques sont considérés: le nombre d'écailles de la ligne latérale (LL) et de branchiospines (B); le nombre de rayons épineux de la nageoire dorsale (Dép) et de rayons mous des nageoires dorsale (Dm), anale (Am) et pectorale (P).

Pour l'analyse statistique des données méristiques et des indices des proportions du corps nous utilisons le test t de comparaison de moyennes; pour décider du type d'allométrie, les pentes des équations logarithmiques reliant les différentes proportions du corps sont comparées à 1 pour un risque de 5% (2).

Résultats et discussion

Nous n'avons pas observé de différences significatives des caractères méristiques entre les sexes ($t < 1,96$; $p > 0,05$); cependant, seuls les nombres d'écailles de la ligne latérale et de branchiospines (avec respectivement $t = 4$, 3 et $t = 4,12$; $p < 0,05$) sont sensiblement inférieurs chez les immatures (Tab. 1). Les moyennes des caractères méristiques s'avèrent semblables à celles du *D. s. sargus* méditerranéen (1) ($t < 1,96$; $p > 0,05$).

La comparaison des indices moyens des proportions corporelles indique que LS/LT, LS/LF, LP/LS, LV/LS, LA/LS, LCé/LS, EC/LS, DpO/LCé, DsO/LCé et EC/HC sont moindres chez les immatures que chez les adultes ($t \geq 1,96$; $p < 0,05$) alors que DO/LCé est plus grand chez les plus petits exemplaires ($t = 11,41$; $p < 0,05$); aussi, EC/HC et DpA/LS sont significativement plus élevés chez les femelles que chez les mâles (avec respectivement $t = 2,72$ et $t = 2,06$; $p < 0,05$).

Tab. 1. Moyennes des caractères méristiques de *D. sargus* du golfe de Tunis. Entre parenthèses: écart-type.

	I	M + F	M	F	Global
Dép	11.51 (0.54)	11.62 (0.48)	11.71 (0.46)	11.59 (0.49)	11.56 (0.51)
Dm	13.66 (0.6)	13.60 (0.60)	13.52 (0.68)	13.64 (0.57)	13.61(0.61)
Am	12.89 (0.56)	12.87(0.45)	12.85 (0.35)	12.88 (0.50)	12.87 (0.50)
P	15.78 (0.60)	15.81 (1.68)	15.87 (0.83)	15.81 (0.66)	15.79 (0.64)
LL	54.05 (3.74)	61.07(5.21)	57.33 (5.70)	61.56 (5.07)	58.28 (6.05)
B	16.10(1.10)	17.04 (1.28)	17.38 (1.07)	16.97 (1.35)	16.64 (1.29)

Tab. 2. Paramètres des équations logY = a logX + b de *D. sargus* du golfe de Tunis. A+ : allométrie majorante; A- : allométrie minorante.

		I		M		F		Global	
X	Y	a	b	a	b	a	b	a	b
LT	LS	0,945 A-	-0,064	1,053 A+	-0,196	1,072 A+	-0,014	1,020 A+	-0,149
LF	LS	0,991	-0,057	1,032	-0,102	1,024 A+	-0,093	1,021 A+	-0,089
LS	LD	1,038	-0,290	0,991	-0,233	1,027	-0,278	1,029	-0,280
LS	LP	1,175 A+	-0,619	0,977	-0,386	1,013	-0,437	1,081 A+	-0,520
LS	LV	1,251	-0,910	0,938	-0,547	0,986	-0,615	1,085 A+	-0,736
LS	LA	1,019	-0,651	0,958	-0,570	0,957	-0,572	1,009	-0,638
LS	DpD	1,140 A+	-0,479	1,002	-0,331	1,089 A+	-0,442	1,044 A+	-0,383
LS	DpP	1,125 A+	-0,596	1,045	-0,522	1,005	-0,568	1,042 A+	-0,514
LS	DpV	1,102 A+	-0,489	1,017	-0,409	1,050 A+	-0,448	1,012	-0,399
LS	DpA	1,010	-0,153	1,073	-0,232	1,087 A+	-0,242	1,045 A+	-0,191
LS	HPC	0,936	-0,892	1,165	-1,144	1,026	-0,980	1,046 A+	-1,004
LS	HC	1,002	-0,305	0,969	-0,262	0,925 A-	-0,252	0,975	-0,276
LS	EC	1,139	-1,005	1,171	-1,049	1,028	-0,855	1,143 A+	-1,009
LS	LCé	1,132 A+	-0,485	1,099 A+	-0,628	1,119 A+	-0,650	1,071 A+	-0,589
LD	LA	0,748 A-	-0,383	0,964	-0,135	0,835 A-	-0,217	0,954 A-	-0,339
LCé	DO	1,275 A+	-0,557	0,696 A-	-0,356	0,669 A-	-0,348	0,672 A-	-0,346
LCé	DiO	0,978	-0,354	1,104	-0,691	0,887	-0,584	1,004	-0,664
LCé	DpO	0,995	-0,367	1,200 A+	-0,515	1,281 A+	-0,573	1,238 A+	-0,541
LCé	DptO	1,110 A+	-0,358	1,051	-0,403	1,080 A+	-0,419	1,042 A+	-0,392
LCé	DsO	1,413 A+	-0,971	1,297 A+	-0,477	1,262 A+	-0,463	1,187 A+	-0,402
LCé	LM	1,120	-0,458	1,079	-0,532	0,895	-0,384	0,931	-0,467
DpO	DO	0,870 A-	-0,560	0,574 A-	-0,055	0,504 A-	-0,042	0,538 A-	-0,510
HC	HPC	0,985	-0,548	1,131	-0,764	1,063	-0,699	1,050 A+	-0,689
HC	EC	0,967	-0,515	1,162	-0,518	1,076	-0,400	1,145	-0,418

Nous pouvons constater, pour une même relation, la disparité du type de croissance lorsqu'on compare les mâles, les femelles, les immatures et l'ensemble des individus (Tab. 2). L'allométrie de croissance, lorsqu'elle existe chez les mâles et les femelles, est toujours de même signe. Par contre, le diamètre oculaire en fonction de la longueur céphalique présente une allométrie positive chez les petits poissons mais négative chez les plus grands. Le mode de croissance des différentes parties du corps du sargue du golfe de Tunis ne coïncide pas toujours avec celui du *D. s. sargus* décrit par Paz (1) qui a étudié 26 poissons provenant de diverses localités du pourtour méditerranéen. Des dissemblances morphologiques sont aussi signalées entre des populations de *D. sargus* d'Alicante, de Trieste et de Crète et seraient induites par les caractéristiques physique et orographique propres à chaque habitat (3). Il serait alors intéressant de caractériser d'autres populations du littoral tunisien vivant dans des milieux différents.

Références

1 - Paz R. M. de la, Bauchot M. L., et Daget J., 1973. Les *Diplodus* (Perciformes Sparidae) du groupe *sargus*: systématique et phylogénie. *Ichthyologia*, 5(1): 113-128.

2 - Dagnélie P., 1981. Théories et méthodes statistiques. Vol. 1 et 2: 378 et 463 p. Les presses Agronomiques de Gembloux.

3 - Palma J., et Andrade J. P., 2002. Morphological study of *Diplodus sargus*, *Diplodus puntazzo*, and *Lithognathus mormyrus* (Sparidae) in the Eastern Atlantic and Mediterranean Sea. *Fisheries Research*, 57: 1-8.

LONG-TERM CHANGES IN PHYTOPLANKTON COMMUNITY STRUCTURE FROM 1989 TO 2002, ADRIATIC SEA

Patricija Mozetic * and Janja France
National Institute of Biology, Marine Biology Station, Piran, Slovenia - * mozetic@mbss.org

Abstract
Phytoplankton abundance was followed from 1989 to 2002 in a shallow coastal area (Adriatic Sea) and the multivariate method STATIS was used to detect any annual pattern common to 14 years. The results indicated a uniform annual distribution of phytoplankton with inter-annual changes of particular groups. Diatoms and nanoflagellates, which generally account for the majority of total abundance, had a very constant distribution through the years but they peaked in different seasons. Other groups were characterised by larger inter-annual changes, although their abundance was too low to affect significantly the general dynamic.

Key words: phytoplankton, long-term study, Adriatic

Introduction

Important information on the functioning of marine pelagic ecosystems comes from planktonic long-term studies. This knowledge is even more valuable in sensitive coastal areas and estuaries (in 1), including Adriatic Sea and its northernmost basin – the Gulf of Trieste (2, 3), where physical and biochemical processes are mainly driven by freshwater flows and nutrient loading. This work comprises a 14-year long time-series of phytoplankton abundance and community structure of the Gulf of Trieste. Phytoplankton dynamic was followed during routine monitoring from 1989 to 2002. Since the number of samples was not the same each year the multivariate method STATIS (4) was used to compare changes between years instead of time-series analysis. With this approach we tried to detect any annual pattern common to 14 years and to determine whether this pattern is stable over time or not.

Material and methods

Seawater samples for phytoplankton analysis were taken almost monthly from 1989 to 2002 on one station (21 m deep) in the Gulf of Trieste. Only data of surface layer were considered. Organisms belonging to diatoms, dinoflagellates, coccolithophorids, silicoflagellates and one non-taxonomic group (nanoflagellates) were counted on an inverted microscope (5). The results of STATIS analysis are based on a total of 160 samples.

Results and discussion

Simple time-series distribution of total abundance' medians suggested moderate differences among the years while the size of the boxes and extend of the maximum values pointed out the years with large blooms (Fig. 1). Instead, the STATIS inter-structure analysis revealed a uniform distribution of phytoplankton abundance over the 14 years on the first axis (data not shown). Since this axis explains 91 % of the total inertia, these results indicated a strong common annual pattern. The intra-structure analysis - the trajectories, showed changes of the phytoplankton groups through the study period (Fig. 2). Grouping of diatoms and nanoflagellates on the opposite sides along the first axis indicated a very constant distribution, though with different seasonal characteristics of both groups. Nanoflagellates had one distinctive and long period of predominance in spring, while diatoms

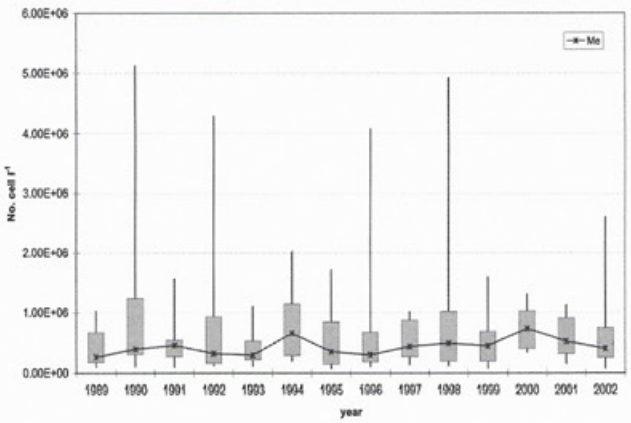

Fig. 1. Medians, quartiles (boxes) and minimal and maximal values (low-high lines) of total phytoplankton abundance, 1989-2002.

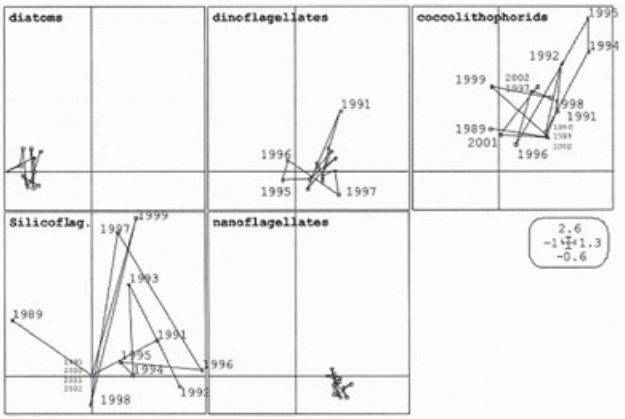

Fig. 2. Trajectories of phytoplankton groups derived from the STATIS intra-structure analysis, 1989-2002.

abrupt significantly in autumn and July. The usual early-spring peak was apparently not constant enough in time to be identified as a baricenter by the STATIS analysis. Dinoflagellates and coccolithophorids were, on the contrary, characterised by larger inter-annual changes. These changes were due to different occurrence of seasonal blooms or to their absence. Although the trajectory of silicoflagellates appeared the most variable among all groups, this is likely due to the combination of very irregular occurrence through the year and low abundance rather than inter-annual variations.

The present study revealed a uniform distribution of phytoplankton with inter-annual changes of particular groups, which, however, did not expose any single year. This would suggest that physical-chemical properties of the Gulf remained relatively stable or they did not affect the structure on the group level. Nevertheless, this necessitates for additional analysis on species level, which would probably point out seasonal variations or shift in dominating species and help to explain changes in trophic structure observed in last decades.

References

1 - Harding L.W. Jr., and Perry E.S., 1997. Long-term increase of phytoplankton biomass in Chesapeake Bay, 1950-1994. *Mar. Ecol. Prog. Ser.*, 157: 39-52.
2 - Cataletto B., Feoli E., Fonda Umani S., and Chen Yong S., 1995. Eleven years netzooplankton community in the Gulf of Trieste: time series analysis. *ICES J. Mar. Sci.*, 52: 669 - 678.
3 - Mozetic P., Fonda Umani S., Cataletto B., and Malej A., 1998. Seasonal and inter-annual plankton variability in the Gulf of Trieste (northern Adriatic). *ICES J. Mar. Sci.*, 55: 711-722.
4 - Lavit C., Escoufier Y., Sabatier R., and Traissac P., 1994. Tha ACT (STATIS method). *Comput. Stat. Data Anal.*, 18: 97-119.
5 - Utermöhl H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton Methodik. *Mitt. int. Ver. Theor. angew. Limnol.*, 9: 1-38.

ANNUAL REPRODUCTIVE CYCLE OF *TRIGLA LYRA*

Marta Muñoz [1] *, Maria Sàbat [1], Sandra Mallol [2] and Silvia Vila [1]

[1] Àrea de Zoologia, Departament de Ciències Ambientals, Universitat de Girona, Spain - * marta.munyoz@udg.es
[2] Centre Oceanogràfic de Balears, Institut Espanyol d'Oceanografia, Palma de Mallorca, Spain

Abstract

Seasonal histological changes of the gonads and the condition factor and the gonadosomatic, hepatosomatic and mesenteric fat indices of *Trigla lyra* were studied for both sexes. Sexual dimorphism was not found. The standard length at first maturity was 200 mm for the females and 180 mm for males. Spawning in Western Mediterranean occurred in late winter, early spring.

Keywords: Trigla lyra, reproduction, annual cycle

The piper gurnard (*Trigla lyra* L., 1758) lives in soft and rocky substrates off the coast up to depths of 700 m (1). In the present work, the seasonal histological changes of the gonads of piper gurnard were studied. The condition factor as well as the gonadosomatic, hepatosomatic and mesenteric fat indices were analysed.

The annual development of the indices in relation to the maturation phase of the gonad is shown in Figure 1. The graphs show the average monthly values of these indices related to reproduction for both sexes. The ovaries were classified according to the more developed type of oocyte they contain (2), and the stage of development of the testis was determined following the criteria of Grier (3).

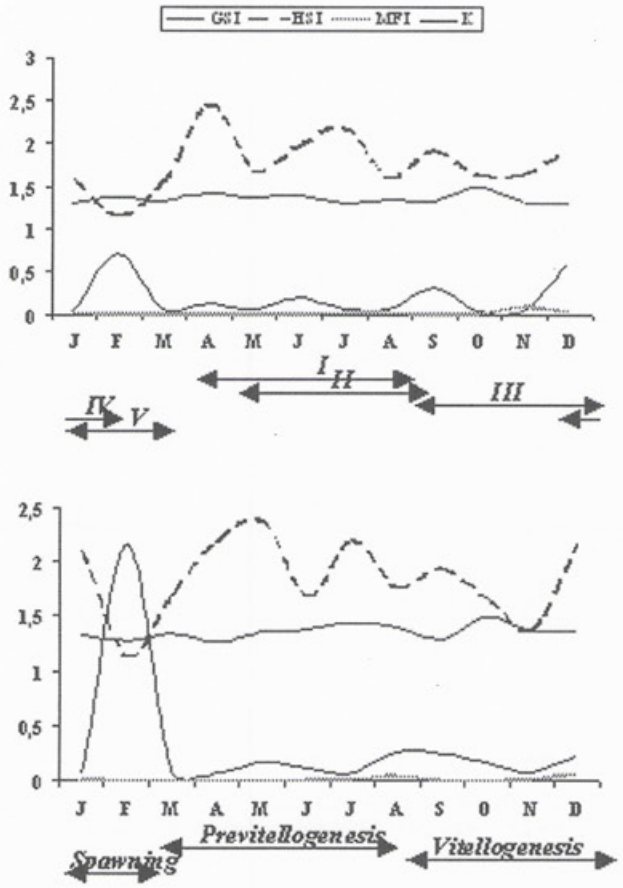

Fig. 1. Annual development of the indices related to reproduction. Below each graph are details of the stage which the gonads are going through.

The gonadosomatic index (GSI = weight of gonad / eviscerated weight) showed monthly significant differences for both sexes (ANOVA, p=0.000 for males, and p=0.029 for females). The energy used up in reproduction is clearly depicted in the changes of the hepatosomatic (HSI = weight of liver / eviscerated weight) and mesenteric fat (MFI = weight of mesenteric fat / eviscerated weight), both of which showed their minimum values after spawning, although we only detected monthly significant differences for the HSI of females (ANOVA, p = 0.002). The condition factor (K = eviscerated weight / standard length^3) was not affected by reproductive activity, since its monthly variations are not considered statistically significant (ANOVA, p>0.05).

The reproductive cycle of piper gurnard started in March, when both the ovary and the testes were in the initial phases of development. In September, and coinciding with the appearance of the first vitellogenic oocytes in the ovaries and the formation of the first spermatozoa in the testes, the activity of the gonads begun to increase progressively. The functional maturity period of the testes, when the lobules and all the ducts were full of sperm, coincided with the observed spawning period (between January and February).

Information about the spawning period of piper gurnard is a little contradictory (4,5,6) probably because of the difficulty to obtain large specimens. Females matured only after they reach a standard length of 200 mm, and males a standard length of 180 mm. In this way, although we only detected mature oocytes and postovulatory follicles in January and February, a more prolonged spawning period up to March cannot be ruled out, because of the lack of large specimens caught in this month.

The sex ratio was 1.4 in favour of males and differed significantly from 1 (χ^2=8.20, g.d.l.=1, p=0.004) especially for smaller sizes. This agrees with the results from Greek waters (7, 8).

References

1 - Whitehead P.J.P., Bauchot M.L., Hureau J.C., Nielsen J., and Tortonese E., 1986. Fishes of the North-eastern Atlantic and the Mediterranean. UNESCO, Paris.
2 - West G., 1990. Methods of assessing ovarian development in fishes: a review. *Aust. J. Marine Freshwater Res.*, 41: 199-222.
3 - Grier H.J., 1981. Cellular organization of the testis and spermatogenesis in fishes. *Amer. Zool.*, 21: 345-357.
4 - Bini G., 1969. Atlante dei pesci delle coste italiane, VII. Roma: Mondo somerso, Roma.
5 - Mouneimné N., 1971. Les triglidae de la mer catalane. Distribution, croissance et reproduction. I. Genre *Trigla lyra*, *Aspitrigla cuculus* et *Aspitrigla lucerna*. Ph. D. Thesis, Fac Sci Univ Paris.
6 - Papaconstantinou C., Petrakis G., and Caragitsou E., 1991. Preliminary study on the biology of piper (*Trigla lyra* L., 1758) in the Aegean Sea. *FAO Fish. Rep.*, 77: 127-137.
7 - Papaconstantinou C., 1981. Age and growth of piper, *Trigla lyra*, in Saronikos Gulf (Greece). *Cybium*, 5: 73-87.
8 - Papaconstantinou C., 1983. Observations on the ecology of gurnards (Pisces, Triglidae) of the Greek seas. *Cybium*, 7 (4) :71-88.

3D SPATIO-TEMPORAL VERTICAL DISTRIBUTION OF ZOOPLANKTON AS ACOUSTICALLY INFERRED IN THE TURKISH SEAS

Erhan Mutlu

Institute of Marine Sciences, Middle East Technical University, Erdemli, Turkey - mutlu@ims.metu.edu.tr

Abstract

Sagitta setosa and *Calanus euxinus* showed spatio-temporal distribution in the Black Sea thereafter they were acoustically identified. *C. euxinus* overwintered from March to May, August. *S. setosa* were completely adult during January-June whereas their juveniles predominated in warm seasons. Their generation's time was July and September. Zooplankton community was restricted in upper water above the interface in Marmara Sea. *Aurelia aurita* aggregated just above the interface (evening), were dispersed towards the surface (midnight) to form community during the daylight. The Mediterranean zooplankton was composed of two scattering layers: one migrated between surface and thermocline and other below thermocline.

Keywords: Zooplankton, distribution, bioacoustics, Black Sea

About 150 zooplankton species are reported for the Black Sea, including numerous brackish-water and freshwater organisms restricted to coastal areas. Only about half of the Black Sea species occur in the Mediterranean. All taxonomic groups of planktonic animals are presented in the Eastern Mediterranean (EMED), but few have penetrated into in the Black Sea. This seems to be mainly due to differences in salinity between the two basins. Typical stenohaline organisms such as radiolarians, siphonophores, pteropods, and salps, common in the Mediterranean, do not occur in the Black Sea. Abundant groups, such as copepods, chaetognaths, and medusae, are present in much reduced numbers in the EMED. Appendicularia, Chaetognatha, Cladocera, Copepoda, Polychaeta, Gastropoda and Bivalvia larvae, Scyphozoa, and Ctenophora were found in the Sea of Marmara (1-6).

Monthly acoustical data from different years were collected with a scientific echosounder and Acoustic-Doppler-Current-Profiler.

Sagitta setosa was acoustically identified by looking at their diel migratory pattern in different months in the Black Sea. In cold-water season when population consisted of adults, they concentration layer coexisted with *Calanus euxinus* in Oxygen-Minimum-Zone (OMZ). In warm-water season when juveniles comprised more 60% of the population, they stayed in the oxycline. In July and September, individuals of new generation did not migrate and stayed in subsurface water. *S. setosa* speeded up in well-oxygenated subsurface water. *S. setosa* completed migration within 4 hrs at 0.38 cm s^{-1} (7).

C. euxinus were acoustically discriminated with respect to vertical migration and swimming speed, according to dissolved oxygen (DO) concentration and timing of migrations. Species became torpid in water with DO values <0.5 mg l^{-1}. Time spent swimming under DO conditions between 2 and 5 mg l^{-1} was insignificant, and varied from the 10% to 25% of total time spent swimming (5 h) under normoxic conditions (5–10 mg l^{-1}). *C. euxinus* formed a concentration layer in the water of 1–3 m thickness. Upward migration was completed in about 3.5 h, starting 2.5 h before and ending 1 h after sunset (average rate: 0.95 cm s^{-1}) in summer. Species ascended discretely from the suboxic to the lower boundary of cold intermediate layer (CIL) at 0.82 cm s^{-1}, and passed up the CIL and thermocline fast (2.3 cm s^{-1}). Downward migration took less time (2 h), starting ~1 h before and ending ~1 h after sunrise. Swimming speed within the thermocline and CIL was 2.7 cm s^{-1}; copepods subsequently returned to daylight depth at 0.57 cm s^{-1} (8).

The noise was 4 dB higher in the Sea of Marmara than in the other two Seas. This could have changed the "hardness" of the interface due to the biological variations as Korneliussen (9) suggested that bottom variations. Hardness of the interface could be associated with density of jellyfish, *Aurelia aurita*. Their swimming rhythms showed that they could be jellyfish (10). A variation of about 10-15 dB and occurrence of a peak every 25-30 s due to swimming of the jellyfish were observed in individual scatterers rising from the interface. 200 kHz data showed significant correlation between measured and calculated volume backscattering (Sv), and density of the taxa. Large-sized copepods and chaetognaths in the Black Sea, *Aurelia*, *Beroe* and chaetognaths and large sized and abundant appedicularians in Sea of Marmara and fish larvae in the Mediterranean Sea contributed most to the Sv. Biological scattering was vertically distributed between surface and suboxic zone in the Black Sea, whereas it was confined between surface and interface formed between waters of the Black Sea and Mediterranean Sea in the Sea of Marmara. The Mediterranean Sea was very different in terms of the volume backscattering due to absence of shallow interface. Acoustical scattering was layered in and above the suboxic zone during the daytime in offshore waters of the Black Sea, while it was aggregated in the mixed layer at night hours. As the bottom depth was shoaled, the volume backscattering strength became homogenous. In the Sea of Marmara, the scattering was much intensified and layered just above the interface during the daytime, whereas it was homogenously distributed within the mixed water characterized with the Black Sea above the interface. During daytime, the layer between interface and transducer depth was deserted by the plankton. Moderately high scattering was observed in the upper 100 m in the Mediterranean Sea at night, while the scattering observed in the upper 60 m layer during the day was less intense since vertical migratory species deserted the upper layers.

References

1 - Niermann U., Bingel F., Ergun G., and Greve W., 1998. Fluctuation of dominant mesozooplankton species in the Black Sea, North Sea and the Baltic Sea: Is a general trend recognizable? *Tr. J. Zool.*, 22: 63-81.

2 - Kovalev A.V., Skryabin V.A., Zagorodnyaya YuA., Bingel F., Kideys A.E., Nierman U., and Uysal Z., 1999. The Black sea Zooplankton: Composition, spatial/temporal distribution and history of investigations. *Tr. J. Zool.*, 23: 195-209.

3 - Kovalev A.V., Mazzocchi M.G., Siokou-Frangou I., and Kideys A.E., 2001. Zooplankton of the Black Sea and the Eastern Mediterranean: Similarities and dissimilarities. *Medit. Mar. Sci.*, 2/1: 69-77.

4 - Mutlu E., 2002. A comparison study on biology and bioacoustics of the Turkish Seas and TS of European flying squid. ICES Symposium "Acoustics in Fisheries and Aquatic Ecology" Montpellier, France 10-14 June 2002, 444-451.

5 - Mutlu E (in review). An intercomparison of the contribution of zooplankton and nekton taxa to the near-surface acoustic structure of three Turkish Seas. *Mar Ecol: PSZN.*

6 - Salihoglu I., and Mutlu E., 2000. National Sea research and monitoring program Mediterranean Sea, Sea of Marmara, Turkish Straits System, Black Sea and atmospheric subprojects period 1995-1999: Synthesis Report. "Ulusal Deniz Araştırma ve İzleme Programı, Akdeniz, Marmara Denizi, Türk Boğazlar Sistemi, Karadeniz ve Atmosfer Alt projeleri, 1995 - 1999 dönemi sentez raporu". TUBITAK, IMS-METU, Erdemli, Nov 2000, 449 p. (In Turkish).

7 - Mutlu E., (submitted). Does the other layer belong to *Sagitta setosa*?: Diel vertical migration as inferred acoustically in the Black Sea. *Mar. Ecol. Prog. Ser.*

8 - Mutlu E., 2003. Acoustical identification of the concentration layer of a copepod species, *Calanus euxinus*. *Mar. Biol.*, 142: 517-523.

9 - Korneliussen R.J., 2000. Measurement and removal of echo integration noise. *ICES J. Mar. Sci.*, 57(4): 1204-1217.

10 - Mutlu E., 1996. Target strength of the common jellyfish (*Aurelia aurita*): a preliminary experimental study with a dual-beam acoustic system. *ICES J. Mar. Sci.*, 53: 309311.

PRELIMINARY RESULTS ON THE BIOLOGY OF *PERISTEDION CATAPHRACTUM* (L., 1758) IN THE EASTERN IONIAN SEA

Mytilineou Ch. *, G. Christidis, A. Terrats and S. Kavadas

National Center for Marine Research, Agios Kosmas, Helliniko, Athens, Greece - * chryssi@ncmr.gr

Abstract

This study provides preliminary data on the reproduction, age and growth of *Peristedion cataphractum* in the deep waters of the Eastern Ionian Sea. The spawning period was extended, starting from summer with a maximum in autumn. The sex ratio was generally in favour of females, although during the spawning period it was close to 1:1. Eight age groups were identified based on ageing otoliths and the von Bertalanffy growth parameters were estimated.

Key-words: Peristedion cataphractum, Eastern Ionian Sea, age, growth, spawning

Introduction

The African armoured searobin, *Peristedion cataphractum* (L., 1758), is a deep-water demersal species found at mud bottoms and depths down to 700 m. Only one study, concerning its biology in Italian waters [1], and few other studies on its early life stages [e.g. 2, 3], are available. Available data from Greek waters concern its reproduction [4]. This study provides preliminary data on the reproductive period, sex ratio, age and growth of *P. cataphractum* in the deep waters of the Greek Ionian Sea.

Material and methods

Samples were collected by trawling in the northern part of the Greek Ionian Sea at depths ranging between 257 and 848 m, during three cruises from September 1999 to July 2000. The study of the reproductive period was based on the examination of the maturity stages of the gonads for 569 individuals using Nikolsky's scale [5]. The otoliths of 346 individuals, ranging in size between 67 and 286 mm total length (TL), were used for age determination. The Von Bertalanffy growth parameters were estimated using non-linear regression.

Results

The analysis of the female maturity stages per cruise (Fig. 1) showed that immature individuals (stage II) were always present in high percentages (>50%). Mature individuals (stages III and IV) increased in numbers from spring to summer. Their percentage decreased again in autumn, when the maximum percentage of spawning individuals (stage V) appeared. The latter appeared from summer. Post-spawning individuals (stage VI) were present from autumn with higher percentage in spring. The results for males were similar to those of females, although spawning individuals were observed only in autumn.

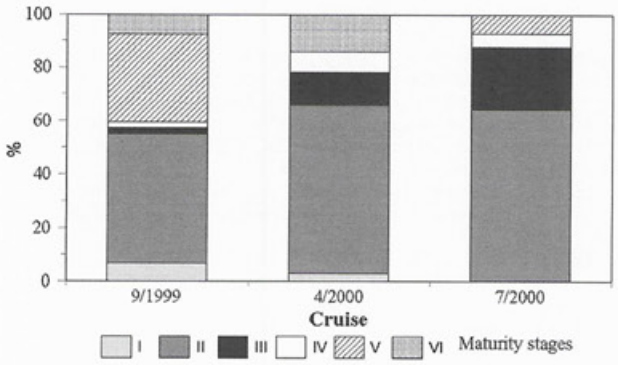

Fig. 1. Maturity stages of female *P. cataphractum* per cruise in the Eastern Ionian Sea.

The sex ratio was almost 1:1 in autumn (Table 1). In spring and summer, the sex ratio was in favour of females. The analysis of the sex ratio in relation to length showed that it was close to 1:1, with very large individuals (>285 mm) being females.

SURVEY	SEX	
	Male (%)	Female (%)
September 1999	49.6	50.4
April 2000	32.9	67.1
July 2000	40.0	60.0

Table 1. Percentage of male and female *P. cataphractum* in the Eastern Ionian Sea per survey.

Eight age groups were identified from age reading (Table 2) and the estimated growth parameters were: L_∞ = 384.03 mm TL, k= 0.182 yr^{-1}, t_o = -1.3606 yr. The observed and estimated lengths-at-age are shown in Table 2.

Table 2. Observed lengths-at-age (mm, ±SE) of *P. cataphractum* in the Eastern Ionian Sea and their calculated estimates using the Von Bertalanffy growth model.

Age	Observed Lengths (TL, mm) ±SE	Calculated Lengths (TL, mm)
0+	92.2± 2.8	-
1	128.4±1.8	134.1
2	176.2±1.5	175.7
3	212.7±1.7	210.4
4	236.5±1.9	239.3
5	265.7±3.6	263.4
6	264*	283.4
7	286*	300.2

* results from only one specimen

Discussion

Our results indicated that the spawning period of the *P. cataphractum* in the northern part of the Eastern Ionian Sea is extended, starting from summer with a maximum in autumn. The end of the period was not identified because of the lack of winter data. Our results coincide with those found for the southern part of the Eastern Ionian Sea [4], which show a long reproductive period with a peak in the gonadosomatic values from May to September and a maximum value in September for females and August for males. However, reproduction in the Sicilian Channel [2] takes place earlier, extending from spring to summer.

Regarding sex ratio, our results were similar with those mentioned for Sicilian Channel [2], indicating generally a slight predominance of females. However, sex ratio in autumn – almost 1:1 – might indicate a movement of males to meet females during the spawning period.

The estimated lengths-at-age, using the von Bertalanffy growth, parameters were close to those estimated for the Sicilian Channel [2], using a length-based method.

References

1 - Pizzicori, P., Ragonese, S., and Rizzo, P., 1995. Sulla distributione e biologia del pesce forca, *Peristedion cataphractum* L. 1758 (Peristeidae) nello Stretto di Sicilia (Mediterraneo Centrale). *Biol. Mar. Medit.* 2 (2): 287-293.

2 - Dodelrein, P., 1879. Manuale ittiologico del Mediterraneo. Palermo. Pp. 313-317.

3 - Sparta, A., 1947. Rilievi su staid atribuiti a *Myctophum gemellari* Cocco e periodo di maturita sessuale, uova, stadi embrionali e post embrionali di *Peristedion cataphractum*. *Boll. Pesca Piscic. Idrobiol.* 23, 2: 5-12.

4 - Terrats, A. and Petrakis, G., 1999. Gonadosomatic and hepatosomatic index fluctuations of two deep-water fish species in the Eastern Ionian Sea. Proceed. 6th Inter. Symp. Reprod. Physiol. Fish, 114 p.

5 - Nikolsky, G. V, 1976. The ecology of fishes. Academic Press, New York-London, 6th ed., 352 p.

A MUCILAGINOUS DIATOM BLOOM IN THE MIDDLE ADRIATIC

Živana Ninčević-Gladan *, Ivona Marasović, Grozdan Kušpilić, Saša Marinović and Sanda Skejić
Institute of Oceanography and Fisheries, Split, Croatia - nincevic@izor.hr

Abstract
In June and July 2002 a mucilaginous bloom appeared in the middle Adriatic Sea in coastal water and the open sea. Microscopic analysis revealed the diatoms *Skeletonema costatum, Nitzschia closterium* and *Pseudonitzschia seriata* complex were associated with the bloom in the coastal water, whereas in a sample from the open waters, filamentous cyanobacteria were abundant as well as diatoms. Unusually high surface temperature and concentration of orthophosphate were recorded during the bloom in Kaštela Bay.

Key-words: Adriatic Sea, mucilaginous bloom, diatom

Introduction

The presence of mucilage or marine snow is a phenomenon that has been known for a long time. It is characteristic in eutrophic waters of the northern Adriatic where mucilage events harm tourism and fisheries. The extracellular release of organic matter by marine phytoplankton is a normal physiological process which is closely related to the rate of the photosynthesis and constitutes up to 5 μg C l^{-1} h^{-1} of the total primary production in coastal waters (1). In June and July 2002 this phenomenon was recorded in the middle Adriatic Sea. The aim of this paper is to determine which phytoplankton species have caused the bloom, and what ecological factors favored it.

Materials and Methods

During the mucilage bloom samples were taken in Kaštela Bay and in Brač channel (coastal water). One sample was taken in the open sea, near the islands Silba and Premuda. Temperatures were recorded *in situ* by CTD. Abundance and structure of phytoplankton community were determined using the Utermöhl method (2). Nutrients concentrations were determined on an AutoAnalayzer II system, using modified automated methods (3). Oxygen concentrations were determined by Winkler method (4).

Results

Surface temperature ranging from 23.2 to 25.1^{0}C were recorded in Kaštela Bay during June, whereas the 12-year average value is 21^{0}C. Unusually high concentrations of orthophosphate in both surface and bottom layers were recorded (Tab. 1). High concentration of silica was recorded in the surface layer.

Table 1. Ranges of oxygen saturation (%) and nutrients concentrations (mmol m^{-3}) in surface and bottom layer in Kaštela Bay.

	O_2%	N-inorganic	PO4	SiO4
Surface layer	123–152	1.47–2.16	0.117–1.010	3.18-5.88
Bottom layer	81–100	1.35–2.79	0.008–0.966	1.14–3.35

In May, the diatoms *Chaetoceros curvisetus* and *Chaetoceros affinis* dominated the phytoplankton community in Kaštela Bay with concentrations up to 1.1 x 10^6 cells L^{-1}. During the mucilaginous bloom, the most abundant species in Kaštela Bay were *Skeletonema costatum Nitzschia closterium* and *Pseudonitzschia seriata* complex with concentrations of 1.9 x 10^6 cells L^{-1}, 2.0 x 10^5 cells L^{-1} and 1.1 x 10^5 cells L^{-1} respectively. In the Brač channel *N. closterium* (Fig.1) prevailed with concentrations of 1.7 x 10^6 cells L^{-1}. In the open sea filamentous cyanobacteria were abundant as well as pennate diatoms. A few days after the appearance of the bloom, the dinoflagellates *Prorocentrum micans, Gymnodinium* spp., *Amphidinium carterae, Alexandrium* sp., as well as microflagellate sp. embedded in mucilage appeared in the coastal waters. Bottom hypoxia or anoxia was not recorded during or after the bloom.

Discussion

The formation of mucilage was mostly associated with diatoms, though in the open sea filamentous cyanobacteria were abundant, implying that ecological factors are more responsible for mucilage formations than specific phytoplankton species. High temperature and imbalance in nutrient ratio seems to play important roles in mucilage formation (5,6). Nutrient limitation can stimulate mucilage production by marine phytoplankton. Experimental study reveals that under phosphorus limitation the diatom *N. closterium* releases high amounts of extracellular polysaccharide, while *Chaetoceros* sp. and *S. costatum* are the best producers of extracellular polysaccharide under nitrogen limitation (6). There is no one unique nutrient-limiting factor that is responsible for extracellular release of polysaccharide by marine phytoplankton.

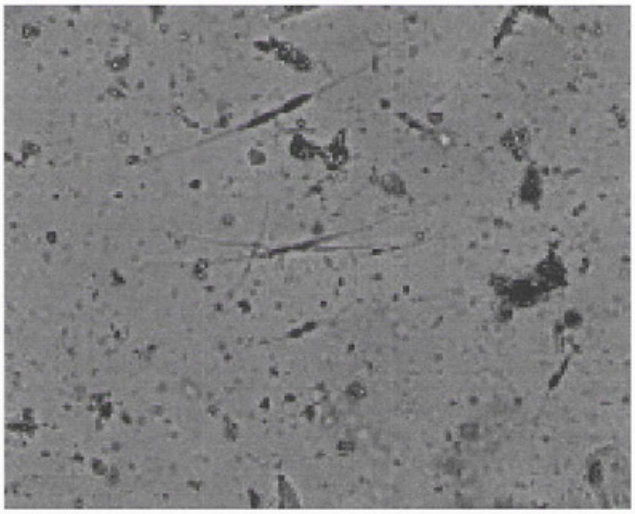

Fig. 1. Diatom *N. closterium* prevailed in mucilage bloom in Brac channel.

References

1 - Mague T.H., Friberg E., Hughes D.J., and Morris I., 1980. Extracellular release of carbon by marine phytoplankton; a physiological approach. *Limnol. Oceanogr.*, 25: 262-279.
2 - Utermöhl H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton Methodik. *Mitt. int. Ver. Limnol.* 9: 1-38.
3 - Grasshof, K., 1976. Methods of seawater analysis. Verlag Chemie, Weinhein, 307 p.
4 - Strickland J.D.H., and Parsons T.R., 1968. A practical Handbook of Seawater analysis, *Fisheries Research Board of Canada*, 167: 1-311.
5 - Penna N., Rinaldi A., Montanari G., Di Paolo A., and Penna A., 1993. Mucilaginous masses in the Adriatic Sea in the summer of 1989. *Wat. Res.*, 27: 1767-1771.
6 - Penna A., Berluti S., Penna N., and Magnani M., 1999. Influence of nutrient ratios on the *in vitro* extracellular polysaccharide production by marine diatoms from the Adriatic Sea. *J. Plankton Res.*, 21: 1681-1690.

IMPORTANCE OF CILIATED PROTOZOA TO THE CULTURE OF THE MUSSEL *MYTILUS GALLOPROVINCIALIS* L. IN THE BAY OF MALI STON, CROATIA

Jakica Njire *, Jakša Bolotin and Davor Lučić

Institute of Oceanography and Fisheries- Split, Laboratory of Plankton Ecology, Dubrovnik, Croatia - * jnjire@yahoo.com

Abstract

This study addresses the influence of ciliated protozoans on the Black Mussel, *Mytilus galloprovincialis*, in Mali Ston Bay (Croatia), an important regional bivalve farming area. A peak in bivalve larvae, mostly Mytilidae, was noted a few weeks after an intensive development of ciliated protozoans. The smallest fraction of ciliates presents a suitable food resource for larvae, whereas the larger fraction appears to be the major food source for adult mussels. These favorable nutrition conditions occur at the onset of spawning, and during the period at which larvae are most numerous.

Keywords: bivalve larvae, ciliated Protozoa, Adriatic

Introduction

Mali Ston Bay on Croatia's southern Adriatic coast is one of the more important bivalve farming areas in Europe. The two main species cultured are the Black Mussel, *Mytilus galloprovincialis* (Lamarck, 1819), and the European flat oyster, *Ostrea edulis* (Linnaeus, 1758).

As filter-feeders, shellfish require an adequate supply of phytoplankton for their successful cultivation (1, 2), but non-algal food also may play an important role in their nutrition, especially when phytoplankton are at seasonal lows. For example, mussels kept in experimental marine enclosures reduced microzooplankton biomass – mainly tintinnids and oligotrich ciliates – by more than 50%.

Systematic description of the interrelations between key ecological factors and ciliate populations – with particular attention to their influence on commercial bivalve larvae – yet has not been made. The present work analyzes the spatio-temporal distribution of bivalve larvae in relation to ciliated protozoa and hydrography in Mali Ston Bay.

Materials and methods

Weekly samples were collected from December 2001 to June 2002 at Bistrina station, in the inner part of Mali Ston Bay (42°53'N 17°42'E). Temperature and salinity were measured with a WTW multiline hydrographical probe, and samples of planktonic ciliates and micrometazoans were taken with a 5-l Niskin bottle at 2-m intervals, down to 6 m.

Results and discussion

The inner part of the Mali Ston bay abounds with natural beds of *M. galloprovincialis*, and their larvae dominate the plankton throughout the year. Spawning is intense from February to June.

Temperature (Table 1) ranged from 6.9° to 25.1° C. Relatively low temperatures (<13°C) correlated significantly with increased numbers of bivalve larvae (Table 2) in Mali Ston Bay, as is the case in the northern Adriatic (3).

There was also a highly significant correlation between larval abundance and salinity. This is consistent with other reports (1, 3) that salinity from 35 to 36 psu is related to mass occurrence and survival of this mussel.

Food availability has, perhaps, the greatest influence on larval development. Despite the accumulated information of the influence of a diverse range of phytoplankton species of the growth and development of mussel larvae, there still are few data that address the possibility of using ciliates for food. The significant correlation between ciliate numbers and bivalve larvae (Table 2) suggests the importance of ciliated protozoa in larval nutrition: The highest protist biomass-recorded from the end of January to mid April, and which spanned the period during which the larvae of commercial bivalves were found in the plankton-consisted mainly (mean 76,5%) of oligotrich ciliates. In the presence of this high number of ciliates, the larvae presumably fed on the smallest fraction (<20 μm in size). On the other hand, according Kršinić (4), the larger size of ciliates found in winter are a major source of food for adult mussels through early spring, the time when spawning begins.

These results present circumstantial evidence that during winter and early spring ciliated protozoans play a great role in the successful culture of mussels in Mali Ston Bay.

Table 1. Range, mean ± SD of temperature (oC) and salinity (psu) from December 2000 to June 2001 at Bistrina station in Mali Ston Bay.

December 2000 – June 2001

	Surface		Depth 2m		Depth 4m		Depth 6m	
	Temp	Sal	Temp	Sal	Temp	Sal	Temp	Sal
Min	6.9	22.1	6.9	31.1	7.3	32.0	7.7	33.1
Max	25.1	36.7	25.0	37.0	24.0	37.5	23.8	37.9
Mean	13.7	33.9	13.7	34.9	13.8	35.8	13.8	36.4
SD	4.5	3.3	4.3	1.5	4.1	1.3	3.7	1.2

Table 2. Pearson r-correlation coefficients between bivalvia larvae, salinity, temperature, oligotrich ciliates, tintinnines and total ciliates.

	Temp	Sal	Olig ciliates	Tin	Total ciliates
Bivalvia larvae	0.544** *	0.634** *	0.233*	0.182	0.218*

(*P<0.05; ***P<0.001)

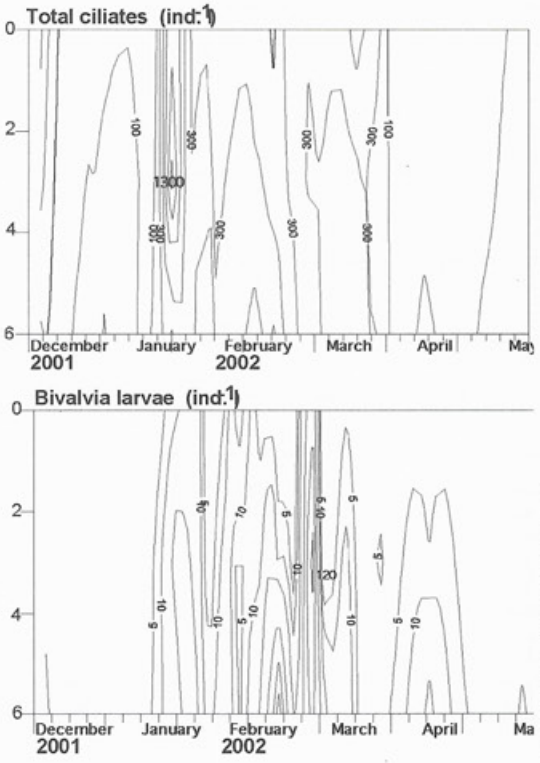

Fig. 1. Distribution of total ciliates and bivalvia larvae density (ind. l-1) at Bistrina station in Mali Ston Bay.

References

1 - Viličić D., Mušin D., and Jasprica N.. Interrelations between hydrographic conditions, nanoplankton and bivalvia larvae in the Mali Ston bay (Southern Adriatic). *Acta Adriat.*, 34: 55-64.

2 - Jasprica N., Carić M., Bolotin J., and Rudenjak-Lukenda M., 1997. The Mediterranean mussel (*Mytilus galloprovincialis* Lmk.) growth rate response to phytoplankton and microzooplankton population densities in the Mali Ston Bay (Souther Adriatic). *Period. biol.*, 99: 255-264.

3 - Hrs-Brenko M., 1980. The settlement of mussels and oysters in the northern Adriatic Sea. *Nova Thalassia*, 4: 67-85.

4 - Kršinić F., 1987. On the ecology of Tintinnines in the Bay of Mali Ston (Eastern Adriatic). *Estuar. coast Shelf Sci.*, 24: 401-418.

RÉGIME ALIMENTAIRE DU SPARAILLON *DIPLODUS ANNULARIS* (L., 1758) DU GOLFE D'ANNABA (ALGÉRIE EST)

Nouacer S. *, Derbal F., Kara M. H.

Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie

Résumé

Le régime alimentaire de *Diplodus annularis* est étudié d'octobre 1999 à septembre 2000. Un total de 719 estomacs est examiné, dont 319 étaient vides. Avec une richesse taxonomique égale à 18, le sparaillon est omnivore. Les végétaux et les ascidies constituent l'essentiel de son alimentation. Cependant, aucun aliment n'est préférentiel ni même principal.

Mots-clés: alimentation, sparaillon, Méditerranée, Algérie

Introduction

Le sparaillon *Diplodus annularis* est l'un des vingt espèces de sparidés qui habitent les côtes Est de l'Algérie (1). Son aire de distribution couvre l'ensemble de la Méditerranée, de l'Adriatique et de la mer Noire. En Atlantique, sa limite septentrionale se situe à proximité d'Arcachon. En Méditerranée, *D. annularis* est peu étudié (2, 3). Sur les côtes de l'Afrique du Nord, les principales données concernent sa morphologie, sa biologie et la dynamique de ses populations (4, 5, 6). Cette étude est consacrée à son alimentation sur les côtes de l'Est algérien.

Matériel et méthodes

Un total de 719 individus, de longueur totale comprise entre 10,4 cm (17 g) et 18,8 cm (118 g), sont considérés. Après examen des contenus stomacaux, les différentes proies ingérées sont identifiées, dénombrées puis pesées au centième de gramme près.

L'analyse quantitative consiste à calculer mensuellement le coefficient de vacuité stomacale (C_v %). Les différentes proies sont classées selon leur prépondérance (fréquence, nombre, poids) en utilisant l'indice d'aliment principal (7).

Résultats

Le coefficient de vacuité stomacale moyen est de 44,3 %. Avec une valeur minimale (20 %) en octobre, il atteint son maximum (76,76 %) en janvier. L'examen de 400 estomacs pleins a permis de reconnaître dix huit unités taxonomiques (Tab. 1). Au total, 4731 proies pesant 47,92 g ont été dénombrées, ce qui correspond à un nombre et un poids moyens respectifs de 12 et 0,12 g par estomac. Le poids moyen de l'unité systématique est de 0,01 g.

Les ascidies dominent numériquement (Cn = 46 %), suivis des mollusques puis des crustacés. Pondéralement, les végétaux sont les mieux représentés (Cp = 25 %), suivis des ascidies et des crustacés. Les macrophytes (F = 49,25 %), notamment les thallophytes (F = 40,25 %), sont les proies les plus fréquentes. Les crustacés viennent au second rang avec une fréquence de 39 %.

Tab. 1. Composition de l'alimentation de *D. annularis* du golfe d'Annaba et classement des proies ingérées selon l'indice d'aliment principal (MFI).

Taxons	F (%)	Cn (%)	Cp (%)	MFI
ASCIDIES	**25,75**	**46,02**	**17,67**	**25,18**
- *Clavelina* sp.	8	35,09	3,81	
- *Ciona* sp.	1,25	0,17	0,71	
- n.d	19,5	42,34	13,15	
CRUSTACES	**38,75**	**15,32**	**17,05**	**21,47**
- Cirripèdes	1	0,21	0,38	
- n.d	0,75	0,13	0,2	
- Branchiopodes	1,75	0,25	0,92	
- Tanaidacés	0,5	0,04	0,01	
- *Apseudes spinosus*	0,25	0,02	-	
- n.d	0,25	0,02	0,01	
- Nebaliacés	1,25	0,13	0,01	
- *Nebalia* sp.	0,75	0,08	-	
- n.d.	0,25	0,04	-	
- Amphipodes	14,75	4,31	0,64	
- *Gammarus locusta*	1	0,15	0,05	
- *Orchestia gammarella*	0,25	0,04	-	
- *Talitrus saltator*	0,5	0,15	0,04	
- *Caprella linearis*	0,5	0,27	0,04	
- n.d	12,75	1,8	0,51	
- Cumacés	7,75	5,62	0,45	
- Mysidacés	7,50	2,07	0,93	
- *Mysis* sp.	0,25	0,06	-	
- n.d	7,25	2,01	0,92	
- Isopodes	3,25	1,29	0,66	
- Décapodes macroures	3,5	0,55	4,36	
- *Scyllarus* sp.	0,5	0,06	0,88	
- n.d	3,25	0,49	3,48	
- Décapodes brachyoures	7,5	0,85	8,71	
- *Liocarinus* sp.	0,5	0,04	0,49	
- n.d	7,5	0,82	8,22	
MACROPHYTES	**49,25**	**4,16**	**25,76**	**26,23**
- Algues	40,25	3,4	24,97	
- Phanérogames	9	0,76	0,8	
MOLLUSQUES	**19,75**	**19,87**	**7,98**	**12,57**
- Gastéropodes	12,05	13,55	1,98	
- *Turritella communis*	0,75	0,06	0,46	
- *Nassarus* sp.	0,25	0,02	0,01	
- n.d.	11,5	13,46	1,51	
- Lamellibranches	16,75	6,11	4,47	
- *Scrobicularia* sp.	1,25	0,11	0,07	
- n.d	16	6,0	4,4	
- Céphalopodes	2,25	0,21	1,53	
- *Loligo* sp.	2,25	0,21	1,53	
CNIDAIRES	**9,75**	**1,75**	**11,09**	**7,99**
- *Asteroides sabylaris*	0,5	0,06	0,01	
- n.d.	9,25	1,69	11,08	
MEROPLANCTON (Œufs)	**1,75**	**5,5**	**3,99**	**3,8**
ANNELIDES	**10,25**	**1,65**	**1,34**	**2,82**
- *Nereis* sp.	4,75	1,25	0,95	
- n.d	5,75	0,4	0,39	
NEMATODES	**8,5**	**1,5**	**1,42**	**2,6**
POISSONS TELEOSTEENS	**11,25**	**1,21**	**0,97**	**2,46**
BRYOZOAIRES	**2,75**	**0,23**	**0,34**	**0,71**
ECHINODERMES (Ophiurides)	**1,5**	**0,17**	**0,36**	**0,55**
- *Amphipholis squamata*	1,5	0,17	0,36	0,55
SPONGIAIRES	**0,25**	**0,15**	**0,25**	**0,22**
DIVERS	**29,25**	**2,47**	**11,78**	**13,67**

Discussion

Le coefficient de vacuité stomacale moyen enregistré dans le golfe d'Annaba est nettement inférieur à celui obtenu dans le golfe de Gabès (CV = 91,4 %) (8). Ses variations mensuelles mettent en évidence un rythme alimentaire saisonnier, caractérisé par une intense activité de février à mai.

La richesse spécifique dans les contenus stomacaux (diversité = 18) est nettement inférieure à celle dans le golfe du Lion (3) ou du golfe de Gabès (8). La présence de végétaux dans environ 50 % des estomacs pleins examinés montre que ce sar est omnivore. Dans le golfe de Gabès (8), les végétaux sont considérés comme des proies accessoires. Les tuniciers prédominent dans les estomacs de *D. annularis* du golfe d'Annaba, alors qu'ils sont absents de la liste des proies ingérées par ce sar dans d'autres localités marines ou lagunaire (3, 8, 9).

D'après l'indice d'aliment principal (MFI), aucune proie ne peut être considérée comme préférentielle ou principale. Les macrophytes et les ascidies sont des proies secondaires. Les autres taxons ne sont ingérées qu'accessoirement.

Références

1 - Derbal F., Kara M. H., 2001. Inventaire des poissons des côtes de l'est algérien. *Rapp. Comm. int. Mer Médit.*, 36: 258.

2 - Rabenevanana A., 1985. Les sars du golfe du Lion : *Diplodus sargus, D. vulgaris, D. annularis*. Ecobiologie – pêche. Thèse de 3ème cycle. Univ. Montpellier II. 361 p.

3 - Rosecchi E., 1987. Alimentation de *Diplodus annularis, D. sargus, D. vulgaris* et *Sparus aurata* dans le Golfe du Lion et les lagunes littorales. *Rev. Trav. Inst. Pêches marit.*, 49(3 et 4): 125-141.

4 - Bradai M. N., 2000. Diversité des peuplements ichtyques et contribution à la connaissance des sparidés du golfe de Gabès. Thèse de Doctorat d'Etat. Université de Sfax (Tunisie).

5 - Nouacer S., Kara M. H., 2001. Taille à la première maturité sexuelle, période de ponte et relation taille-poids chez le sparaillon *Diplodus annularis* des côtes d'Annaba. *Rapp. Comm. int. Mer Médit.*, 36: 408.

6 - Nouacer S., Kara M. H., 2003. Biologie du sparaillon *Diplodus annularis* des côtes d'Annaba. Deuxièmes Rencontres de l'ichtyologie en France (RIF 2003). Paris, 25-28 mars 2003.

7 - Zander C. D., 1982. Feeding ecology of littoral gobiid and blennioid fish of the Banyuls area (Mediterranean sea). I. Main food and trophic dimension of niche and ecotype. *Vie et Milieu*, 32(1): 1-10.

8 - Bradai M. N., Jarboui O., Ghorbel M., Bouain A., El-Abed A., 1998. Régime alimentaire de *D. annularis* et *Lithognathus mormyrus* dans la région du Golfe de Gabès, Tunisie. *Bull. INSTM*, 4: 12-15.

9 - Porcile P., Repetto N., Wurtz M., 1989. Comportamento alimentare di giovani sparidi in una prateria di *Posidonia oceanica* del mar ligure. *Oebalia*, 15: 311-314.

CROISSANCE, MORTALITÉ ET EXPLOITATION DE *HELICOLENUS DACTYLOPTERUS DACTYLOPTERUS* (DELAROCHE, 1809) DES CÔTES ALGÉRIENNES

Ahmed Nouar

Laboratoire Halieutique, USTHB, Alger, Algérie - ahmednouar@hotmail.com

Résumé

Les paramètres de croissance de *H. dactylopterus* des côtes algériennes sont déterminés par analyse des structures de taille. D'autres paramètres, notamment les coefficients de mortalité totale, naturelle et par pêche ainsi que les tailles de recrutement et de sélection ont servi à l'application d'un modèle analytique qui indique que l'exploitation des zones de pêche se situe à un niveau actuel optimal.

Mots clés: Helicolenus dactylopterus, croissance, exploitation, Algérie

Introduction

Les chalutiers algériens exploitent des fonds de pêche situés entre 200 et 400 mètres à la recherche des crevettes profondes en particulier *Aristeus antennatus* pour sa haute valeur commerciale (1). Sur ces fonds *Helicolenus dactylopterus dactylopterus* (Delaroche, 1809) présente une fréquence et une abondance relativement élevées. L'utilisation d'un modèle analytique permet de situer le niveau d'exploitation de ce poisson.

Matériel et méthode

Les données utilisées proviennent des apports des chalutiers de la région centrale algérienne. Ces navires exploitent les zones de pêche connues pour leur bon rendement en crevettes à des profondeurs allant de 200 à 400 mètres (2).

Les paramètres de croissance de von Bertalanffy sont déterminés par analyse des structures de taille avec les méthodes de Powell-Wetherall (in 3) pour $L\infty$, de (4) pour K et de (5) pour to.

Le coefficients de mortalité totale (Z) est estimé par la méthode de Powell-Wetherall, celui de la naturelle (M) par l'équation de (6). Connaissant Z et M, le coefficient de mortalité par pêche F est estimé. La taille de recrutement est calculée à partir des jeunes individus observés dans les captures pendant la période de recrutement et la taille de capture est estimée par la méthode de (7).

L'utilisation du modèle analytique de (8) permet d'évaluer le rendement relatif par recrue Y'/R dont les calculs sont effectués à l'aide logiciel FISAT (9).

Résultats

A partir de la distribution de fréquence de taille de 1051 individus, $L\infty$ et Z/K déterminés sont respectivement de 34,32 cm et 5,04. La valeur moyenne de vitesse de croissance Ø' m est égale à 2,13. Ainsi la valeur de K est estimée à 0,114, celle de t_0 est de -2,11.

Le coefficient de mortalité totale Z obtenu est de 0,57. Pour les paramètres de croissance définis précédemment et une température moyenne de 13,2 °C, la valeur du coefficient de mortalité naturelle M estimée est de 0,26. Le coefficient de mortalité par pêche F est de 0,31 et la valeur du taux d'exploitation E est égale à 0,54.

Sur la base de la distribution de fréquence de taille de 192 jeunes individus (de 5 à 8 cm et âgés de 6 et 12 mois) la taille moyenne de recrutement est de 6,6 cm ; elle correspond à un âge moyen de 9 mois. La présence de jeunes individus durant toute l'année dans les zones de pêche signifie que le recrutement est continu. La taille de première capture est de 12,6 cm et correspond à un âge de 1,9 an.

Les paramètres de croissance et d'exploitation ainsi obtenus (Tab. 1) permettent de calculer les rendements relatifs par recrue Y'/R (Tab. 2). Pour la taille actuelle de première capture Lc égale à 12,6 cm, le maximum de Y'/R est obtenu à un taux d'exploitation E de 0,624, très proche du taux actuel d'exploitation égal à 0,54. Ce résultat met en évidence que l'exploitation actuelle se situe à un niveau optimal et qu'une augmentation de l'effort de pêche ou une modification de la maille du chalut n'améliorent pas le rendement des apports actuels.

Tab. 1. Paramètres de croissance et d'exploitation de *H. dactylopterus* utilisés pour le calcul de Y'/R.

W∞ (g)	K (an)	t_0 (an)	Z (an)	M (an)	F (an)	Lr (cm)	tr (an)	Lc (cm)	tc (an)
596,85	0,114	-2,11	0,57	0,26	0,31	6,6	0,75	12,6	1,90

Discussion

Nos résultats sur la croissance en accord avec les travaux de (10) de (11) et de (12) indiquent que, dans l'ensemble, l'espèce présente une même croissance en Méditerranée.

Tab. 2. Rendement relatif par recrue Y'/R en fonction du taux d'exploitation E et pour différentes valeurs de la taille de première capture Lc.

Lc E	6	8	10	12	14	16	12,6
0,1	0,0071	0,0071	0,0070	0,0069	0,0066	0,0062	0,0068
0,2	0,0121	0,0124	0,0126	0,0125	0,0122	0,0116	0,0125
0,3	0,0153	0,0160	0,0166	0,0169	0,0167	0,0161	0,0169
0,4	0,0166	0,0180	0,0192	0,0199	0,0201	0,0198	0,0201
0,5	0,0164	0,0184	0,0203	0,0217	0,0225	0,0226	0,0220
0,6	0,0147	0,0174	0,0200	0,0223	0,0238	0,0245	0,0228
0,7	0,0120	0,0154	0,0187	0,0218	0,0242	0,0256	0,0226
0,8	0,0088	0,0126	0,0165	0,0204	0,0236	0,0257	0,0214
0,9	0,0058	0,0096	0,0139	0,0184	0,0222	0,0252	0,0196
1	0,0034	0,0069	0,0112	0,0160	0,0205	0,0242	0,0174

Sur les fonds de pêche situés entre 200 et 400 mètres de profondeur l'exploitation de l'espèce atteint son niveau optimal. Le déplacement de l'effort de pêche vers des zones plus profondes (au delà des 400 mètres) encore inexploitées et riches en crevettes permet d'améliorer les rendements.

Références

1- Nouar, A., 2001. Bio-écologie de *Aristeus antennatus* (Risso, 1816) et de *Parapeneaeus longirostris* (Lucas, 1846) des côtes algériennes. *Rapp. Comm. int. Mer Médit.*, 36: 304.

2 - Nouar, A., 1985. Contribution à l'étude de la crevette Péneidé: *Parapeneaeus longirostris* (Lucas, 1846) dans la région d'Alger. Ecologie, biologie, exploitation. *U.S.T.H.B. Thèse Magister,* 136 p.

3 - Sparre, P., Venema, S. C., 1996. Introduction à l'évaluation des stocks de poissons tropicaux. Prem. part. Manuel. *FAO Doc. tech. pêches*. 306 (1): 401 p.

4- Pauly, D., Munro, J. L., 1984. Once more on the comparison of growth in fish and invertebrates. *ICLARM Fishbyte*, 2 (1): 21.

5- Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters, and mean environmental temperature in 175 fish stocks. *J. Cons. CIEM*, 39 (2): 175-192.

6- Djabali, F., Mehailia, A., Koudil, M., Brahmi, B., 1993. Empirical equations for the estimation of natural mortality in Mediterranean. Teleosts. *NAGA, the ICLARM* quart.: 35-37.

7- Pauly, D., 1984. Length-converted catch curves. A powerful tool for fisheries research in the tropics. (Part II). *ICLARM Fishbyte*, 2 (1): 9-17.

8- Beverton, R.J.H., Holt, S.J., 1966. Manuel of methods for fish stock assessement. Part 2. Tables of yield functions. *FAO Fish. Tech. Pap.*, 38 (1): 67p.

9- Gayanilo, J., Sparre, P., Pauly, D., 1995. The FAO ICLARM Stock Assessment Tools User's guide. *FAO Comp. Inf. Ser. Fish.*, 8: 129.

10- Ragonese, S., Reale, B., 1995. Distribuzione e crescita dello scorfano di fondale, *Helicolenus dactylopterus dactylopterus* (Delaroche 1809), nello Stretto di Sicilia (Mar Mediterraneo). *Biol. Mar. Médit.*, 2 (2): 269-273.

11- D'Onghia, G., Mastrotaro, F., Panza, M., 1996. On the growth and mortality of rockfish, *Helicolenus dactylopterus* (Delaroche 1809), from the Ionian Sea. F.*A.O Fish. Rep*. 533, 143-152.

12- Massuti, E., Morales-Nin, B., Moranta, J., 2000. Age and growth of blue-mouth, *Helicolenus dactylopterus* (Osteichthyes: Scorpaenidae); in the western Mediterranean. *Fish. Res.*, 46: 165-176.

BIOGEOGRAPHICAL STRUCTURE OF ZOOPLANKTON COMMUNITY ALONG THE NORTHWESTERN COAST OF EGYPT

Nehad M. Nour El-Din

Oceanography Department, Faculty of Science, Alexandria University, Egypt - nmnoureldin@yahoo.com

Abstract

The biogeographical structure of zooplankton assemblages was studied for the NW coast of Egypt. Vertical and horizontal hauls were collected from 4 sectors during 2002. The zooplankton population appears both qualitatively and quantitatively quite heterogeneous. Copepods represent the most important group followed by Chaetognaths, Cladocera, Appendicularians and larval stages of Gastropods. The specific diversity of the zooplankton community is generally quite high. About 30 to 39 species per station have been counted, with a total of about 96 species identified over the whole survey. The exposure of the area to different types of pollutants, the hydrography of the area as well as food availability are the main factors affecting the geographical distribution and abundance of zooplankton community.

Keywords: Zooplankton distribution, diversity, environmental stress, Egyptian coast

Introduction

The NW coast of Egypt extends from west of Alexandria to the Libyan borders. The coast is a fragile environment receiving less amount of discharge from Land-based activities when compared to the Nile delta and Alexandria coastal waters. However, the development along the NW coast and its exposure to pollution discharge, especially from oil tankers, renders the area to fall continuously under environmental stress.

Environmental factors play a major role in the distribution pattern of zooplankton and species composition in the marine system. Their abundance are not only associated with changes in food supply but also with combined effect exerted by hydrographic conditions and pollution stress. In view of the increasing exposure of the NW coast of Egypt to man-made activities, the present survey aimed to investigate the impact of such activities on the numerical abundance, distribution pattern and diversity of the zooplankton community.

Results and discussion

Along the NW coast of Egypt, zooplankton samples were collected from four sectors namely from east to west: Agami, Krir, W. Dabaa and Matrouh, extending west of Alexandria city, using an 0.5 m mouth diameter and 120 µm net. Samples locations were chosen in inshore/offshore sectors opposite to main man-made-activities as well as oil related activities in the area.

The zooplankton population is quantitatively very heterogonous varying between 35 and 2940 individuals/m^3. The population density increased towards the eastern inshore sectors presenting an absolute and relative maximum density for certain number of species such as: *Centropages kroyeri*, an epiplanktonic hot tempered area copepod, frequent in the region; *Evadne spinifera* (Cladocera) thermophilic, very frequent in the eastern part of the Mediterranean Sea and *Sagitta friderici* (Chaetognatha) also an indicator of the Atlantic Ocean waters. The oceanic influence at the offshore stations is confirmed by the appearance of some Tunicata and especially Appendicularia belonging to the Oikopleura genus. *Tretomphallus bulloides* (Foraminifera) formed 65% of the zooplankton population at areas rich with *Posedonia oceanica* leaves. The poverty of holoplanktonic forms off Krir (subjected to deliberate disposal of ballast water) is probably related to the abundance of plastic rubbish and hydrocarbon pellets collected concurrently at this sector.

Copepods dominated the zooplankton community constituting more than 70% in most stations. The main copepod group was Calanoidae represented by the neritic species: *Clausocalanus furcatus, Labidocera brunescens, Paracalanus parvus, Centropages kroyeri. Acartia josephina*, which reached its maximum number at the inshore stations of the most eastern sector, indicated the exposure of the area to organic pollution.

Despite the exposure to land-based discharge, the zooplankton community of the eastern sectors is more richer and diversified. These sectors were dominated by *Clausocalanus furcatus*. High values of Shanon Diversity Index (3-3.5) indicate great structuring and maturity of the population.

The extreme povirty of the phytoplanktonic population is the most characteristic feature of the area (range 230 to 22,605 cells/liter). Chlorophyll a values were normally < 1 µg/L, especially for the western sectors. While food availability seems to control zooplankton abundance along the western sectors, the distribution of zooplankton community is more controlled with the discharge from Land-based activities.

A PROPOSAL FOR A UNIFORM TERMINOLOGY ON BIOINVASIONS FOR MEDITERRANEAN MARINE SCIENTISTS

Anna Occhipinti-Ambrogi [1] * and Bella S. Galil [2]

[1] University of Pavia, Department of Genetics and Microbiology, Ecology Section, Pavia, Italy - * anna.occhipinti@unipv.it
[2] National Institute of Oceanography. Israel Oceanographic and Limnological Research, Haifa Israel.

Abstract

A consensual set of definitions regarding bioinvasions is essential in order to facilitate discourse among the science, policy and management communities dealing with the issue. Considering both the extent of the impact and the mode of entry of an alien species into a new environment, some definitions are being proposed as an operative tool for marine scientists working in the Mediterranean Sea.

Key words: biological invasions, definitions

The advent and spread of alien species in the Mediterranean has been repeatedly discussed in various forums over the past three decades, and it has been widely perceived that the littoral and infralittoral biota of the Mediterranean Sea is undergoing a rapid and profound change (1-5). The rapidly expanding study of marine bioinvasions raised awareness and concern of governmental and regulatory bodies as well as the public, and resulted in a glut of specialized terms. The words used to describe non-native species vary among scientific disciplines, linguistic and national borders, and frequently constitute synonyms, partial synonyms and neologisms that hinder communication. Confronted with a plethora of unsettled and overlapping terms for alien organisms, we have sought to clarify the terminology for Mediterranean marine scientists. Our goal is to compile clear and brief definitions for terms needed by students, researchers, and policy and management personnel interested or concerned about invasions in the marine environment. We have combed the literature for the new terminology generated by recent initiatives, including the proposed new IUCN categories defining the status of alien species [1].

Our view of native species and their natural ranges and, *inter alia*, of alien species, is largely dependent on scientific knowledge of the taxa in a certain geographic region. In the Mediterranean Sea, for instance, a number of extensive biological surveys and identifications were conducted after 1950, thus allowing a reasonable measure of confidence in separating the alien from the native biota, and reducing the cases of cryptogenic species to earlier possible introductions. A notable exception are the Red Sea taxa, where 1920 was chosen as a cut-off date, because the Cambridge expedition to the Suez canal furnished a body of valuable scientific data (4).

In defining the terms we deliberately made a distinction between the scale and impact of the alien populations on the native ecosystem, and their mode of entry. From our studies of alien organisms in the Mediterranean Sea, we have noted that some are known only from chance collections of non-breeding individuals, other from breeding populations that remain for decades in low numbers, whereas in some cases we have witnessed rapid population growth and high impact upon the ecosystem and risk to humans. Accordingly we have ordered our definitions in a nested hierarchy of increasing order of the alien's population size and impact. As to mode of entry, we have made a distinction between introduction, which is wholly derived from human actions, and range expansion, which can result from natural phenomena or from both natural and human-induced environmental changes. Introduction is further divided into primary and secondary introduction and each of these can be intentional or unintentional. Secondary introduction could also result naturally.

In the course of our classification effort, we are aware that nature is a continuum and not easily divided into objective units, we therefore aim to produce a pragmatical tool in order to facilitate the exchange of ideas among the scientists of the many countries bordering the Mediterranean Sea. Moreover, the dynamics of invasion and of research progress mean that organisms may be recognised as fitting in different categories according to the spatial and temporal setting of their observation.

Terms and definitions

• Native : an organism occurring within its known or consensual range (as documented in scientific publications).
• Alien : an organism, inclusive of parts, gametes or propagules that may survive and subsequently reproduce, occurring outside of its known or consensual range (as documented in scientific publications). It includes established aliens, invasive aliens, nuisance aliens in increasing order of population expansion and impact. (Synonymous terms: non-native, non-indigenous, allochtonous, foreign, exotic, immigrant).
• Established alien : an alien organism that is reproducing in the wild and has established a permanent population outside its natural range.
• Invasive alien : an alien organism whose population has undergone an exponential growth stage and may threaten the diversity or abundance of native species and the ecological stability of the impacted ecosystem.
• Nuisance alien : an alien organism that poses a risk to the well-being of humans.

As to mode of entry:

• Expanding alien : an alien organism that has extended its range as a result of changing environmental conditions (e.g. temperature, current regime) or by chance events, such as the attachment to drifting objects and phoresy.
• Introduced alien : an organism occurring outside its native range as a consequence of intentional or unintentional human action.
• Intentional introduction : the deliberate transfer of alien organisms.
• Unintentional introduction : the unintentional transfer of alien organisms through shipping, aquaculture, canals, research etc.
• Secondary introduction : a dispersal of an alien organism beyond its primary location of introduction; secondary introduction could be intentional, unintentiona, or by natural means.

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References

1 - Boudouresque C.F. and Ribera M.A., 1994. Les introductions d'espèces végétales et animales en milieu marin – conséquences écologiques et économiques et problèmes législatifs. In: Boudouresque C.F., Meinesz A., Gravez V. (eds), First International workshop on *Caulerpa taxifolia.* GIS Posidonie Marseille. pp. 29-102.

2 - Ribera M.A., 2002. Review of non-native plants in the Mediterranean Sea. pp. 291-310. In: Leppäkoski, E., S.Gollash S.Olenin (eds). Invasive aquatic species of Europe - Distribution, Impacts and Management. Kluwer Academic Publishers, Dordrecht, The Netherlands.

3 - Galil B., 2000. A sea under siege – alien species in the Mediterranean. *Biol. Invas.* 2: 177-186.

4 - Galil B., C. Froglia and P. Noël, 2002. CIESM Atlas of exotic species in the Mediterranean. Vol.2. Crustaceans: decapods and stomatopods. F. Briand (ed.), CIESM Publishers, Monaco, 192 p.

5 - Golani D., L.Orsi-Relini, E.Massuti and J.-P. Quignard, 2002. CIESM Atlas of exotic species in the Mediterranean. Vol.1 Fishes. F. Briand (ed.), CIESM Publishers, Monaco, 256 p.

6 - Occhipinti Ambrogi A., 2002. Current status of aquatic introductions in Italy. Pp. 311-324. In: Leppäkoski E., S. Gollash, S. Olenin (eds). Invasive aquatic species of Europe - Distribution, Impacts and Management. Kluwer Academic Publishers, Dordrecht, The Netherlands.

1 - Explanatory note on terminology and definitions used in the "IUCN Guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species" - Information paper - Sixth meeting of the Conference of the Parties to the Convention on Biological Diversity (COP6). The Hague, Netherlands, 7-19 April 2002. http://invasivespecies.gov/other/pubs.shtml
- IAS Report Body v4.doc. An initial survey of aquatic invasive species issues in the Gulf of Mexico Region (2000). http://epa.gov/reg4gmpo/pdf/IAS_report_v4.pdf
- Glossary of Biodiversity Terms. UNEP-WCMC WRI.2003. http:/www.unep-wcmc.org/reception/glossary.htm
- Marine pest information sheet. Introduction mechanisms for exotic marine species. CSIRO (2000) http://crimpt.marine.csiro.au
- Multilingual Glossary Forest Genetic Resources. FAO Forestry Department and the IUFRO SilvaVoc Terminology Project, 2002. http://iufro.ffp.csiro.au/iufro/silvavoc/glossary/index.html
- Report of the Working Group on Introductions and Transfers of Marine Organisms, annex 7: 2002 version of the ICES Code of Practice. http://www.ices.dk/reports/acme/2002/WGITMO 02.pdf
- Recommendation No. 57 (1997) on the Introduction of Organisms belonging to Non-Native Species into the Environment. The Standing Committee of the Convention on the Conservation of European Wildlife and Natural Habitats. Council of Europe. http://www.nature.coe.int/english/main/Bern/texts/rec9757.htm

TRACKING THE INDOPACIFIC PELAGIC OCTOPUS *TREMOCTOPUS GRACILIS* IN THE MEDITERRANEAN

Orsi Relini L. [1] *, Belluscio A [2], Ardizzone G. D. [2]

[1] Laboratorio di Biologia Marina ed Ecologia Animale, Dip. Te. Ris, University of Genoa, Italy
[2] Dipartimento di Biologia Animale e dell'Uomo University of Roma "La Sapienza", Roma, Italy

Abstract

Underwater photographs of a pelagic octopus of the genus *Tremoctopus* in the Tyrrhenian Sea allowed to identify the Indopacific species *T. gracilis*. Both *T. gracilis* and *T. violaceus* have been tracked in the old and recent Mediterranean literature, and the hypothesis of the arrival of *T. gracilis* since at least the Thirties in the Mediterranean is proposed.

Keywords: Tremoctopus gracilis, alien cephalopod, Mediterranean

A large berried female of *Tremoctopus* was observed and photographed in coastal waters of the isle of Ponza, in the Tyrrhenian Sea in August 2002. Underwater photographs show an astonishing set of brilliant colours (1). We present here some taxonomical and biogeographical considerations regarding this record.

Pelagic octopuses of genus *Tremoctopus* have an asymmetrical crown of arms, with the dorsal pairs connected by a web, which develops to large sizes in adult females. The genus is characterized by a sharp sexual dimorphism, with a male/female ratio, in terms of mantle length, of about 1:10. Both sexes present autotomic processes in the arms: the male autotomizes his hectocotylized arm during maturity and more than one of these detached arms can be found in the mantle cavity of females. The females sheds segments of the first pair of arms, with the large web and its peculiar colour patterns.

Reviewing the genus, Thomas (2) described two species and two subspecies; at present four species are recognized (3): *T. violaceus* in the Atlantic Ocean and the Mediterranean Sea; *T. gracilis* in the Pacific and Indian Oceans; *T. gelatus* in deep waters worldwide and T. robsoni in New Zealand waters.

T. violaceus was described in the Mediterranean by Stefano delle Chiaje (4; 5). Verany (6) and Jatta (7) presented nice colour tables of this species; however the dorsal arms of females are cut at a short distance from the basis and only few spots in longitudinal array can be seen in the basal segment of the dorsal arms. The fully developed ocelli and wonderful colour pattern of the web of adult females was observed by Müller (8) in Messina (Sicily): the colour of the oral side was changing from orange to red or to violet and the ocellar spots were red with a ring of dazzling white.

The monographs by Jatta (7) and Naef (9) scarcely mention Müller's observations (8) probably because adult females were lacking in the material studied at the Zoological Station of Naples. They were completely forgotten also, 85 years later, when another similar observation was made in the North Adriatic. Kramer (10) obtained several females of *Tremoctopus* from fishermen, including three specimens bearing eggs. He observed some of these in the aquaria of the Station of Marine Biology of Rovigno d'Istria and noted that the dorsal arms of the female can be quickly dilated to a very long shape with large web or shortened and contracted, and that along the arm there are transversal lines of autotomy, which separate segments each one with a sucker and a typical pattern of ocelli. He provided a figure in which the ocellar spots are something different both from figures of previous literature and from those obtained on material of the Ligurian Sea (Villefranche) some years later (11).

The significance of the autotomy of the dorsal arm and the role of ocellar spot was given by Nesis (12): the detached segments have a defensive role "the broken off portion instantly widens up to the size of an handkerchief and the bright spots suddenly blazing before predator's eyes on the transparent membrane distract and probably frighten the enemy thus allowing the female to flee". According to Nesis (12) the specific pattern of ocelli on the arms of females has also a taxonomic value, being useful to separate the Atlantic Mediterranean form (at present *Tremoctopus violaceus*) from the indopacific form (at present *T. gracilis*): a single line of ocelli in the former and double lines of ocelli in the latter.

The Mediterranean literature presents the two cases: *T. violaceus* on the basis of the figures of Verany (6), Jatta (7) and especially of Portmann (11); *T. gracilis* in the figures of Kramer (10) and the recent photos (1). These facts represent an interesting geographical problem: is *T. gracilis* native of the Mediterranean (as *T. violaceus*) or does it represent an alien species arrived through the Suez Canal?

In 1896 a specimen of the Indian ocean fish *Pampus argenteus*, probably transported by a ship, was fished in the Adriatic along the Istrian coast and thereafter preserved in the Museum of Zagreb (13). This event occurred some years before the first Red Sea species, *Atherinomorus lacunosus* was found in the Levantine area (1902) representing the beginning of lessepsian fish migration (14). At present several Red Sea species have been found as sparse records in the Adriatic (14 plus 2003 updating) suggesting transport by ships. The Istrian specimens of *T. gracilis* could have had the same origin. The fecundity of *T. gracilis* is high: Hamabe (15) counted 139.000 embryos on a single female. This fact could explain the local abundance of the introduced cephalopod.

Knowledge of *T. gracilis*, especially in the adult phase, seems poor: in fact its display of luminescent tissues, a rare characteristic in octopuses, has only been recorded in underwater observations in the Red Sea (16).

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References

1 - Belluscio A., Ardizzone G.D., Ponticelli M., Pellicciari C., 2003. Prima documentazione fotografica di una femmina ovigera di *Tremoctopus* (Cephalopoda, Octopoda) nel Mediterraneo – *Biol. Mar. Medit.* (submitted).

2 - Thomas R.F., 1977. Systematics, distribution and biology of cephalopods of the genus *Tremoctopus* (Octopoda, Tremoctopodidae). *Bullettin of marine science,* 27(3): 353-392.

3 - Mangold K.M., Vecchione M., Young R., 1996. Tremoctopodidae. In: Tree of life. Web Project. www.tolweb.org/tree.

4 - Delle Chiaje S., 1829. Memorie sulla storia e notomia degli animali senza vertebre del Regno di Napoli. Napoli, Vol. 1.

5 - Delle Chiaje S., 1841. Descrizione e notomia degli animali invertebrati della Sicilia citeriore – I Molluschi cefalopodi e pteropodi, Napoli.

6 - Verany J.B., 1851. Mollusques méditerranéens, observés, décrits, figurés et chromolithographiés d'après le vivant. I Partie : Céphalopodes de la Méditerranée, Gênes.

7 - Jatta G.I., 1896. Cefalopodi viventi nel Golfo di Napoli. Fauna u. Flora d. Golfes v. Neapel, Monogr. 23, Berlin.

8 - Müller H., 1852. Ueber das oberste Armpaar von *Tremoctopus*. Verh. Physik. Med. Ges. Würzburg. Bd. 3.

9 - Naef A., 1921-28. Die Cephalopoden. Fauna u. Flora d. Golfes v. Neapel, Monogr. 35.

10 - Kramer G., 1937. Einige Beobachtungen an *Tremoctopus violaceus*. Note Ist. It.-Germ. Biol. Mar. Rovigno, N°25: 3-11.

11 - Portmann A., 1952. Les bras dorsaux de *Tremoctopus violaceus* Delle Chiaje. *Rev. Suisse Zool.*, 59 : 288-293.

12 - Nesis K., 1987. Cephalopods of the world. Neptune City, TFH Publications: 351 p.

13 - Soljan T., 1975. I pesci dell'Adriatico. Mondadori Ed., 522 p.

14 - Golani D., Orsi Relini L., Massutì E., Quignard J.P., 2002. CIESM Atlas of exotic species in the Mediterranean - Vol 1 Fishes (F. Briand, Ed.). CIESM publ., Monaco, 256 p.

15 - Hamabe M., 1973. Egg mass and newborns of *Tremoctopus violaceus* Delle Chiaje, caught in the harbour of Kazumi, Hyogo prefecture. *Bull. Tokai Reg. Fish. Res. Lab.*, 75: 1-5.

16 - Goud J., 1989. Een bijzondere waarneming tijdens de Rode Zee-reis. Luminescente bij *Tremoctopus violaceus*: een pelagique octopusoort. *Vita Marina*, Vol. Nov/Dec : 75-78.

RÉGIME ALIMENTAIRE DE *LABRUS VIRIDIS* (PISCES, LABRIDAE) DES CÔTES SUD DE LA TUNISIE

A. Ouannes Ghorbel [1] et A. Bouain [2] *

[1] Institut National des Sciences et Technologies de la Mer, Centre de Sfax, Tunisie - amira.Ouannes@instm.rnrt.tn
[2] Faculté des Sciences de Sfax, Tunisie

Résumé

Le régime alimentaire de *Labrus viridis* des côtes sud tunisiennes est constitué par des petits invertébrés benthiques des herbiers peu profonds. Les proies préférentielles de ce poisson labridé sont les crustacées et les mollusques.

Mots-clès: Labridae, diet, South of Tunisia

Introduction

Labrus viridis est le poisson labridé le plus dominant du genre *Labrus* sur les côtes tunisiennes et notamment celles de la region sud (1). Dans ce travail nous étudions le régime alimentaire de cette espèce sous ses aspects quantitatif et qualitatif par l'analyse du coefficient de vacuité et de certains indices alimentaires.

Matériel et méthodes

La présente étude a porté sur 583 individus de *L. viridis* de longueur totale comprise entre 114 et 370 mm. Les proies des estomacs pleins ont été déterminées et pesées par item. Les estomacs vides ont été notés. Le coefficient de vacuité (Cv) a été determiné selon les sexes et les tailles et ses variations ont été analysées en fonction des mois. Pour étudier l'aspect quantitative du régime alimentaire et pour classer les proies ingérées, nous avons calculé pour chaque item les indices suivant: pourcentage en nombre (Cn), pourcentage en poids (Cp), coefficient alimentaire (Q) et fréquence d'occurrence (F). Le classement de proies a été fait selon la méthode de Hureau (2) et de Geistdoerfer (3).

Résultats

La valeur du coefficient de vacuité moyen pour *L. viridis* est égale à 61,063%. Toutefois, cet indice ne varie pratiquement pas avec le sexe (Cv % mâles = 63,964; Cv % femelles = 60,352). Cependant, nous constatons que la valeur de ce coefficient chez les jeunes est inférieur à celui des adultes (Cv % jeunes = 56,618 ; Cv % adultes = 64,952). Ceci pourrait s'expliquer par le fait que les gonades occupent la majeure partie de la cavité abdominale chez les adultes matures.

L'analyse des variations mensuelles du coefficient de vacuité chez les deux sexes de *L. viridis* sont plus ou moins comparables et en relation étroite avec la période de reproduction (Fig. 1). Par ailleurs, cette analyse montre des fluctuations d'un mois à l'autre avec deux minima se situant au cours des mois d'avril et octobre. Le premier minimum est atteint avant la ponte et le deuxième juste après. Les valeurs maximales de cet indice sont surtout enregistrées pendant l'été.

Donc, aussi bien chez les mâles que chez les femelles de ce poisson l'appétit augmente pendant la pré-ponte et la post-ponte et diminue en dehors de ces périodes (Fig. 1).

A partir du calcul des différents indices alimentaires relatifs à l'analyse quantitative, nous avons établi le classement des différentes proies pour cette espèce (Tab. 1).

La première constatation qui ressort de cette analyse est que *L. viridis* est essentiellement carnivore; les crustacés avec notamment les crevettes, les crabes et les isopodes sont des proies préférentielles; les mollusques et les poissons sont des proies principales, d'après la proposition de Geistdoerfer et deviennent secondaires d'après la subdivision de Hureau. Cependant, les mollusques gastéropodes sont des proies secondaires. Toutes les autres proies ingérées sont accessories d'après Hureau et complémentaires d'après Geistdoerfer. Toutefois, bien que les végétaux (posidonies) sont des proies accessories ou complémentaires pour *L. viridis* dans les deux classements, nous pensons qu'ils sont pris avec d'autres proies.

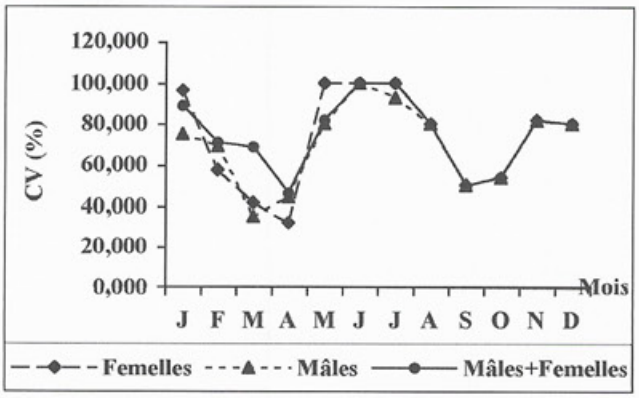


Fig. 1. Variations mensuelles du coefficient de vacuité (Cv) chez *L. viridis*.

Tab. 1. Valeurs des différents indices alimentaires de *L.viridis* C1 (d'aprés Hureau) et C2 (d'après de Geistdoerfer).

Proies	Cn%	Cp%	Q	F%	C1	C2
Spongiaires	0,211	0,232	0,172	0,441	Accessoires	Compl.
Mollusques	20	5,068	101,366	13,216	Secondaires	Principales
- Bivalves	2,947	1,109	3,268	4,405	Accessoires	Compl.
-Gastéropodes	16	1,297	20,757	6,608	Secondaires	Secondaires
-Céphalopodes	0,842	2,762	2,326	1,762	Accessoires	Compl.
Crustacés	58,737	75,181	4415,877	86,344	Préférentielles	Principales
- Brachyoures	14,316	30,471	436,217	27,313	Préférentielles	Principales
- Macroures	17,474	28,593	499,631	30,837	Préférentielles	Principales
- Amphipodes	0,632	0,066	1,322	1,322	Accessoires	Compl.
- Copépodes	0,632	0,379	0,24	0,881	Accessoires	Compl.
- Isopodes	23,579	13,964	329,266	32,159	Préférentielles	Principales
Echinodermes	1,263	2,138	2,701	2,643	Accessoires	Compl.
Bryozoaires	0,632	0,145	0,091	1,322	Accessoires	Compl.
Foraminifères	5,053	0,055	0,279	2,203	Accessoires	Compl.
Végétaux	4,842	1,679	8,129	10,132	Accessoires	Compl.
Poissons	9,263	15,562	144,151	15,859	Secondaires	Principales

Références

1 - Bradai M.N., 2000. Diversité du peuplement ichtyque et contribution à la connaissance des sparidés du golfe de Gabès. Thèse Doct. Etat Sciences nat. Fac. Scien. de Sfax. 600 p.
2 - Hureau J.C., 1970. Biologie comparée de quelques poissons antarctiques (Nototheniidae). *Bull. Inst. Ocean. Monaco*, 68 (1391): 244 p.
3 - Geistdoerfer P., 1975. Ecologie alimentaire des Macrouridae, Téléostéens Gadiformes. Thèse de doctorat. Univ. Paris 6. 315 p.

ÂGE ET CROISSANCE DE *SYMPHODUS (CRENILABRUS) TINCA* (TELEOSTEI, LABRIDAE) DES CÔTES SUD DE LA TUNISIE

A. Ouannes Ghorbel [1] et A. Bouain [2] *

[1] Institut National des Sciences et Technologies de la Mer, Centre de Sfax, Tunisie - Amira - Ouannes@instm.rnrt.tn
[2] Faculté des Sciences de Sfax, Tunisie

Résumé

Dans cette note nous étudions à partir des écailles, l'âge et la croissance de *Symphodus (Crenilabrus) tinca* des côtes sud de la Tunisie. A partir des données observées, nous avons ajusté le modèle de Von Bertalanffy et nous avons par conséquent, déterminé les paramètres ($L\infty$, K et t_0). Les relations taille-masse ont été également établies.

Mots-clés: Labridae, growth, South of Tunisia

Introduction

Symphodus (Crenilabrus) tinca est l'espèce de labridé la plus commune sur les côtes tunisiennes et notamment dans la région du golfe de Gabès (1). Cette espèce est pêchée surtout au printemps par les engins de la pêche artisanale de la région. Dans ce travail, nous présentons l'étude relative à l'âge et la croissance en longueur et en masse de cette espèce.

Matériel et méthodes

La présente étude a porté sur 727 individus de *S. (C.) tinca* de longueur totale comprise entre 85 et 230 mm. Pour chaque poisson nous avons relevé la longueur totale (Lt) en millimètre, la masse du poisson entier (Mp) en gramme. Par ailleurs, nous avons mesuré le rayon total (R) de l'écaille, du focus au bord antérieur, ainsi que les rayons R1, R2, ..., Rn relatifs aux différents stries d'arrêt de croissance. Afin de connaître le nombre de strie d'arrêt de croissance se formant annuellement ainsi que la période de leur formation, nous avons analysé les variations mensuelles de l'allongement marginal calculé selon la formule suivante:

$$AM = \frac{R - r_n}{r_n - r_{n-1}}$$

R: rayon total de l'écaille, r_n: rayon du dernier anneau d'arrêt de croissance et r_{n-1}: rayon de l'avant dernier anneau d'arrêt de croissance.

Nous avons par la suite, ajusté les équations de régression exponentielle reliant la longueur totale (Lt) du poisson au rayon total (R) de l'écaille qui est de la forme:

$$Lt = a\,R^b$$

A partir de cette équation, et par la méthode de rétrocalcul, nous avons pu calculer la taille du poisson à l'apparition de chaque anneau d'arrêt de croissance. Enfin, nous avons ajusté le modèle de croissance de Von Bertalanffy à ces données de longueurs par âge.

L'ajustement de la courbe de croissance ainsi que la détermination de ces différents paramètres ont été effectués à l'aide d'un logiciel informatique "FSAS" basé sur l'adaptation non linéaire de Maquardt. Dans nos procédures d'ajustement nous avons considéré, la population entière et les deux sexes séparés.

La relation taille-masse a été également déterminée, elle est de la forme:

$$M = a\,L^b$$

a et b sont deux constantes. La croissance massique absolue est décrite aussi par l'équation de Von Bertalanffy.

$$Mt = M\infty\,(1 - e^{-K\,(t\,-to\,)})^3$$

Résultats

Les fluctuations de l'allongement marginal en fonction des mois présentent deux minima (Fig. 1), le premier coïncide avec la période de ponte; le deuxième, le plus important, correspond à l'anneau d'hiver. Le premier anneau d'arrêt de croissance apparaît donc à 18 mois chez cette espèce.

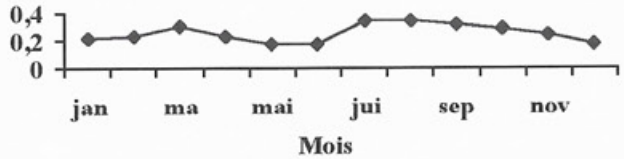


Fig. 1. Variation mensuelle de l'allongement marginal (A.M.) chez *S.(C.) tinca*.

Les équations de régression exponentielles reliant la longueur totale (Lt) du poisson aux rayons des écailles (R) nous ont permis de calculer rétrospectivement les longueurs totales moyennes par âge (Tab. 1).

Les paramètres de l'équation de Von Bertalanffy sont les suivants:

$L\infty = 211,8$	$k = 0,284$	$t_0 = 0,654$
$L\infty = 231,5$	$k = 0,254$	$t_0 = 0,736$
$L\infty = 230,5$	$k = 0,245$	$t_0 = 0,761$

Les valeurs des longueurs totales théoriques en fonction de l'âge sont très proches de celles déterminées par le calcul rétrospectif. Nous pouvons donc déduire que le modèle de Von Bertalanffy s'applique bien à l'étude de la croissance en longueur de ce labridé (Tab. 1).

Tab. 1. Comparaison de la taille (Lt en mm) estimée par le modèle de Von Bertalanffy et celle calculée par scalimétrie pour *S. (c.) tinca*.

Age (ans)	1	2	3	4	5	6	7	8
Lt. Scalimétrie (Femelles)	79,046	112,998	137,288	154,499	169,991	178,802	188,28	194,04
Lt.VonBertalanffy (Femelles)	79,48	112,242	136,895	155,445	169,404	179,908	187,812	193,76
Lt. Scalimétrie (Mâles)	82,088	116,496	141,971	161,339	177,127	189,975	198,497	206,64
Lt. Von Bertalanffy (Mâles)	82,452	115,838	141,747	161,853	177,457	189,566	198,963	206,26
Lt.Scalimétrie (Mâles+Femelles)	79,883	114,24	139,252	157,755	174,044	185,628	195,34	204,53
Lt.VonBertalanffy (Mâles+Femelles)	80,622	113,126	138,581	158,515	174,126	186,351	195,925	203,42

Les coefficients a et b des relations taille-masse de l'animal plein ont été calculés en considérant les mâles et les femelles prix séparément et les deux sexes confondus. Les valeurs de ces deux coefficients ainsi que celle des paramètres de Von Bertalanffy de la croissance massique en fonction de l'âge se trouvent dans le Tab. 2.

Tab. 2. Paramètres de l'équation de Von Bertalanffy relative à la croissance massique de *S. (c.) tinca*. b: Pente de la relation logarithmique taille- masse.

Sexe	Mp_∞ (g)	K	t_o	b
M	163,872	0,254	-0,736	2,924
F	109,808	0,284	-0,654	2,898
M +F	144,735	0,245	-0,763	2,903

Conclusion

Cette étude a montré que la croissance du crénilabre paon des côtes Sud de la Tunisie s'avère assez lente. Ce phénomène a été egalement constaté chez le crénilabre cendré (2).

Références

1 - Bradai M. N., 2000. Diversité du peuplement ichtyque et contribution à la connaissance des sparidés du golfe de Gabès. Thèse Doct. d'Etat Sciences nat. Fac. Scien. de Sfax. 600 p.

2 - Ouannes-Ghorbel A., Bouain A., 2001. Age et Croissance de *Symphodus (Crenilabrus) cinereus* (Bonnaterre, 1788) des côtes de la région du golfe de Gabès (Tunisie). *Rapp. Comm. int. Mer. Médit.*, 36: 307-307.

SOME BIOLOGICAL INFORMATION OF THE PARROTFISH, *SPARISOMA CRETENSE* (LINNAEUS, 1758) FROM THE EASTERN ADRIATIC

A. Pallaoro * and J. Dulčić

Institute of oceanography and Fisheries, Split, Croatia - * pallaoro@izor.hr

Abstract

This paper deals with the horizontal distribution and range spreading of the parrotfish in the Eastern Adriatic during the period 2000 – 2003. According to obtained data of 51 collected and measured specimens (27 females and 24 males) the length frequency distribution, length - weight relationship, age and growth parameters are given.

Key words: Parrotfish, distribution, population parameters, Adriatic

Introduction

The parrotfish, *Sparisoma cretense* (Linnaeus, 1758) is subtropical, reef-associated marine fish, found on photophile macroalgae covered rocky substrates, sometimes in sea-grass (*Posidonia oceanica*) meadows, at depths ranging from 20 to 50 m. It occurs in Eastern Atlantic (from Portugal to the Canary Island and Senegal) and in the Mediterranean (common in the Eastern, rather rare in Western Basin) (1). The aim of this study is to present first data on some biological parameters of parrotfish from the eastern Adriatic.

Material and methods

Total of 51 measured specimens, 24 males (47.1%) and 27 females (52.9%) were caught on 8 stations in southern and middle Adriatic, using the trammel bottom nets, fish trap and underwater speargun.

Results and discussion

The total body length (TL) (cm) of males ranged from 11.6 to 29.5 cm ($\bar{\chi}\pm$ SD = 22.2 ± 4.98) and females from 10.2 to 27.4 cm ($\bar{\chi}\pm$ SD = 20.2± 4.99). Overall mean TL of males did not differ significantly (t-test = 1.458; t_{crit} = 2.021; $p > 0.05$) from that of females.

The commonly used length - weight relationship was applied: $W = a\ Lt^{b}$. Weight of total collected fish ranged from 20.7 to 404.2 g. Since the mean length did not differ significantly with sex, length - weight relationship was calculated for sexes combined: $a = 0.0243$; $b = 2.871$; $r^2 = 0.9781$ (Fig. 1). The slope (b value) was significantly ($t = 7.21$, $t_{crit.} = 2.704$) ($P > 0.05$) different from 3.0 indicating negative allometry.

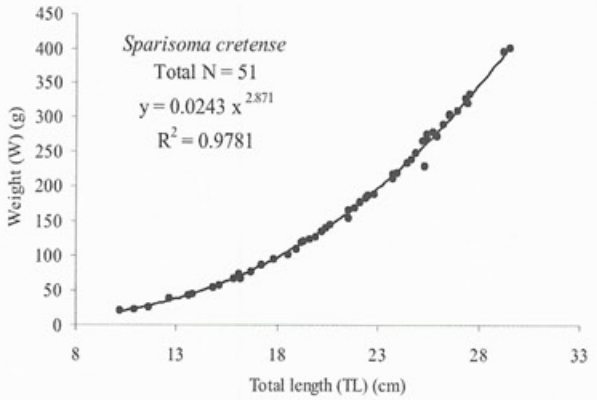


Fig. 1. *Sparisoma cretense*. Length - weight relationship, sexes combined.

After reading scales for individuals the mean observed lengths at age were estimated and used for fitting the von Bertalanffy growth model. The growth parameters for sexes combined were: $Lt = 35.14\ (1 - e^{-0.298\ (t + 0.597)})$; $r^2 = 0.9689$. The theoretical maximum length, 35.1 cm of parrotfish in our investigation is not unrealistic since the largest specimens can reach 50.0 cm Lt in Mediterranean (1) and slightly less in the Adriatic (2). The oldest collected specimens were 6 years old.

Slightly different values of these biological parameters were obtained for Greek waters (3).

As a result of scarce number of records up to 2000, parrotfish belonged to the rare species in the Eastern Adriatic (4). Periodically it was found mainly in the middle and southern part (one specimen - Dubrovnik, 1900; Biševo Island, 1962; Šćedro Island, 1965; two specimens - Hvar Island, 1904; Vis Island, 1925) but one unconfirmed specimen was caught also in Venice, 1924 in north Adriatic (5). Probably as a result of a warming up of the Mediterranean waters (6) and changes in oceanographical conditions of the Adriatic Sea, population density of *Sparisoma cretense* suddenly increased in very warm 2000. From that year findings and captures of this thermophilous species occurred more and more frequently, moving northwards to the northern part of the middle Adriatic (Table. 1).

Table 1. *Sparisoma cretense*. The successive northward spreading during 2000-2003.

2000.	2001.	2002.	2003.
Palagruža Island (42°26'Nx16°13'E)	SW Lastovo Island (42°42'Nx16°50'E)	Svetac Island (43°01'Nx15°46'E)	SW Kornat Island (43°44.5'Nx15°28'E)
NW Mljet Island (42°47'Nx17°20'E)	SE Vis Island (43°02'Nx16°15'E)	SW Žirje Island (43°38'Nx15°39'E)	Dugi otok Island (44°08'Nx14°52'E)

References

1 - Randall J.E., 1990. Scaridae. Pp. 883-887.*In:* Quero J.C., Hureau J.C., Karrer C., Post A. and Saldanha L., (eds) Check-list of the fishes of the eastern tropical Atlantic (CLOFETA). UNESCO, Paris, 2.

2 - Jardas I., 1996: Adriatic ichthyofauna. Školska knjiga Publ., Zagreb, 533 (in Croatian).

3 - Petrakis G. and Papaconstantinou C., 1990. Biology of *Sparisoma cretense* in the Dodecanese (Greece). *J. Appl. Ichthyol.*, 6:14-23.

4 - Pallaoro A. and Jardas I., 1996. Ichthyological collection of the Institute of Oceanography and Fisheries in Split (Croatia). *Nat. Croat.*, 3: 177–219.

5 - Dulčić J. and Pallaoro A., 2001. Some new data on *Xyrichthys novacula* (Linnaeus, 1758) and *Sparisoma (Euscarus) cretense* (Linnaeus, 1758) from the Eastern Adriatic. *Annales, Ser. Hist. Nat.*, 11: 35-40.

6 - Francour P., Boudouresque C.F., Harmelin J.G., Harmelin-Vivien M.L. and Quignard J.P., 1994. Are the Mediterranean Waters becoming Warmer? Information from Biological Indicators. *Mar. Poll. Bull.*, 28 (9): 523–526.

RETAINED AND DISCARDED CATCHES FROM COMMERCIAL BOAT SEINES IN GREEK WATERS

George Petrakis *, Anna Chilari and Stefanos Kavadas
National Centre for Marine Research, Hellinikon, Athens, Greece - * gpetr@ncmr.gr

Abstract
Observer-based estimates of the quantities of discarded and retained catches from the commercial boat seine in Greek waters are presented. A total of 112 species were identified in catches sampled between October 2000 and May 2001 in three areas (Ionian Sea, Cyclades Islands, Pagassitikos Gulf). The catch composition varied significantly between the areas. The most abundant commercial species were bogue (*Boops boops*), pilchard (*Sardina pilchardus*), picarel (*Spicara smaris*), common squid (*Loligo vulgaris*), blotched picarel (*Spicara flexuosa*) and horse mackerel (*Trachurus mediterraneus*). The most abundant discarded species were bogue, damselfish (*Chromis chromis*), rainbow wrasse (*Coris julis*) and common pandora (*Pagellus erythrinus*).

Keywords: boat seine, catch, discards, by-catch, Greece

Introduction

In Greek waters the annual landings of boat seiners are estimated to represent 5.8% and 4.5% of the annual total fisheries l production and value, respectively. The boat seine catch is dominated mainly by picarel (46.6%) and, to a lesser degree, by pilchard (14.1%) and bogue (11.1%) (National Statistic Service of Greece).

Boat seines are considered to have a negative impact on stocks since the fishing activity takes place in coastal areas in the nursery grounds of many commercial species and in some areas the gear is fished on *Posidonia* sea beds which are considered to be vulnerable to the action of the gear (EC regulation 1626/94). There are few studies on the impacts of this gear in Greek waters. In this study, funded by the Greek Ministry of Agriculture, observers were used to quantify the catches of boat seines operating in three areas in Greece and to evaluate the impact of this fishing gear in terms of by-catch and discards.

Materials and methods

Scientific observers accompanied commercial boat-seine crews on 17 fishing trips between October 2000 and May 2001, covering the entire fishing period, in three regions of Greece: Ionian Sea (5 trips), Aegean Sea-Cyclades Islands (6 trips) and Pagassitikos Gulf (6 trips) (Fig. 1). The mesh size used was 16 mm and fishing took place in depths 15-47 m. The total catch was sorted into the retained and discarded components by the fishermen. The total weights and numbers of each individual species were recorded. Mean catch rates per haul were calculated for each month. One-factor analysis of variance was used to test for differences between months in weights and quantities of retained and discarded catches.

Results and discussion

A total of 112 species (94 teleosteans, 6 elasmobranchs, 11 cephalopods and 1 crustacean) distributed in 48 families were identified in catches throughout the survey. A total of 37 families were retained and 38 families were discarded. Only 17 families were solely retained, 22 were solely discarded and another 27 families were both retained and discarded.

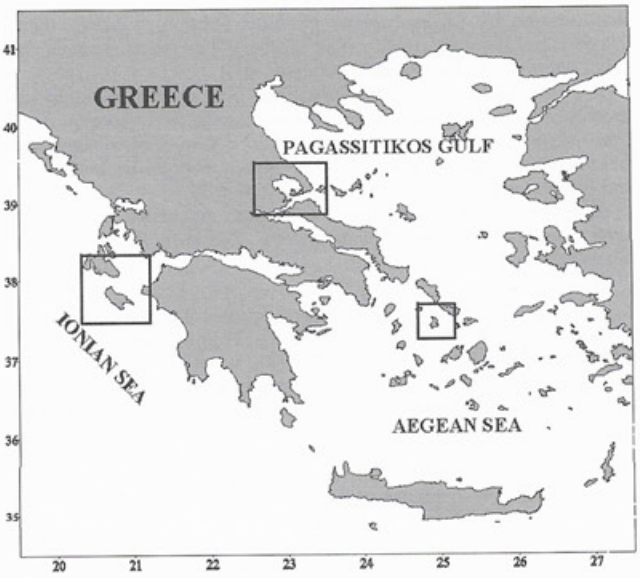


Fig. 1. Map of the sampling areas.

Species were assigned a relative index of abundance according to their mean retained and discarded catch rates per haul. Retained catch rates of bogue, pilchard and picarel in Aegean Sea, were estimated to be greater than 100 individuals per haul, while in the Ionian Sea, only picarel and bogue had estimated retained catch rates greater than 100 individuals per haul. The corresponding species from Pagassitikos Gulf were blotched picarel, horse mackerel and pilchard. Concerning the discarded species, bogue and rainbow wrasse from the Aegean Sea, damselfish from the Ionian Sea and common pandora from Pagassitikos Gulf had estimated rates greater than 100 individuals per haul.

Retained and discarded catch rates varied throughout the survey (Fig. 2), but significant differences between months were reported only for retained catches from the Ionian Sea (P-value = 0.0045).

Ratios of the total numbers discarded to retained were 0.19 in the Aegean Sea, 0.07 in the Ionian Sea and 0.22 in Pagassitikos Gulf. The estimated ratios are considered to be very low for Mediterranean fisheries, and they are generally less than those observed for bottom trawls (about 0.44) (1), for the sole métier (0.26), the sepia métier (0.60) and the hake métier (0.21) in Greek waters (2).

Our results indicated that: a) the proportion of the discarded was low and varied between areas and b) catches of juveniles of commercial species were generally low except for common pandora in Pagassitikos Gulf.

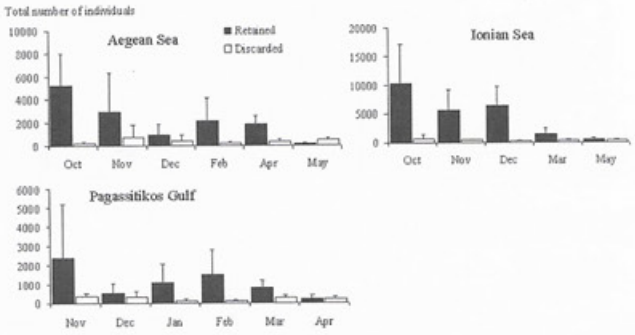


Fig. 2. Mean numbers of retained and discarded total numbers of individuals taken in each season in each sampling area.

References

1 - Machias A., Vassilopoulou V., Vatsos D., Bekas P., Kallianiotis A., Papaconstantinou C., and Tsimenides N., 2001. Bottom trawl discards in the northeastern Mediterranean Sea. *Fish. Res.*, 53: 181-195.
2 - Petrakis G., 1998 (ed.). Selectivity of fixed nets in Mediterranean-SELMED. EEC contract: 95/C/76/12, NCMR.

VERTICAL DISTRIBUTION OF COPEPOD ASSEMBLAGES IN THE UPPER LAYER OF THE EASTERN IONIAN SEA (GREECE) DURING MIXED AND STRATIFIED CONDITIONS

Alexis Ramfos *, Stamatina Isari, Nina Fragopoulou and Constantin Koutsikopoulos
Laboratory of Zoology, Biology Department, University of Patras, Greece - * marlab@upatras.gr

Abstract

The copepod community structure and vertical distribution in the eastern Ionian Sea were examined during two seasons with different hydrological conditions. Community structure seemed to follow the well-mixed structure of the water column in March and the strong stratification in September. Deep layer samples showed less seasonal differentiation than the surface and intermediate layers. The differences in density with depth in most abundant species were more profound in September than in March.

Keywords: zooplankton, copepods, eastern Mediterranean

Introduction

The Ionian Sea pelagial is oligotrophic (1), characterized by the low abundance and high diversity of its zooplankton (2). The NE part of this region has been studied in a fragmentary fashion in space and time (1,3,4). The main goal of this study is the description of the copepod community structure during two periods with different hydrological characteristics.

Materials and Methods

A total of 87 mesozooplankton samples were collected during March and September 2000 in the eastern Ionian Sea, from three depth layers (0-50m, 50-100m and 100-200m), using a vertically towed opening-closing WP2 net (200μm). The sampling grid was comprised of 18 stations (Fig. 1). The copepods were identified to species. Hydrographic conditions were measured by vertical CTD casts.

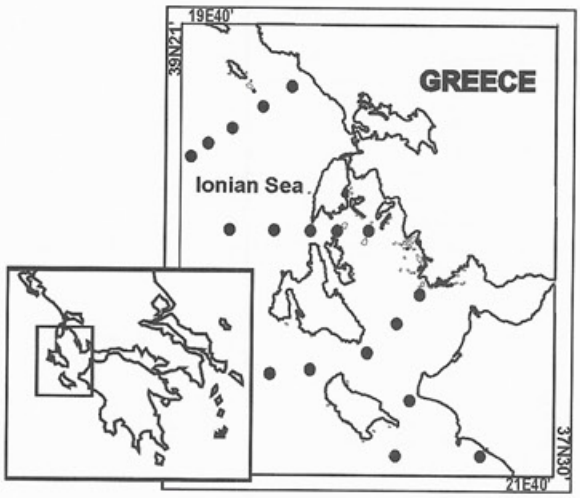


Fig. 1. Sampling stations in March and September 2000.

Results

The physical structure of the water column differed markedly between the two sampling periods. In March the water column appeared homogenized. Temperature from surface to 200m depth ranged between 14.4 and 15.1°C. In September strong thermal stratification was noted, with surface temperature values ranging from 22 to 25°C and a sharp thermocline in an average depth of 45m. Below the thermocline, temperature appeared quite constant between 14 and 14.5°C. Salinity ranged between 38.4 and 38.9 during both sampling periods.

Maximum mesozooplankton density values were recorded in the upper layer (0-50m) decreasing with increasing depth, in both March and September. Mean density values were 288 ind/m^3, 208 ind/m^3 and 93 ind/m^3 for the three depth layers respectively in March and 389 ind/m^3, 201 ind/m^3 and 77 ind/m^3 in September.

Copepods, appendicularians, chaetognaths and ostracods comprised the 90-95% of the total zooplankton during both sampling periods in all layers. Copepods were by far the dominant taxon in all samples, its percentage varying between 62% and 91%. Only 12 copepod species in March (out of 88) and 14 in September (out of 81) were considered as abundant, 11 were common to both sampling periods.

Group average cluster analysis of samples on copepod species only, produced 4 major groups at the 52% similarity level and 2 additional subgroups at the 55% level. NMDS ordination showed that the four major groups were quite distinct (stress value 0.14) while the distinction between the subgroups was unclear. Group A consisted of March samples from all layers (Subgroup A1: all surface and 5 intermediate samples, Subgroup A2: 8 intermediate and 5 deep layer samples). Group B consisted of all surface September samples and Group C of all intermediate layer September samples. Group D included 13 deep layer and one intermediate sample (Subgroup D1: 4 March and 2 September samples, Subgroup D2: 8 September samples) (Fig. 2).

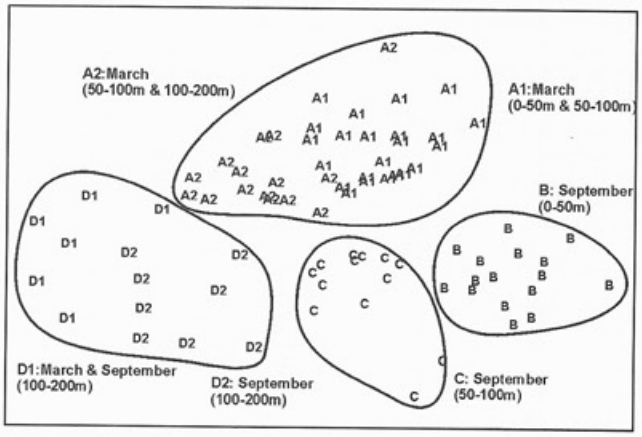


Fig. 2. NMDS ordination plot of the comparison of all samples using Bray-Curtis similarity index. Respective cluster groups are superimposed.

Copepodites of the genera *Clausocalanus* and *Oithona* were dominant in all surface samples. The surface layer was also characterised by *Clausocalanus paululus* (March), *Clausocalanus furcatus* and *Temora stylifera* (September), *Farranula rostrata* and *Calocalanus spp.* copepodites (both periods).

The intermediate layer in September, was characterised by the species *Oithona* copepodites, *Farranula rostrata, Mecynocera clausi, Clausocalanus paululus* and copepodites, *Ctenocalanus vanus* and *Ischnocalanus plumulosus;* while in March *Haloptilus longicornis* and *Paracalanus denudatus* were present as well.

Haloptilus longicornis showed maximum abundance in the deep layer along with *Pleuromamma gracilis, Lucicutia flavicornis* and *Mormonilla minor* (March).

References

1 - Stergiou K.I., Christou E.D., Georgopoulos D., Zenetos A. and Souvermezoglou,C. 1997. The Hellenic seas: Physics, chemistry, biology and fisheries. *Ocean. Mar. Biol.* 35: 415-538.

2 - Siokou-Frangou I., Christou E.D., Fragopoulu N. and Mazzocchi M.G. 1997. Mesozoolankton distribution from Sicily to Cyprus (Eastern Mediterranean): II. Copepod assemblages. *Oceanologica Acta*, 20: 537-548.

3 - Christou E.D., Siokou-Frangou I., Georgopoulos D. and Theocharis A. 1990. Study of the distrubion of zooplankton in Levantine and Ionian Seas in relation with the hydrology of the regions. Proceedings of the 3rd Nat. Symp. Ocean. Fish. Athens.

4 - Scotto di Carlo B., Ianora A., Mazzocchi M.G. and Scardi M. 1991. Atlantis II Cruise: uniformity of deep copepod assemblages in the Mediterranean Sea. *J. Plankton Res.*, 13: 263-277.

MACROFAUNAL BENTHIC ASSEMBLAGES OF A CLAM-DREDGED SANDY BEACH IN THE GULF OF VALENCIA (WESTERN MEDITERRANEAN)

Montserrat Ramón * and Pere Abelló

Institut de Ciències del Mar (CSIC), Passeig Marítim de la Barceloneta, Barcelona, Spain - mramon@icm.csic.es

Abstract

The macrofaunal benthic community of a sandy beach exposed to the effects of commercial clam dredging was studied to characterise the species distributions and assemblages. Two well-differentiated macrofaunal communities were found: a shallower one characterised by the bivalve *Donax trunculus* and the crab *Portumnus latipes*, occurring between 0.5 and 2.5 m depth, typical of fine and medium sandy sediments subjected to strong hydrodynamism, and a deeper, more diverse one, characterised by the bivalves *Chamelea gallina, Donax semistriatus*, *Mactra stultorum*, the gastropod *Nassarius mutabilis* and the crab *Liocarcinus vernalis*, typical of well sorted fine sand sediments.

Key words: beach, communities, Mediterranean, Donax, Chamelea

Sandy shores are dynamic environments which faunistic structure is determined by factors related with both the sediment and hydrographic characteristics. Infralittoral sandy beach ecosystems are often exploited by dredging for bivalves along the Mediterranean (1). One of such fisheries takes place along the Gulf of Valencia, the target species being the bivalves *Donax trunculus* and *Chamelea gallina* (2,3). The present study set out to characterise the distribution patterns of the two species and their associated communities in relation with depth and sediment characteristics.

Material and methods

Monthly samples were collected subtidally between June 1989 and May 1990 at two stations located in a sandy beach off Cullera (eastern coast of Spain; 39° 10' N, 0° 13' W). Sampling was performed between 0.5 and 6 m depth using an experimental dredge of 4.5x4.5 mm steel mesh-size. The abundance of all species was quantified. Percentage occurrence and mean density (number/m^2) of each species was estimated per depth intervals. Bottom and surface temperature, salinity, oxygen content, granulometry and organic matter content of the sediment were taken at every station. Cluster and correspondence analysis methods were applied to the matrix of species density in each sample to analyse community composition and structure.

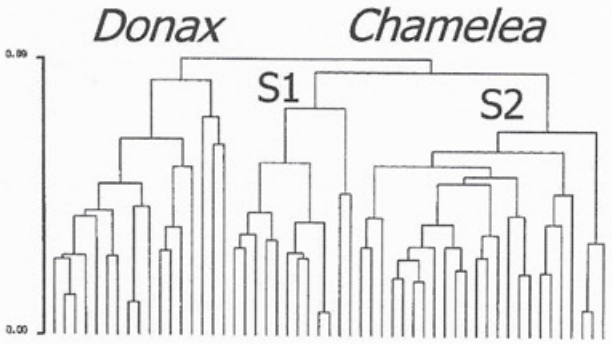
Table 1. Species collected in over 40% of the samples taken within each depth interval, listed in order of decreasing percentage occurrence. n = number of samples taken at each depth interval.

1.6-2.5 m		2.6-3.5 m	
n=15		n=13	
Donax trunculus	100.0	*Diogenes pugilator*	100.0
Diogenes pugilator	93.3	*Chamelea gallina*	92.3
Chamelea gallina	73.3	*Donax semistriatus*	92.3
Portumnus latipes	40.0	*Mactra stultorum*	69.2
		Donax trunculus	61.5
		Siphonoecetes sabatieri	53.8

3.6-4.5 m		4.6-5.5 m	
n=11		n=14	
Chamelea gallina	100.0	*Chamelea gallina*	100.0
Diogenes pugilator	100.0	*Diogenes pugilator*	100.0
Donax semistriatus	90.9	*Donax semistriatus*	100.0
Mactra stultorum	90.9	*Nassarius mutabilis*	85.7
Nassarius mutabilis	90.9	*Spisula subtruncata*	78.6
Spisula subtruncata	81.8	*Mactra stultorum*	78.6
Liocarcinus vernallis	72.7	*Pandora inaequivalvis*	71.4
Acanthocardia tuberculata	63.6	*Liocarcinus vernallis*	57.1
Macoma cumana	45.5	*Acanthocardia tuberculata*	50.0
Tellina nitida	45.5	*Macoma cumana*	42.9

Results and discussion

A total of 18 bivalves, 7 crustaceans, 5 gastropods, 1 scaphopod, and 2 echinoderms was collected. The seven crustacean species included one amphipod, one penaeid and two caridean prawns, two brachyuran and one anomuran crabs. The commonest species within each depth stratum differed widely (Table 1), with a marked boundary found at around 3 m, which is confirmed by cluster (Fig. 1) and ordination analysis.



The specific diversity was much lower in the community of *D. trunculus*, in which two species, *D. trunculus* and *Portumnus latipes* accounted for most of the species abundance. The community of *C. gallina* showed a higher diversity, and was typically characterised by high densities of the bivalves *C. gallina* and *Spisula subtruncata*. Other characteristic species of this community were the bivalves *Donax semistriatus*, *Acanthocardia tuberculata*, and *Mactra stultorum,* the gastropod *Nassarius mutabilis,* and the swimming crab *Liocarcinus vernalis*. Densities of the hermit crab *Diogenes pugilator* were higher in this community than in the *D. trunculus* community, where this species occurred frequently, but with low densities.

The community of *D. trunculus* in the western Mediterranean can be established as characteristic of beaches of medium and fine sand subjected to a strong hydrodynamism (4). The community of *C. gallina* is found deeper, with a sediment characterised by a higher proportion of fine sand and lower hydrodynamism.

References

1 - Froglia C., and Bolognini S., 1987. Clam fishery with hydraulic dredges in the Adriatic Sea. *G.F.C.M. Stud. Rev.*, 62: 37-40.

2 - Ramón M., and Richardson C.A., 1992. Age determination and shell growth of *Chamelea gallina* (Bivalvia: Veneridae) in the western Mediterranean. *Mar. Ecol. Prog. Ser.*, 89: 15-23.

3 - Ramón M., Abelló P., and Richardson C.A., 1995. Population structure and growth of *Donax trunculus* (Bivalvia: Donacidae) in the western Mediterranean. *Mar. Biol.*, 121: 665-671.

4 - Zeichen M., Agnesi S., Mariani A., Maccaroni A., and Ardizzone, G.D., 2002. Biology and population dynamics of *Donax trunculus* L. (Bivalvia: Donacidae) in the South Adriatic coast (Italy). *Estuar. Coast. Shelf Sci.*, 54: 971-982.

CONNAISSANCES EXPERIMENTALES OU TRAITEMENTS STATISTIQUES DES DONNÉES: UNE "QUERELLE DES ANCIENS ET DES MODERNES" ?

Chafika Rebzani-Zahaf [1 *], Jean-Claude Gaertner [2], Gérard Bellan [2a], Denise Bellan-Santini [2]

[1] Faculté des Sciences Biologiques - USTHB, Alger, Algérie - * chafika4@caramail.com

[2] Centre d'Océanologie de Marseille, Station marine d'Endoume, Marseille, France

gaertner@com.univ-mrs.fr, gbellan@com.univ-mrs.fr

Abstract

The impact of anthropogenic activities on marine benthic communities has been investigated for several decades. The first experimental works, conducted during the 60', have been considered as too empirical and were superseded by more recent quantitative approaches. In the present contribution, we draw a preliminary comparative analysis of the respective contribution of these two contrasted approaches. Such a comparison is based on data collected in Algerian harbours and in the vicinity of Marseilles (France). We conclude that former empirical approaches and recent quantitative works are complementary rather than conflictual.

Mots-clés: espèces indicatrices, communautés, statistiques multivariées

Mesurer l'impact des activités humaines sur le milieu marin et plus précisément sur les communautés d'organismes qui y vivent et en déduire leur évolution en particulier en fonction de la réduction de ces activités est, depuis plusieurs décennies, un des objectifs majeurs de l'écologie marine (1, 2). La notion et l'utilisation d'espèces indicatrices et d'indicateurs ont constitué une des premières applications des recherches entreprises. Ces tentatives ont été très critiquées, notamment parce qu'elles n'auraient pas eu de bases théoriques suffisantes (3) même si elles étaient efficaces. Il en est résulté un relatif discrédit de ces approches "anciennes" au bénéfice de l'utilisation d'outils statistiques "modernes", diversifiés et de plus en plus sophistiqués (4, 5, 6, 7, 8) parmi lesquelles nous citerons sans souci d'exhaustivité: les indices de diversité, les méthodes d'ordination et les méthodes typologiques. Il est admis que ces méthodes statistiques offrent des perspectives d'objectivité plus grandes que les approches "anciennes". Il est, aussi, observé que les espèces présentant le plus grand poids dans la création des axes dans les méthodes d'ordination, donc dans l'explication des phénomènes et des conclusions qui en découlent sont, parfois, des espèces reconnues comme ayant une importance particulière dans la structuration et le fonctionnement des assemblages étudiés, mais aussi peuvent répondre à des états plus "labiles" de ceux-ci. L'utilisation de telles méthodes est, par contre, limitée par deux obstacles majeurs: la nécessité de disposer de systématiciens compétents et le temps nécessaire aux déterminations. Il est demeuré latent l'espoir de concilier validité – c'est-à-dire l'obtention de résultats fiables et scientifiquement corrects – et efficacité – soit maîtrise du temps et des coûts – dans la même optique que ce qui est souvent préconisé pour les eaux continentales.

L'intérêt porté par les scientifiques, poussés par les politiques et les techniciens confrontés aux perturbations anthropiques et à leur gestion, vis-à-vis de la recherche de critères fiables et économes en temps et argent ne s'est jamais démenti (9, 10). Récemment, de nouvelles tentatives ont été faites afin de concilier les différentes méthodes et proposer de nouveaux outils "robust, simple and effective" (11). Différentes modalités de sélection des espèces indicatrices ont été faites après évaluation de leur niveau de sensibilité à l'égard de stress subis ou à partir du trophisme (10). D'autres auteurs (11) s'appuyant sur la connaissance étendue que l'on a des communautés benthiques dans l'ensemble de la Méditerranée et des modifications qu'elles subissent en fonction de la nature et du niveau des actions anthropiques auxquelles elles sont soumises, s'emploient à "revisiter" certains travaux anciens à la lumière de méthodes plus objectives, comme il a été dit précédemment.

C'est à une telle comparaison critique que nous nous sommes appliqués à partir de travaux réalisés, à différentes étapes de temps dans différents ports algériens et, notamment dans celui d'Alger (12, 13), éventuellement confortés avec des données similaires dans la région marseillaise (2, 13, 14).

Références

1 - Reish D.J., 1959. An ecological study of Pollution in Los Angeles-Long Beach Harbors, California. Allan Hanckock Foundation Publication, occasional papers, 252, 117 p.

2 - Bellan G., 1967. Pollution et peuplements benthiques sur substrats meubles dans la région de Marseille. Première partie. Le secteur de Cortiou. *Revue Internationale d'Océanographie Médicale*, 6-7: 53-87. Deuxième partie. L'ensemble portuaire marseillais. *Revue Internationale d'Océanographie Médicale*, 8: 51-95.

3 - Washington H. G., 1984. Diversity, biotic and similarity indices. A review with special relevance to aquatic ecosystems. *Water Research*. 18: 653-694.

4 - Legendre L. et Legendre P. 1984. Écologie numérique. II: La structure des données écologiques. Masson, Paris et Les Presses de l'Université du Québec, 2ème Édition, 658 p.

5 - Gaertner J.C., Mazouni N., Sabatier R., Millet B., 1999. Spatial structure and habitat associations of demersal assemblages in the Gulf of Lions: a multicompartmental approach. *Marine Biology*, 135: 199-208.

6 - Bellan-Santini D. Dauvin J. C., G. Bellan, 1994. Analyse de données en écologie benthique: utilisation de la méthode de Parcimonie. *Oceanologica Acta*, 17 (3): 331-340.

7 - Salen-Picard C., Bellan G., Bellan-Santini D., Arlhac D., Marquet R., 1995. Changements à long terme dans une communauté benthique d'un golfe méditerranéen soumis à des apports fluviatiles et à d'importants travaux d'aménagement portuaire. *Oceanologica Acta* 20 (1):299-310.

8 - Bellan-Santini D., Bellan G., 1997. Utilizzazione delle analisi di parsimonia (cladistica) in sinecologia bentonica: esempi in una zona inquinata. *Ecologia*, S.It.E. Atti, 18: 247-250.

9 - Gray J., Pearson, J. 1982. Objective selection of sensitive species indicative of pollution-induced change in benthic communities. I. Comparative Methodology. *Marine Ecology Progress Series*, 9: 111-119.

10 - Grall J., Glemarec M., 1997. Using biotic indices to estimates macrobenthic community perturbations in the Bay of Brest. *Estuarine Coastal and Shelf Science*, 44: 43-53.

11 - Simboura, Zenetos A., 2002. Benthic indicators to use Ecological Quality classification of Mediterranean soft bottom marine ecosystems, including a new Biotic Index. *Med. Mar. Sci.*, 3/2.

12 - Rebzani-Zahaf C., 2003. Les peuplements macrobenthiques des milieux portuaires de la côte algérienne: Alger, Bejaia et Skikda. Thèse Doct. État, Sciences de la Nature (Océanologie), Univ. Sc. Tech. Alger, 239 p. + Annexes 63 p.

13 - Rebzani-Zahaf C., Bellan G., Bakalem A., Romano J.C., 1997. Cycle annuel du peuplement macrobenthique du port d'Alger. *Oceanologica Acta* 20(2): 299-310.

14 - Bellan G., Bourcier M., Salen-Picard C., Arnoux A., Casserley S., 1999. Benthic Ecosystem Changes Associated with Wastewater Treatment at Marseille: Implications for the Mediterranean Protection and Recovering. *Water Environment Research*, 71 (4): 483-493.

BIOLOGIE DE QUELQUES ESPÈCES IMPORTANTES AUX RÉCIFS ARTIFICIELS

L. Recasens *, P. Sanchez, M. Demestre et A. Lombarte
Institut de Ciències del Mar (CSIC), Barcelone, Catalogne, Espagne - * laura@icm.csic.es

Résumé
On a étudié la démographie et la reproduction de la rascasse, la seiche et le pageau qui habitent le récif artificiel de Calafell à la côte catalane. On a capturé les individus avec des pêches experimentales bimensuelles et un filet maillant. Les résultats montrent que la rascasse et la seiche vivent et se reproduisent à l'abri du récif artificiel tandis que dans le cas du pageau, le récif est seulement utilisé pour les petits individus.

Mots clés: Récifs artificiels, démographie, reproduction

Introduction

L'installation des récifs artificiels en Catalogne a commencé dès l'année 1978. Un total de 22 récifs sont actuellement installés. Ces systèmes peuvent être importants pour quelques espèces qui trouvent dans ces milieu abri et lieu pour se nourrir ou se reproduire. D'autre part, les récifs artificiels peuvent favoriser la concentration des organismes et les rendre plus vulnérables à la pêche. Donc, quelques aspects de la biologie des espèces liées à ces systemes sont étudiés dans un cadre de suivi biologique et de pêche dans les récifs artificiels. À la fin, on veut determiner le degré d'utilisation des récifs artificiels par les espèces propres de ces milieux.

Materiel et méthodes

On a étudié les especes qui vivent dans un récif artificiel placé entre 15 et 30 mètres de profondeur au Sud de Barcelone, à la ville de Calafell. Ce récif se compose de 40 modules de production et 215 modules mixtes (production + protection). Pendant les années 2000 à 2003, on a réalisé bimensuellement des campagnes de pêches expérimentales. On a utilisé un bateau de pêche artisanale équipé avec un filet maillant comme échantilloneur. À partir des captures obtenues, on a identifié les espèces commerciales les plus abondantes qui sont la rascasse (*Scorpaena notata*), la seiche (*Sepia officinalis*) et le pageau (*Pagellus acarne*). On a mesuré taille (centimètre inferieur), poids total (grams), sexe, état sexuel et poids gonadal. On a determiné la fréquence de tailles et le rapport gonadosomatique (IGS) des femelles (poids gonadal x 100 / poids total).

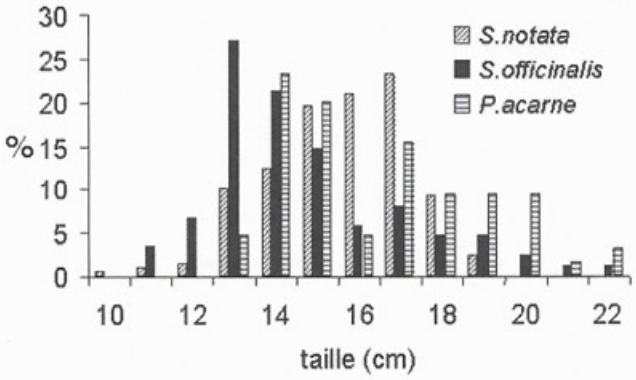


Fig. 1. Fréquence de taille des trois espèces.

Résultats et discussion

Rascasse. On a capturé 220 rascasses, entre 10 et 19 cm TL (taille moyenne 15.6 cm) (Fig. 1). Le période reproductive se situe en été (juillet à septembre) avec de valeurs d'IGS prochains à 3 (Fig. 2). Cette espèce habite et se reproduit dans le récif.

Seiche. On a capturé 89 seiches, de taille moyenne et grande (femelles: 11 à 22 cm DML, mâles: 11 à 19 cm), taille moyenne 14.7 cm la même pour les deux sexes (Fig. 1). Le période reproductive de l'espèce est toute l'année, avec un pic de ponte entre février et septembre (1). L'IGS indique que le pic de ponte est centré entre avril et juillet (Fig. 2) et que la ponte se déroule à la zone entre les modules du récif.

Pageau. On a capturé 65 pageaux. Les tailles entre 13 et 22 cm, taille moyenne 16.5 cm TL (Fig. 1), appartienent à des individus juveniles (taille de première maturité 20.95 cm) (2). Comme on n'a capturé pas un nombre important d'individus adultes on n'a trouvé pas reproduction au récif, le rapport gonadosomatique est par dessous de 1 (Fig. 2). Dans ce cas seulement les petits pageaux utilisent le récif probablement pour se nourrir ou se protéger.

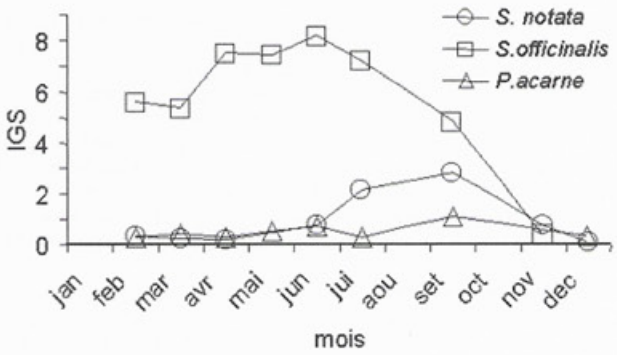


Fig. 2. Rapport gonadosomatique (IGS) des trois espèces.

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Bibliographie

1 - Guerra, A., 1992. Mollusca, Cephalopoda. 327 pp., 12 lám. *In*: Ramos, M. A. *et al.* (eds.). Fauna Ibérica, vol. 1. Museo Nacional de Ciencias Naturales. CSIC. Madrid.
2 - Neves Santos, M., Monteiro, C. C., and Erzini, K., 1995. Aspects of the biology and gillnet selectivity of the axillary seabream (*Pagellus acarne*, Risso) and common pandora (*Pagellus erythrinus*, Linnaeus) from the Algarve (south Portugal). *Fish. Res.*, 23: 223-236.

RECAPTURES OF TAGGED DEEP-SEA SHRIMPS *ARISTEUS ANTENNATUS* (RISSO, 1816) IN THE MEDITERRANEAN

Relini M. [1], Maiorano P. [2] *, D'Onghia G. [2], Orsi Relini L. [1], Tursi A. [2], Panza M. [2]

[1] Laboratorio di Biologia marina ed Ecologia animale (DIP.TE.RIS.), Università di Genova, Italy
[2] Dipartimento di Zoologia, Università di Bari, Italy - * p.maiorano@biologia.uniba.it

Abstract

A tagging experiment on *Aristeus antennatus* was carried out in the Ionian Sea during May 1998-September 2000. A total of 693 shrimps were tagged and released, 23 recaptured, two of which 1 and 9 months later. A displacement of about 10 and 8 nm respectively was recorded. A growth rate of 1 mm/month in the CL range 29-38 mm was observed in the specimen recaptured after 9 months.

Key words: Aristeus antennatus, tagging, displacement, growth, Mediterranean Sea

Introduction

Tagging experiments provide useful information on displacement, growth rate and population abundance of the marine living resources (1). Such experiments have been extensively carried out on crustacean species living in coastal waters (2; 3) while most probably the first case of tagging the deep water shrimp belonging to Natantia regards the stock of *Aristeus antennatus* (Risso, 1816) in the Ionian Sea, along the Calabrian coast (4; 5). One month after tagging 45 shrimps, one female specimen was recaptured at about 10 nautical miles from the release point. Its carapace length was unchanged. Further tagging experiments on *A. antennatus* were conducted both in the Ionian and Ligurian Sea until September 2000. As part of one of them a second specimen was recaptured 9 months after the tagging and releasing. New information on its displacement and growth is reported in this note.

Material and methods

The tagging experiment was carried out in the Ionian Sea, along the Calabrian coast, off Roccella Ionica (Fig. 1), an area where vertical displacements of *A. antennatus* occur during night hours (6). Sampling was conducted during the night in shelf waters (150-200 m), when smaller thermic and light changes occur from water to air, in order to reduce the impact of the capture on the specimens. A commercial vessel equipped with an otter-trawl net with 40 mm stretched mesh in the cod-end was hired. The catch was rapidly sorted and all live specimens were put in a tank containing cooled sea water. After half an hour in the tank, all swimming individuals were measured, sexed and tagged. The tag was a green streamer 4S HALLPRINT 95x4 mm, narrower in the middle (20x2 mm) placed through the pleon. Each tagged specimen was replaced in the tank and left from half an hour to two hours to allow the vessel to reach the release site. This time lag was also useful to evaluate vitality after tagging. Each tagged specimen was released in a segment of PVC tube (40 cm length and 10 cm in diameter) full of water, closed and ballasted at the lower end. The tube was gently released over-board with the ballasted end down, so that it descended to the bottom in a vertical position and then lay down on it, allowing the shrimp to swim out (4). During May 1998-September 2000 a total of 693 individuals of *A. antennatus* were tagged and released in the study area.

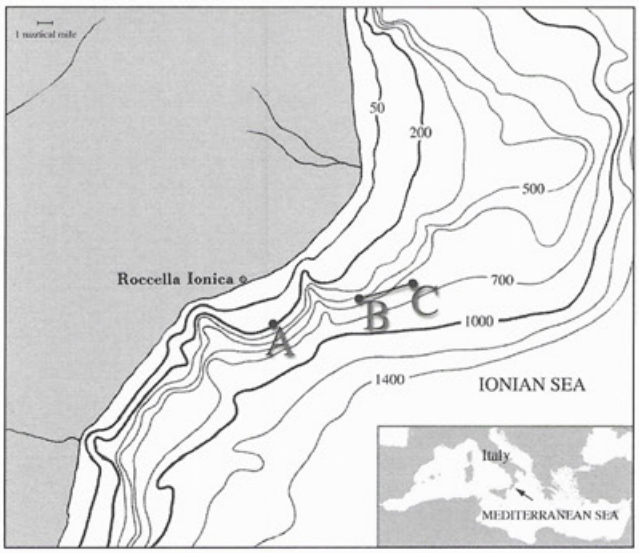


Fig. 1. Release point and area of recapture (haul route) of the specimen caught after 9 months.

Results and discussion

Twenty-one specimens tagged and released were recaptured shortly after by the same vessel used for the experiment. One individual was captured and released on 22.05.98 and recaptured after one month (4). One specimen captured and released on 22.11.99 at 159 m depth (38°16.76N-16°26.98E) was recaptured on 5.08.00, 9 months later, during daylight fishing at depths between 500 and 600 m (haul starting point 38°18.19N-16°34.00E; haul ending point 38°19.13N-16°38.31E). This specimen was recaptured at a distance between approximately 5.7 and 9.4 nm from the releasing point (Fig. 1). It was a female whose size at capture and recapture were 29 and 38 mm carapace length, respectively. The presence of spermatophores on the *thelycum* was only recorded during the recovery.

This second result confirms the feasibility of the technique for this deep water living resource even though taking into account the high mortality rates estimated for this species as part of stock assessment studies, the number of tagged specimens must be large.

The present result also confirms the displacement capacity of *A. antennatus* both vertically and horizontally. Furthermore, considering the difference in carapace length between release and recovery, the specimen recaptured grew according to a mean growth rate of 1 mm/month. This agrees with the slowest growth performance proposed (7) based on the study of a very abundant cohort followed for three years in Ligurian Sea. Although this pattern comes from only one specimen, it provides the first direct measure of the growth in *A. antennatus*.

References

1 - Jones R., 1976. The use of marking data in fish population analysis. *FAO Fish. Tech. Pap.*, 153, 42 p.

2 - Montgomery S.S., 1981. Tagging studies on juvenile eastern king prawn reveal record migration. *Australian Fisheries*, 40 (9): 1-13.

3 - Dall W., Hill B.J., Rothlisberg P.C., Staples D.J., 1990. The biology of Penaeidae. *Adv. Mar. Biol.*, 27: 1-489.

4 - Relini M., Maiorano P., D'Onghia G., Orsi Relini L., Tursi A., Panza M., 2000. A pilot experiment of tagging the deep shrimp *Aristeus antennatus* (Risso, 1816). *Sci. Mar.*, 64 (3): 357-361.

5 - Relini M., 2000. Valutazione delle risorse biologiche rappresentate dai gamberi di ambiente batiale, *Aristeus antennatus* e *Aristaeomorpha foliacea*, in due bacini mediterranei. PhD Thesis. University of Bari, 255 p.

6 - Matarrese A., D'Onghia G., De Florio M., Panza M., Costantino G., 1995. Recenti acquisizioni sulla distribuzione batimetrica di *Aristaeomorpha foliacea* ed *Aristeus antennatus* (Crustacea, Decapoda) nel Mar Ionio. *Biol. Mar. Medit.*, 2(2): 299-300.

7 - Orsi Relini L., Relini G., 1998. Seventeen instars of adult life in females of *Aristeus antennatus* (Decapoda Aristeidae). A new interpretation of life span and growth. *J. Nat. Hist.*, 32: 1719-1734.

DEMERSAL SELACHIANS IN THE LIGURIAN SEA

G. Relini *, A. Mannini, T. Piano

Università di Genova, Dip.Te.Ris, Laboratori di Biologia Marina ed Ecologia Animale, Genova, Italia - * biolmar@unige.it

Abstract

Since 1985 national trawl surveys (GRUND) were carried out in the Ligurian Sea (NW Mediterranean) and a considerable set of data about demersal species was collected. In this short note the number of Selachian species caught during 25 surveys was compared with those fished in previous years and the decrease in species richness is outlined.

Key-words: Selachians, trawl surveys, Ligurian Sea

Introduction

Twenty-five national trawl surveys (GRUND) have been conducted since 1985 within the framework of national coordination on demersal resource assessment (1-3). The aim of these surveys is the knowledge of the exploitation state of the demersal resources. In this short note the Selachians caught in the Ligurian Sea (NW Mediterranean Sea) are described and compared with previous data. It is well known that Chondrichthyes are very sensitive to fishing pressure and can be used as biological indicator of overexploitation in an area (4).

Material and method

From 1985 to 2002 twenty-five otter trawl surveys were carried out in spring and in late summer/early autumn (2). A total number of 620 daylight hauls were performed at depths between 10 to 800 m off the Ligurian coast. Data was processed to obtain a percentage index of presence (percentage frequency catches of i species of Selachians per total number of surveys performed) for the different species and a total number of species caught per surveys.

Results

Overall 13 species (one *Chimaeridae*, four *Rajidae* and eight *Squalidae*) were caught during the surveys. They represented about 30% of the total demersal species recorded in the Italian seas (5) and about 43% of the total number of species known in the area based on historical data (6)

Figure 1 shows the percentage of presence observed in the twenty-five surveys. Only two species *Galeus melastomus* and *Etmopterus spinax* were caught in all surveys. *Scyliorhinus canicula* had a high percentage followed by *Chimaera monstrosa*, *Dalatias licha* and *Raja asterias*. The remaining seven species had values lower than 50%.

The total number of species caught in each survey (Fig.2) ranged from 4 to 9 species and no trend was observed. The most frequent species were represented by *G. melastomus, E. spinax, S. canicula, C. monstrosa, D. licha* and *R. asterias*.

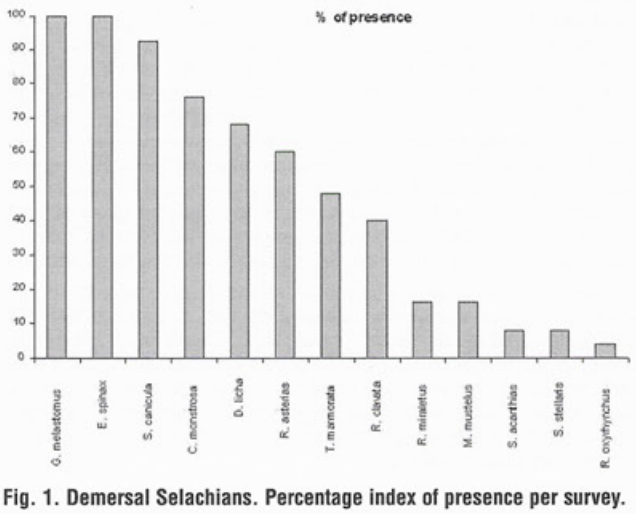


Fig. 1. Demersal Selachians. Percentage index of presence per survey.

Discussion

Selachians, generally caught by bottom trawlers, play an important role not only in the structure of the demersal communities, but also for managing the implicated fisheries despite the fact that they are largely discarded. Selachians are very vulnerable to increased fishing

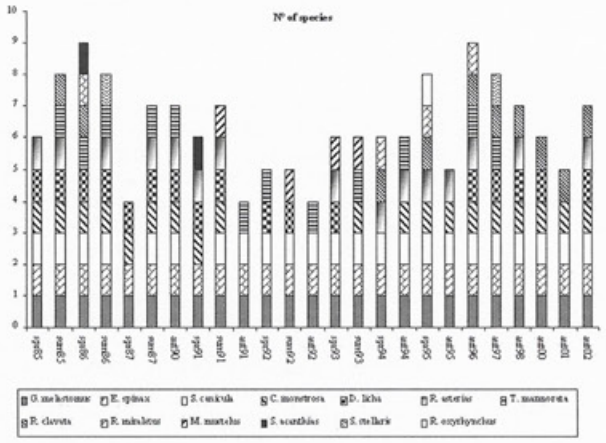


Fig. 2. Demersal Selachians. Total number of species caught per survey.

mortality and their qualitative and quantitative can changes reflect high fishing pressure, due to their low fecundity and high age/length of first maturity (4).

The lower diversity in the area when compared to historical data (6) and to the other Italian seas (5), may reflect the overexploitation of local bottoms communities. In fact only two species are caught with a 100% of frequency (*G. melastomus* and *E. spinax*) and only other four with a frequency > 50% of surveys. The remaining species were very rare when compared to early eight's, especially *Mustelus mustelus* and *Squalus acanthias* whereas some, like *R. brachyura,* have disappeared (7). In terms of management a continuous monitoring of this important group, not only at the diversity level (species richness) but also at the biomass/abundance level of the species more frequently caught, is essential.

References

1 - Relini G., 1998. I progressi della ricerca italiana sulla pesca a strascico. *Biol. Mar. Medit.*, 5 (2): 3-21.

2 - Relini G., 1998. Valutazione delle risorse demersali. *Biol. Mar. Medit.*, 5 (3) parte prima: 3-19.

3 - Relini G., 2000. La ricerca sulla pesca: le risorse demersali. *Biol. Mar. Medit.*, 7 (4): 13-45.

4 - Baum J.K., Myers R.A., Kehler D.G., Worm B., Harley S.J., Doherty P.A., 2003. Collapse and conservation of shark populations in the Northwest Atlantic. *Science* Vol. 299: 289-392.

4 - Relini G., Biagi F., Serena F., Belluscio A., Spedicato M.T., Rinelli P., Follesa M.C., Piccinetti C., Ungaro N., Sion L. and Levi D, 2000. I selaci pescati con lo strascico nei mari italiani. *Biol Mar. Medit.*, 7 (1): 347-384.

5 - Parona C, 1898. La pesca marittima in Liguria. *Boll. Mus. Zool. Anat. Comp. Univ. Genova* 3 (66): 1-69.

6 - Relini G., Peirano A. e Tunesi L., 1986. osservazioni sulle comunità dei fondi strascicabili del Mar Ligure Centro-Orientale. *Boll. Mus. Ist. Biol. Univ. Genova* 52 suppl.: 139-161.

SMALL–SCALE FISHERIES IN CABRERA ARCHIPELAGO NATIONAL PARK (W MEDITERRANEAN): IDENTIFICATION OF FISHING MÉTIERS

Olga Reñones, Raquel Goñi, José Luis Fernández, Xavier Mas * and Miguel Pozo
IEO- Centro Oceanográfico de Baleares, Palma de Mallorca, Spain

Abstract

This study identified the small-scale fixed net fishery métiers in the Cabrera Archipelago National Park. This is an important first step in any study focusing in evaluating the fisheries effects of management measures. From a data set of 113 fishing operations collected year-round, five fishing métiers were identified. The "picarel", "red mullet" and "large-scaled scorpion-fish" métiers exhibited strong seasonal, habitat and location patterns whereas "black scorpion-fish" and "star gazer" métiers were more evenly practised during the warm seasons in mixed habitats.

Key words: Marine reserves; small-scale fisheries, métiers

Introduction

Marine reserves have been widely promoted as fishery management tools that enhance local fisheries through spillover of juveniles and adults (1). A first step on the evaluation of the fisheries effects of marine reserves is the identification of métiers (fishing tactics) in the protected area. Identifying these involves acquiring knowledge of the fishing gears used and the species composition, yields and length structure of the catches as well as the seasonality and characteristics of the fishing grounds. The aim of this study was to identify fishing métiers of the small-scale fixed net fishery operating in the Cabrera Archipelago National Park (CANP) (Balearic Island, Western Mediterranean), and is part of an ongoing study evaluating the fisheries benefits of fisheries restrictions in CANP. The CANP, created in 1991, extends from the shore to 110 m depth and includes a network of five Integral reserves (IR) closed to all fishing covering 4% of the 87 Km^2 of marine area protected. Only small–scale fisheries are allowed in CANP and 59 boats are licensed to fish there. In spite of the recovery of most of the high-value species, mainly caught with long-lines(1), fishermen have been resistant to adapting to the new conditions, and 12 years after its creation, fixed nets are still the main gears used.

Material and methods

Data were collected from 1998 to 2001 on board artisanal vessels that fished in CANP. In each fishing operation (set) date, location, depth, habitat, net length, mesh size, fishing time, species composition of the catch and length of all the specimens captured were recorded. Métiers were identified based on ordination and classification techniques (2). We performed Principal Component Analysis to use the principal components (PC) scores as transformed variables, and Agglomerative Hierarchical Clustering (AHC) for classifying fishing operations into groups. Eight PCs that explained approximately 48% of the variance, were used as variables for HAC. For each cluster, identifying a species or group of species as typical, a new categorical variable (catch profile) was created. In a second step fishing métiers were identified by means of Multiple Correspondence Analysis (MCA) based on the following categorical variables: catch profile, fishing location, season, depth (four depth range) type of gear and mesh size. For the target species, the size structures exploited by each métiers were compared using Kolmogorov-Smirnov test.

Results and discussion

A total of 65 species were captured (4 crustaceans, 3 molluscs and 58 fishes) in the 113 sets sampled. Five cluster were identified (Table 1). The "red mullet" (35 sets) cluster, characterised by *Mullus surmuletus* and *Diplodus annularis* was the best discriminated. The "picarel" (8 sets) cluster was the only one characterised by a single species (*Spicara smaris*). The "large-scaled scorpion-fish" (10 sets) cluster encompassed species characteristics of maërl or soft substrates. The two remaining clusters "star grazer" (15 sets) and "black scorpion-fish" (41 sets), were not as well discriminated and differed in terms of both the target species and the relative proportions of soft and hard bottom species. The MCA results showed a close link between catch profiles and some of the categorical variables considered.

According to these results the artisanal fleet fishing with fixed nets in CANP involves five métiers. During winter the fleet targets *S. smaris* on soft bottom at depths from 20 to 40 m using gill nets of 36mm mesh size. This métiers is highly selective (*S. smaris* is 91% of the catch in number). In autumn, the fleet targets *M. surmuletus* along the edge of the *Posidonia* meadows using gill nets of 50mm mesh. This activity is restricted to the north and east areas of CANP, due to the loss of the fishing grounds located in the south and west (nowadays IR areas). In summer, some boats target *Palinurus elephas* and the bycatch species *Scorpaena scrofa*, on maërl habitats with trammel nets of 62 to 100mm mesh. Fishing takes place at greater depth, mainly in the west of the archipelago and near the limits of the IRs. The three above mentioned métiers exhibit strong seasonal, habitat and location patterns, whereas the other two métiers are more widely practised during the warm seasons all round the archipelago in mixed habitats. The catch of the later trammel net métiers contained a mixture of species and only the higher yield of species of either hard or soft bottoms, which reflects the proportion of different habitats fished and to a lesser extend the fishing depth, characterised them.

Table 1. Characterization of the métiers of the net small-scale fixed net fleet in the Cabrera Archipelago National Park based on categorical variables.

Catch profile	Cluster size	Gear	Main fishing Location	Season	Main species	Depth (m)	Habitat
Red mullet	35	Gill net 50mm mesh size	Small Islands E. main Island	Autumn	*M. surmuletus* *D. annularis*	20 - 40	*Posidonia* edge
Picarel	8	Gill net 36mm mesh size	N. main Island Small Islands	Winter	*S. smaris*	20 – 40	Sand
Large-scaled scorpion-fish	10	Trammel net 62-100mm mesh size (inner panel)	W. main island N. small islands	Summer	*S. scrofa* *S. canícula* *P. elephas*	30 - 80	Maërl
Star gazer	15	Trammel net 62–80mm mesh size (inner panel)	Small islands W. main island	Spring Summer	*U. scaber* *P. phycis* *S. porcus*	20 - 60	Sand – Rock
Black scorpion-fish	41	Trammel net 62–80 mm mesh size (inner panel)	Small Islands E. main island W. main island	Spring Summer Autumn	*S. porcus* *U. scaber* *D. vulgaris*	15 - 50	Rock, sand and *Posidonia*

There were significant differences in the length structure of the catch of most of the species captured by two or more métiers. In general the "red mullet" and "picarel" tactic caught small specimens (lower mean, modal size and length range) than the other ones. These differences, which may be attributed to the size selectivity of the gear used in each metier and to the depth range fished, have important implications for the design of studies that aim to assess biomass export from marine reserves.

References

1 - Sanchez-Lizaso J.L., Goñi R., Reñones O., García-Charton J.A., Galzin R., Bayle J.T., Sanchez-Jerez P., Perez-Ruzafa A., and Ramos A., 2000. Density dependence in marine protected populations: a review. *Env. Conserv.*, 27(2): 144-158.

2 - Pelletier D. and Ferraris J. 2000. A multivariante approach for defining fishing tactics from commercial catch and effort data. *Can. J. Fish. Aquat. Sci.*, 57: 51-65.

SEASONAL RECRUITMENT OF HAKE IN THE ALBORAN SEA (SW MEDITERRANEAN)

Rey J. *, del Árbol J., Gil de Sola L.
Instituto Español de Oceanografía, Málaga, Spain - * javier.rey@ma.ieo.es

Abstract

In this study, the recruitment of the European hake (*Merluccius merluccius*) in the Alboran Sea was examined based on data collected from five trawl surveys carried out on the shelf and upper slope of the Alboran Sea during 2001-2002. Abundance of recruits was highest in spring 2002 and autumn 2001 at depths between 100 and 200 m.

Key words: hake, recruitment areas, Alboran, Mediterranean

Introduction

The catches of hake in the Alboran Sea are derived almost exclusively from trawl fishing and composed mainly of juveniles. The description of the main recruitment areas and recruitment variability are important for managing this resource, which is targeted by the Alboran trawl fleet (1)

Material and methods

This study is based on data obtained from five seasonal trawl surveys carried out in the Alboran Sea. Two of them were conducted by the R/V *Cornide de Saavedra* during spring 2001 and 2002 (MEDITS time series: 2). The remaining ones were conducted by the R/V *Fco. de Paula Navarro* during summer, autumn and winter between both spring cruises. A total of 190 hauls were made in the study area at depths ranging from 40 to 796 m, based on random stratified sampling. A GOC73 gear with a mesh size of 40 mm was used in every survey following the same protocol (2). Catches were standardized per 1h of trawling and abundances were weighted to the number of fish per trawling hour. The spatial representation of recruit abundance was analysed using geostatistis (ordinary kriging method: 3). Nodes each 5x5 nautical miles were considered for density estimations and spherical variograms were fitted, using SURFER 7.0 software.

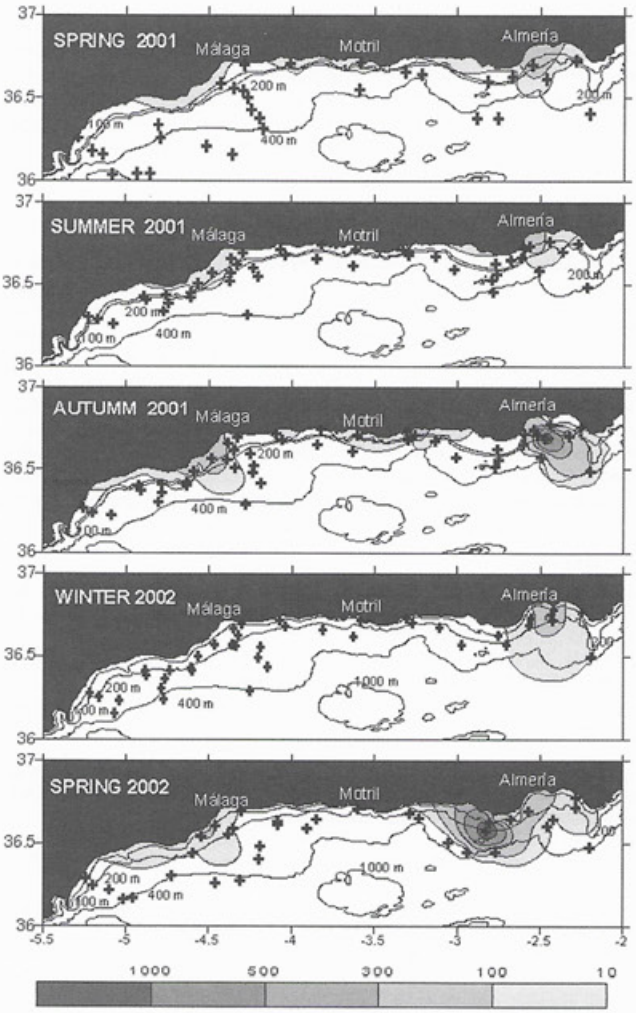


Fig. 1. Seasonal distribution of hake recruits (<17 cm) expressed as number of individuals per trawling hour.

Results and discussion

Hake recruits were concentrated mainly between 100 and 200 m, although individuals of total lengths up to 17 cm were found between 42 and 261 m.

The highest abundances were recorded in spring 2002 and autumn 2001, with maxima of 1800 and 1400 recruits/h, respectively. Maximum abundance in winter 2002, and spring and summer 2001, was 340, 280 and 180 recruits/h, respectively. Throughout the whole year maximum abundances were reached in the eastern part of the Alboran Sea.

Although individuals with lengths <17 cm were found at all stations, they dominated the spring and autumn 2001 catches, comprising >80% of the total number of specimens caught. In spring 2002, juveniles made up 99% of the total catch by number.

In the Iberian Mediterranean (from Gibraltar to cape of Creus), the recruitment of hake increases with latitude, with the highest concentrations found at the Catalan shelf (4).

Some studies have pointed out that hake recruitment strength is strongly influenced by oceanographic variables in the Atlantic (5) and the Mediterranean (6). The exceptional circulation pattern in the Alboran Sea (7) should explain anyhow these results though further studies are needed in the area in order to improve the management of this target species.

References

1 - Gil de Sola L., 1993. Las pesquerías demersales del mar de Alborán (surmediterráneo ibérico). Evolución en los últimos decenios. *Informes Técnicos del Instituto Español de Oceanografía*, 142: 179 p.

2 - Bertrand J.A., Gil de Sola L., Papaconstantinou C., Relini G., and Souplet A., 2002. The general specifications of the MEDITS surveys. Scientia Marina, 66 (suppl. 2): 9-17.

3 - Petitgas P., 1996. Geostatistics and their applications to fisheries survey data. Pp. 113-142. *In*: Megrey, B. A. and Moksness E. (ed.), Computers in fisheries research. Chapman & Hall Publ., London.

4 - Relini L., Papaconstantinou C., Jukic-Peladic S., Souplet A., Gil de Sola L., Piccinetti C., Kavadas S. and Rossi, M., 2002. Distribution of the Mediterranean hake populations based on six years monitoring by trawl-surveys: some implications for management. *Scientia Marina*, 66 (suppl. 2): 21-38.

5 - Sánchez F., and Gil J., 2000. Hydrographic mesoscale structures and Poleward Current as a determinant of hake (*Merluccius merluccius*) recruitment in southern Bay of Biscay. *ICES Journal of Marine Science*, 57: 152-170.

6 - Maynou F., Lleonart J., and Cartes J. E., 2003. Seasonal and spatial variability of hake (*Merluccius merluccius* L.) recruitment in the NW Mediterranean. *Fisheries Research*, 60: 65-78.

7 - Parrilla G., and Kinder T. H., 1987. Oceanografía física del mar de Alborán. *Bol. Inst. Esp. Oceanogr.*, 4(1): 133-165.

APPLYING THE ECOPATH ECOSYSTEM MODELLING APPROACH TO THE MEDITERRANEAN BASIN

Yvette Rizzo * and Daniel Pauly
Fisheries Center, University of British Columbia, Vancouver, Canada

Abstract

This paper discusses the applications of the Ecopath-with-Ecosim ecosystem modelling approach to assess the role of fisheries targeting top-predators as drivers of ecological change across the Mediterranean basin. The Ecopath model consists of a generic basin-wide model, with large pelagic, highly-migratory species as key functional groups. The ways in which this model can be used to assess fisheries impacts on the ecosystem at the basin level was outlined.

Keywords: Mediterranean Sea; Ecosystem impacts; Fisheries; Ecopath

Introduction

The Mediterranean Sea is undergoing a fundamental ecosystem change (1), a consequence of environmental and human factors acting on the local, regional and global scales. Fisheries is one key factor that is known to impact marine ecosystems worldwide, yet despite its importance in driving ecosystem changes very few studies have tackled fisheries impacts at the basin-ecosystem level in the Mediterranean Sea. Landings of capture fisheries provide an indication of the possible impacts of fisheries on the ecosystem. The mean trophic level of landings from the Mediterranean has significantly decreased over the last fifty years (2). This implies an increasing diversity of species in landings composition possibly a result of fishing-down-the-food-web but also of other factors including changes in primary production, changes in exploitation patterns and the introduction of new gear technologies (3, 4).

The Ecopath-with-Ecosim (EwE) ecosystem modelling approach has been used to assess the trophic impacts of fisheries across a range of geographical and temporal scales (5).

This paper highlights the possible applications of an Ecopath model for the Mediterranean ecosystem in assessing the role of fisheries targeting top-predators as drivers of ecological change in the basin.

Modelling protocol

The Ecopath model for the entire Mediterranean basin is generic and represents an annual average of the present-day ecosystem. The model structure is primarily based on communities of the central region, which is considered to be "typical" Mediterranean and not significantly influenced by adjacent seas as are the extreme ends of the basin (1). It includes both coastal and offshore components and describes predator-prey interactions between functional groups (aggregates of similar species) across the food-web. The model incorporates all species of commercial importance with the primary focus on large pelagic, highly migratory species. Key functional groups are top-predators of commercial importance in the Mediterranean and include bluefin tuna, swordfish, albacore, bonito, other tuna-like species, billfishes and sharks.

Applications of the model

At this geographical scale the Mediterranean model represents a gross simplification of ecological interactions that occur at the local and individual-species level. However it provides a tool to assess fishery-mediated trophic responses of the ecosystem at the larger geographical scale in the Mediterranean. The geographical range of large-pelagic fish spans the whole basin. These species constitute an important biological link between coastal and offshore sub-systems and support an important fishery in the Mediterranean, with very high levels of exploitation. Their biological characteristics and the importance of the fishery targeting them implies potentially significant ecosystem impacts at the basin level resulting from the fishery.

The Ecopath model is the basis for simulated fisheries experiments using Ecosim, the dynamic component of the model. Ecosim simulations show the extent of top-down control mechanisms and the type of cascade effects occurring across the food-web. Fisheries simulation experiments identify target and non-target functional groups in the Mediterranean coastal and offshore areas that are likely to be vulnerable to fishing of bluefin tuna, swordfish and other top-predators, as well as those which are likely to benefit. The simulations also highlight key ecosystem linkages and functional groups that are vital to ensure ecosystem integrity.

Ecopath incorporates a number of routines based on classical theoretical ecology that quantify ecosystem properties such as gross primary production, respiration and biomass, total system throughput and system ratios (e.g. Production/Respiration, Biomass/Respiration, etc.) (6). Quantification of ecosystem attributes for the Mediterranean Sea provides a general measure of the status of ecosystem health and provides useful ecosystem indicators. The change in such ecosystem indicators as a result of different top-predator harvesting strategies reflects the extent to which such fishing can alter the general structure and performance of the ecosystem.

A third application of the model concerns the role of coastal nutrient enrichment from land discharges in enhancing the overall productivity across the basin (7). The key issue with respect to fisheries impacts is the relative importance of bottom-up and top-down controls in promoting ecosystem changes at the Mediterranean basin level. Ecosim time-dynamic simulations are used to compare the responses of the ecosystem to increasing fishing pressure on top-predators (top-down control) with ecosystem responses to increased nutrient enrichment (bottom-up control). The latter can be simulated in Ecosim through a forcing function. Comparing the results of model simulations to the actual trends in the Mediterranean where available, leads to a better understanding of the underlying ecological mechanisms that prevail at this geographical scale and hence of the role that fishing at the top of the food-web has in modifying marine ecosystems as opposed to environmental factors.

Conclusions

The large pelagics of the Mediterranean Sea constitute a shared resource that supports high value fisheries, however, declines in landings in recent years despite increasing fishing effort and a high incidence of juveniles and small fish in the catch indicate that the resource is overexploited. This trend is likely to continue in the future, with little control over fishing effort. There is therefore a real need to understand how the Mediterranean ecosystem could respond to high fishing pressure at the top of the food-web. Ecopath-with-Ecosim provides the ideal simulation tool in this context and the results will not only shed light on the role fisheries have in modifying ecosystems at the basin level; they can also provide a general framework for the development of strategic fisheries policy in the Mediterranean basin.

References

1 - Bianchi, C. N. and Morri, C., 2000. Marine Biodiversity of the Mediterranean Sea: situation, problems and prospects for future research. *Mar. Pollut. Bull.*, 40(5): 367-376.

2 - Pauly, D., V. Christensen, Dalsgaard, J., Froese, R. and Torres, F. Jr., 1998. Fishing Down Marine Food Webs. *Science,* 279: 860-863.

3 - Pinnegar, J.K., Polunin, N.V.C. and Badalamenti, F., 2003. Long-term changes in the trophic level of western Mediterranean fishery and aquaculture landings. *Can. J. Fish. Aquat. Sci.,* 60: 222-235.

4 - Caddy, J.F. and Garibaldi, L., 2000. Apparent changes in the trophic composition of world marine harvests: the perspective from the FAO capture database. *Ocean Coast. Manage.,* 43: 615-655.

5 - Pauly, D., V. Christensen, and Walters, C., 2000. Ecopath, Ecosim, and Ecospace as tools for evaluating ecosystem impact of fisheries. *ICES J. Mar. Sci.,* 57: 697-706.

6 - Christensen V., 1995. Ecosystem maturity – towards quantification. *Ecol. Model.,* 77: 3-32.

7 - Caddy, J. F., R. Refk, and Do-Chi, T., 1995. Productivity estimates for the Mediterranean: evidence of accelerating ecological change. *Ocean Coast. Manage.*, 26(1): 1-18.

SIGNALEMENT POUR LA PREMIÈRE FOIS D'UNE BALEINE DE LA FAMILLE BALEINOPTIRIDAE ÉCHOUÉE SUR LA CÔTE SYRIENNE (MÉDITERRANÉE ORIENTALE)

Adib Saad

Laboratoire des Sciences Marines, Faculte d'Agriculture, Université de Techrine, Lattaquie, Syrie

Résumé

Le cinq Avril 2003 une baleine à bosse *Megaptera novaeangliae* (Borowski 1781) a été observée par des pêcheurs flottant sur la surface de l'eau à environ 1 km de la côte au nord de Tartous en Syrie. Nous avons été appelés pour examiner et analyser ce phénomène nouveau pour la côte syrienne.

Mots clés: Cétacés, Megaptera novaeangliae, Syria, Méditerranée orientale

Après avoir amené la baleine, morte depuis 24-48 h environ, sur terre, nous avons pris les mesures morphométriques et des photos pour les différentes parties du corps afin d'en faciliter l'identification (Fig. 1). Il est apparu que cette baleine appartient à l'espèce *Megaptera novaeangliae* (Borowski 1781), Classe: Mammalia, Ordre: Cetacea, Sous-Ordre: Mysticeti, Famille: Balaenopteridae, Genre: *Megaptera*. Il s'agit d'un mâle d'environ un an et pesant environ deux tonnes. Nous avons noté les mesures suivantes: longueur total (LT = 785 cm, longueur de la nageoire pectorale (N. P) = 164 cm.

A notre connaissance, et d'après les pêcheurs locaux, c'est la première fois qu'on observe une telle baleine dans cette région de la Méditerranée orientale.

La cause de l'échouage reste inconnue, mais nous pensons qu'elle est due soit à une explosion dans des champs d'entraînement militaire de la force marine, soit à une collision avec un bateau ou à cause de la mort de sa mère car le jeune baleineau reste normalement avec sa mère pendant quelques mois.

Suite à la dissection du corps, nous avons trouvé que l'estomac et les intestins étaient vides sauf une petite quantité des zooplanctons et crustacés dans la dernière partie des intestins. D'après la littérature scientifique (1, 2), le Juparte *Megaptera novaeanliae* fréquente à peu près tous les océans du globe (2). C'est surtout dans l'hémisphère sud que l'espèce est abondante. Selon Cousteau et Paccalet (2) on peut accepter l'idée de deux populations d'origine assez réduite, et chacune vraisemblablement divisée en troupeaux plus petits. Ainsi, la population de l'Atlantique oriental se partage probablement, l'hiver, en un groupe des Canaries et des îles du Cap-Vert (migrant à la belle saison vers l'Ecosse et la Norvège), et un groupe des Açores (voyageant l'été vers l'Islande et la pointe du Groenland, et même jusqu'à l'océan Glacial).

Le troupeau de l'Atlantique de l'ouest s'échelonne en hiver de la Guyane aux Antilles et aux Bermudes, effectuant sa migration de printemps vers la Nouvelle-Angleterre, Terre-Neuve, l'entrée du détroit de Davis et l'océan Glacial. Il est probable que le mégaptère échoué sur la côte syrienne au printemps faisait partie de la population de l'est de l'Atlantique et que sa mère est passée en Méditerranée pour se reproduire en hiver.



Fig. 1. Baleine après l'échouage.

Références

1 - Marchessaux D., 1980. A review of the current knowledge of the cetaceans in the Eastern Mediterranean Sea. *Vie Marine*, 2: 59-66.

2 - Cousteau J.-Y.; Paccalet Y., 1986. La planète des Baleines. Ed. Robert Laffont, Paris. Pp. 110-111.

LISTE COMMENTÉE DES CHONDRICHTHYENS DE SYRIE (MÉDITERRANÉE ORIENTALE)

Adib Saad [1] *, Bernard Seret [2] et Malek Ali [1]

[1] Tishreen University, Lattakia, Syria - * adibsaad@scs-net.org

[2] Muséum national d'Histoire naturelle, Paris, France - seret@mnhn.fr

Abstract

Few studies have been carried out on the chondrichthyans of the eastern Mediterranean and no specfic systematic inventory had been done for those of the Syrian waters. A field study was recently carried out to inventory the chondrichthyans landed in the main fishing places along the Syrian coast. As a result, 37 species were collected including 20 sharks, 16 batoids and 1 chimaera. *Carcharhinus obscurs* and *Torpedo sinuspersici*, are recorded for the first time, the latter is also a new Lessepsian migrant from the Red Sea. The results are compared to the check lists available for the Mediteranean.

Mots-clés: Chondrichthyes, Checklist, Syria, Mediterranean

Introduction

Les travaux de faunistiques relatifs aux chondrichtyens de la Méditerranée orientale sont peu nombreux si bien que dans les faunes générales pour la Méditerranée (1, 2, 3), les cartes de distribution de certaines espèces sont parfois établies sur des présences présumées ou probables. Pour la Syrie, il n'existait aucune étude spécifique sur les chondrichtyens depuis le premier inventaire établi par Gruvel en 1931 (4). Le présent article fournit une liste des chondrichtyens de Syrie basée sur des spéciemens récemment récoltés.

Matériel et méthodes

Les observations et les récoltes de spécimens ont éte faites entre mars 2000 et avril 2003 dans les principaux centres de pêche, notamment ceux de Lattaquie et de Tartous. La classification utilisée est celle de Compagno (5).

Résultats

Au cours des trois années d'observations, 37 espèces de chondrichtyens ont été recensées (Tab. 1): 20 requins, 25 raies et 1 chimère.

Certaines identifications sont provisoires dans l'attente d'une étude approfondie des spécimens récoltés, e.g. *Squalus* sp. cf. *megalops*, *Centrophorus* sp. cf. *uyato* et *Centrophorus* sp. Deux espèces sont signalées pour la première fois en Méditerranée orientale, *Carcharhinus obscurus* et *Torpedo (Torpedo) sinuspersici*, cette dernière représente un nouveau signalement de migrant lessepsien.

Certaines espèces signalées précédemment n'ont pas été retrouvées, il s'agit des espèces qui ont toujours été rares (e. g. *C. carcharias*) mais même des espèces relativement communes comme *Scyliorhinus stellaris* ou *Mustelus asterias*, *Torpedo torpedo* et *Myliobatis aquila*, n'ont pas été observées durant la période d'étude, peut-être du fait d'un déclin de leurs populations.

En comparant ces résultats avec les listes faunistiques disponibles, on constate qu'un potentiel de 74 espèces existe en Méditerranée orientale, incluant 41 requins, 32 raies et une chimère. La faune de Syrie est donc relativement peu diversifiée par rapport à ce potentiel. Cela s'explique sans doute par la faible longueur de côte de ce pays, mais aussi par le fait que les eaux profondes de cette région ont encore été peu étudiées.

Références

1 - Whitehead P. J. P., Bauchot M.-L., Hureau J.-C., Nielsen J. and Tortonese E., 1984. Fishes of the North-eastern Atlantic and the Mediterranean. Volume 1: 1-509. UNESCO, Paris.

2 - Fischer W., Schneider M. et Bauchot M.-L., 1987. Fiches FAO d'identification des espèces pour les besoins de la pêche. Méditerranée et Mer Noire. Zone de pêche 37. Révision 1. Volume 2: 761-1530. Vertébrés. FAO, Rome.

3 - Fredj G. et Meinardi M., 2001. Banque de données sur la faune marine méditerranéenne. Medifaune 2001 (http://nephi.unice.fr/Medifaune/).

4 - Gruvel A., 1931. Les états de Syrie. Richesses marines et fluvilaes. Exploitation actuelle. Avenir. Bibliothèque de la Faune des Colonies Françaises. Société d'éditions géographiques, maritimes et coloniales, Paris. 453 p.

5 - Compagno L. J. V., 1999. Checklist of living elasmobranchs. Pp. 471-498. *In*: Hamlett W.C. (ed.). Sharks, skates and rays: the biology of elasmobranch fishes. John Hopkins University Press ; Maryland.

6 - Golani D., 1996. The Marine Ichthyofauna of the Eastern Levant. History, Inventory and Characterization. *Israel Journal of Zoology*, 42: 15-55.

7 - Mater S., Kaya M. and Bilecenoglu M., 2000. Checklist of marine fishes of Turkey (CLOMFOT). Part 1. Check-list of cartilaginous fishes (Classes Chondrichhyes and Holocephali). Web pages: http://bornova.ege.edu.tr/~mbilecen/chond_list.html of the Ege University, Izmir, Turkey.

Tab. 1. Liste des espèces de chondrichtyens observées sur les côtes de Syrie (présente étude) et signalées en Méditerranée orientale (données de la littérature).

Taxons	Gruvel 1931	FNAM 1984	FAO 1987	Golani 1996	CLOM FOT 2000	MEDI FAUNE 2002	Présente étude
Hexanchus griseus		+	+	+	+	+	+
Heptranchias perlo			+	+	+	+	+
Echinorhinus brucus					+		
Squalus acanthias	+		+	+	+	+	
Squalus blainvillei		+	+	+	+	+	+
Squalus sp. cf. megalops							+
Centrophorus granulosus	+	+	+	+	+	+	+
Centrophorus sp. cf. uyato					+	+	+
Centrophorus sp.							+
Somniosus rostratus				+			+
Oxynotus centrina		+	+	+	+	+	+
Dalatias licha				+	+		+
Etmopterus spinax				+	+		
Squatina aculeata				+	+		+
Squatina oculata			+	+	+	+	+
Squatina squatina	+	+	+	+	+	+	+
Cetorhinus maximus				+	+		
Alopias superciliosus				+			+
Alopias vulpinus			+	+	+	+	
Carcharodon carcharias			+	+	+	+	
Isurus oxyrinchus		+	+	+	+	+	+
Lamna nasus				+	+	+	
Carcharias taurus			+	+	+	+	
Odontaspis ferox			+	+	+	+	
Galeus melastomus		+	+	+	+	+	+
Scyliorhinus canicula	+	+	+	+	+	+	+
Scyliorhinus stellaris	+		+		+	+	
Galeorhinus galeus			+		+	+	
Mustelus asterias			+	+	+	+	
Mustelus mustelus	+	+	+	+	+	+	+
Mustelus punctulatus			+		+	+	
Carcharhinus altimus				+			
Carcharhinus brevipinna			+	+	+	+	
Carcharhinus limbatus			+	+	+	+	
Carcharhinus melanopterus			+	+	+	+	
Carcharhinus obscurus							+
Carcharhinus plumbeus		+	+	+	+		+
Prionace glauca			+	+	+	+	
Sphyrna tudes						+	
Sphyrna zygaena	+		+	+	+	+	
Pristis pectinata	+		+	+		+	
Rhinobatos cemiculus G. St Hilaire, 1817			+	+	+	+	+
Rhinobatos rhinobatos			+	+	+	+	+
Torpedo nobiliana			+	+	+	+	+
Torpedo marmorata	+		+	+	+	+	+
Torpedo sinuspersici							+
Torpedo torpedo	+		+	+	+	+	
Dipturus batis					+		
Dipturus oxyrhynchus		+	+	+	+	+	+
Leucoraja circularis					+		
Leucoraja fullonica			+		+	+	
Leucorala naevus			+				
Raja asterias			+	+	+	+	
Raja clavata	+	+	+	+	+	+	+
Raja miraletus	+	+	+	+	+	+	+
Raja montagui			+		+	+	
Raja polystigma					+		
Raja radula		+	+	+	+	+	+
Raja undulata			+	+	+	+	
Rostroraja alba					+		
Dasyatis centroura			+	+	+	+	
Dasyatis chrysonota						+	
Dasyatis pastinaca	+	+	+	+	+	+	+
Dasyatis sp. cf. tortonesei				+	+	+	+
Pteroplatytrygon violacea			+	+	+	+	+
Himantura uarnak			+	+	+	+	
Taeniura grabata			+	+	+		
Gymnura altavela		+	+	+	+	+	+
Myliobatis aquila	+		+	+	+	+	
Pteromylaeus bovinus		+	+	+	+	+	+
Rhinoptera marginata		+	+	+	+	+	+
Mobula mobular		+	+	+	+	+	+
Chimaera monstrosa	+	+		+	+	+	+
requins	7	10	26	31	33	28	20
raies	7	9	25	23	28	25	16
chimères	1	1	0	1	1	1	1
CHONDRICHTYENS	15	20	51	55	62	54	37

OVARIAN STRUCTURE AND ANNUAL REPRODUCTIVE CYCLE OF *SCORPAENA PORCUS*

Maria Sàbat *, Maria Rosa Hernández, Marta Muñoz and Margarida Casadevall
Àrea de Zoologia, Departament de Ciències Ambientals, Facultat de Ciències, Universitat de Girona, Spain
* maria.sabat@udg.es, rosa.hernandez@udg.es, marta.munyoz@udg.es and margarida.casadevall@udg.es

Abstract

The ovarian structure, the seasonal histology of the ovary, and various indices related to reproduction of *Scorpaena porcus* were analysed. The ovary showed many characteristics that are not typical for oviparous fishes: central ovarian stroma, pedunculate oocytes, scarcity and small size of cortical alveoli, thinness of the zona radiata, and a gelatinous matrix secreted during the maturation phase. The hepatic reserves were basically used for the final process of maturation. Spawning takes place between June and August.

Keywords: Scorpaena porcus, ovarian structure, reproductive cycle

The black scorpionfish (*Scorpaena porcus* L. 1758) is one of the most common species of the Scorpaenidae family. It is a sedentary species, living mainly in rocky and sea-grasses bottoms, at depths of up to 800 m (1). Although it is very abundant off the coasts of Catalonia and of commercial interest, there is not much information about its reproductive biology. The aim of the present work was to study the annual reproductive cycle of female black scorpionfish, on the basis of the ovarian structure, its histological changes, and various indices related to reproduction. The ovaries were classified according to the most developed type of oocyte (2).

The ovary of black scorpionfish shows a lot of peculiar characteristics that are not usual in oviparous species. Firstly, the ovary is of the cystovarian II-3 type (3), as it is surrounded by the ovarian wall and has the muscular-connective rachis and the blood vessels in its centre. Furthermore, the oocytes develop ovarian vascularized peduncles, considered in viviparous species to be protuberances of the placentary or pseudo-placentary connections (4). Finally, the cortical alveoli are scarce and with small size, and the thickness of the zona radiata is considerably less than that in other oviparous species. Both these characteristics have also been associated with viviparity in fishes (5). This special ovarian structure it is similar to that described for another scorpionfish, *Scorpaena notata* (6).

The female reproductive cycle begun in September, when the entire ovary is in the previtellogenesis stage. In April, oocyte in cortical alveoli stage appeared for the first time, and in May begun the vitellogenic and maturation phase. From May to August, the internal epithelium of the ovarian wall developed many cytoplasmic projections which, together with the lamellar epithelium, secret a transparent and gelatinous ovarian fluid.

The annual development of gonadosomatic index (GSI = gonad weight/evicerated weight x 100), hepatosomatic index (HIS = liver weight/evicerated weight x 100) and condition factor (K = evicerated weight/standard length x 100), is shown in figure 1. As is it shown in this graphic, in the beginning of vitellogenesis the liver stored energetic reserves, which will be used for the final process of maturation. On the other hand, there were not any monthly significant differences for the condition factor (K) (ANOVA, $p = 0{,}550$), although it has to be pointed out the slightly decrease between June and July which is related to the demand of energy for the vitellogenesis process (7). The mean gonadosomatic index changed significantly throughout the year (ANOVA, $p < 0{,}001$), showing a peak in the final maturation phase of the ovary. Based on GSI and the presence of hydrated oocytes and postovulatory follicles during June and July, spawning in black scorpionfish extends from June to August.

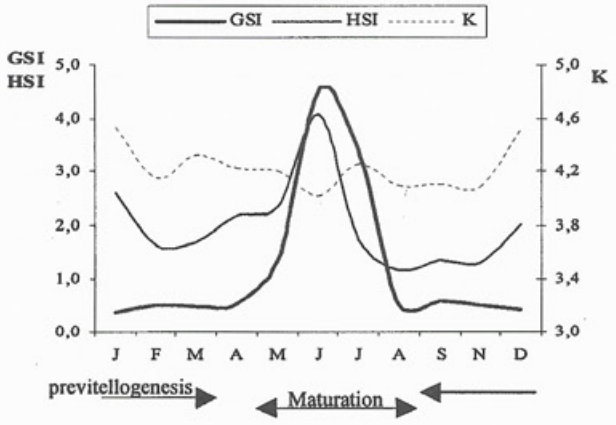


Fig. 1. Annual development of gonadosomatic index (GSI), hepatosomatic index (HSI) and condition factor (K) related to the reproductive cycle of black scorpionfish.

References

1 - Whitehead P.J.P, Bauchot M.L., Hureau J.C., Nielsen J., Tortonese E., 1986. Fishes of the North-eastern Atlantic and the Mediterranean. UNESCO, Paris.

2 - West G., 1990. Methods of assessing ovarian development in fishes: a review. *Aust. J. Mar. Freshwat. Res.*, 41: 199-222.

3 - Takano K., 1989. Ovarian structure and gametogenesis. Pp. 3-34. *In:* Takashima F. and Hanyu I. (ed.). Reproductive Biology of Fish and Shellfish. Midori-Shobo, Tokyo.

4 - Erickson D.L. and Pikitch, 1993. A histological description of shortspine thornyhead, *Sebastolobus alascanus*, ovaries: structures associated with the production of gelatinous egg masses. *Environ. Biol. Fish.*, 36: 273-282.

5 - Takemura A., Takano K. and Takahashi H., 1987. Reproductive cycle of a viviparous fish, the white-edged rockfish, *Sebastes taczanowskii*. *Bull. Fac. Fish. Hokkaido Univ.*, 38(2): 111-125.

6 - Muñoz M., Casadevall M. and Bonet S., 2002. The ovarian morphology of *Scorpaena notata* shows an specialized mode of oviparity. *J. Fish Biol.*, 61: 877-887.

7 - Santos R.S, Hawkins S.J. and Nash R.D.M., 1996. Reproductive phenology of the Azorean rock pool blenny a fish with alternative mating tactics. *J. Fish Biol.*, 48: 842-858.

LAGRANGIAN TRACKING OF LOW SALINITY SURFACE WATERS FROM THE GULF OF LIONS AND ADVECTION OF ANCHOVY LARVAE ALONG THE CATALAN SLOPE (NW MEDITERRANEAN)

A. Sabatés [1] *, J. Salat [1], I. Palomera [1], M.P. Olivar [1] and M.L. Fernández de Puelles [2]

[1] ICM-CSIC., Barcelona, Spain - * sabates@icm.csic.es

[2] IEO Balears, Palma de Mallorca, Spain

Abstract

The results of a Lagrangian survey of waters of continental origin from the Gulf of Lions are presented. Three drifters were launched at the edge of the continental shelf around the core of the shelf-slope current and followed up to near Barcelona. The current was carrying surface waters with relatively low salinity from the Gulf of Lions, influenced by Rhone runoff. Monitoring of environmental conditions, planktonic communities and anchovy larvae living in the surface water parcel tracked by the drifters was conducted in order to evaluate the suitability of these waters for the survival of anchovy larvae.

Keywords: NW Mediterranean, continental waters, advection, anchovy larvae, larval growth

Introduction

In the Mediterranean, once the seasonal thermocline has been established by the end of spring, the nutrient content of surface waters is rapidly exhausted and primary production can only be sustained at deeper layers (1). Only at certain places, in conditions of favourable winds for coastal upwelling or near river mouths, there can be some nutrient input into the surface water allowing a relatively high biological production. In the Catalan Sea, the spawning peak of anchovy, *Engraulis encrasicolus,* takes place at the end of spring. High egg and larval abundances are clearly associated with areas of freshwater input (2). During the earliest stages of development anchovy larvae are located near the surface (3). This coincidence is related to: (i) the relative high production of these waters at the end of spring, when the continental runoff reaches its annual maximum, and (ii) the ability of these larvae to survive in a low salinity environment.

The continental shelf of the Gulf of Lions is influenced by water of continental origin from the outflow of the Rhône River. The stratification conditions at the end of spring play a role, favouring a wide spreading of these continental waters, because the surface mixed layer is still very thin. It is, then, not difficult to find these low salinity surface water as far as more than 250 km away from the river mouth, downstream the shelf-slope current (5).

Data

A lagrangian survey was carried out in June 2000, during 10 days in the northern Catalan coast. Three drifters were launched at the shelf edge of the Gulf of Lions, around the core the shelf-slope current, and followed up to near Barcelona, along a path of more than 200 km. The current was carrying surface waters with relatively low salinity from the Gulf of Lions. The objective was to monitor the environmental conditions, planktonic communities and anchovy larvae living in the surface water parcel tracked by the drifters and evaluate the suitability of these waters for the survival of anchovy larvae. The experiment was completed by a general survey of the whole area to compare the situation inside and outside the tracked water.

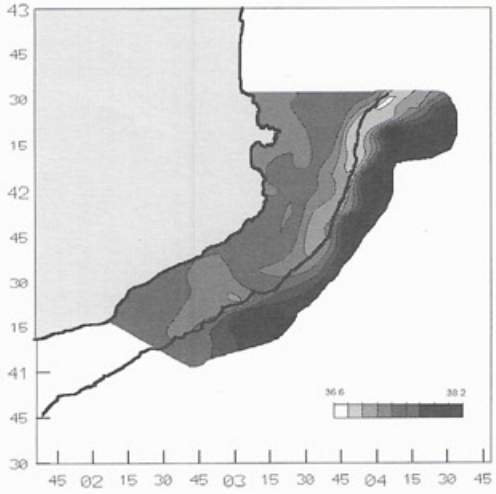


Fig. 1. Surface Salinity distribution showing the trajectory of the drifters along the experiment.

Results

The general surface salinity distribution showed both relatively low salinity and high fluorescence waters over the drifters' path (Fig.1). Concentration of copepod nauplii and copepodites, potential larval fish food, did not show important variations along the experiment. At the starting point of the drifters, high concentrations of small anchovy larvae were detected, which were progressively decreasing in number, while larval size increased along the survey track (Fig. 2). Larval growth rates obtained through otolith microstructure analysis revealed that mean size increased along the path and this corresponded well with the time elapsed from the beginning of the experiment (Fig. 2). This suggests that larval cohorts were growing inside the tracked plume of continental influence.

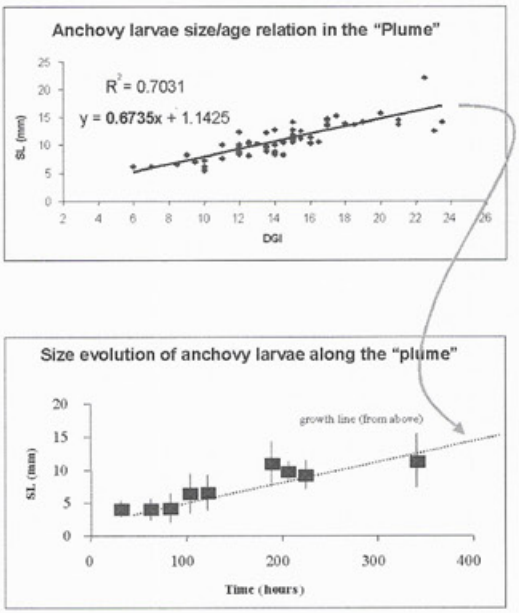


Fig. 2. Anchovy larval growth and mean larval size (± SD) along the experiment.

References

1 - Estrada, M., 1985. Deep phytoplankton and chorophyll maxima in the Western Mediterranean. Pp. 247-277. *In*: Moraitou-Apostolopoulou, M., and Kortsis, V. (eds.), Mediterranean Marine Ecosystems, Plenum Press, New York.

2 - Palomera, I., 1992. Spawning of anchovy *Engraulis encrasicolus*, in the North-Western Mediterranean relative to hydrographic features in the region. *Mar. Ecol. Prog. Ser.*, 79: 215-223.

3 - Olivar, M.P., Salat, J. and Palomera, I., 2001. A comparative study of the spatial distribution patterns of the early stages of anchovy and pilchard in the NW Mediterranean Sea. *Mar. Ecol. Prog. Ser.*, 217: 111-120.

4 - Castellón, A., Salat, J. and Masó, M., 1985. Some observations on Rhône fresh water plume in the Catalan Coast. *Rapp. Com. Int.. Mer Médit.*, 29: 3.

5 - Sabatés, A., Salat, J., Olivar, M.P., 2001. Advection of continental water as an export mechanism for anchovy, *Engraulis encrasicolus*, larvae. *Sci. Mar.* 65: 77-88.

TAILLE À LA MATURITÉ SEXUELLE DE *SCYLIORHINUS CANICULA* DES CÔTES EST ET SUD-EST DE LA TUNISIE

Bechir Saidi [1] *, Mohamed Nejmeddine Bradai [1] and Abderrahmen Bouain [2]

[1] Institut National des Sciences et Technologies de la mer (INSTM), Sfax, Tunisie
[2] Faculté des Sciences de Sfax, Tunisie

Résumé

Le long des côtes Est et Sud-Est de la Tunisie, les mâles et les femelles de la petite roussette *Scyliorhinus canicula* sont matures à partir respectivement de 400 et de 420 mm LT ($LT_{100\%}$).

Mots clés: Scyliorhinus canicula, maturité sexuelle, Tunisie

La petite roussette, *S. canicula*, est un requin atlanto-mediterranéen (1), pêché au-delà de 50 m de profondeur le long des côtes Est (golfe de Hammamet) et Sud-Est (golfe de Gabès) du pays. La biologie de cette espèce a fait l'objet de plusieurs études en Atlantique (2, 3) et en Méditerranée occidentale, y compris sur les côtes nord de la Tunisie (4, 5) alors qu'elle est peu abordée dans le bassin oriental, auquel appartient notre zone d'étude (6, 7). Dans ce travail, nous estimons la taille à la maturité sexuelle de la petite roussette le long des côtes Est et Sud-Est de la Tunisie.

Matériel et méthodes

Les échantillons examinés (92 mâles et 107 femelles) proviennent des campagnes de chalutage expérimental, réalisées entre 2001 et 2003 à bord du navire océanographique *Hannibal* de l'INSTM. Pour chaque spécimen nous avons mesuré la longueur totale (LT) au mm près, chez les mâles nous avons prélevé en outre la longueur des ptérygopodes. La taille à la maturité sexuelle a été estimée par le suivi de la croissance relative des ptérygopodes par rapport à la longueur totale chez les mâles et par l'observation du développement des ovaires et par la présence d'œufs dans l'oviducte chez les femelles.

Résultats

Les premiers mâles matures apparaissent dès 350 mm LT. A partir de 400 mm LT tous les mâles sont matures (Fig. 1). Les femelles matures apparaissent dès 350 mm LT. A partir de 420 mm toutes les femelles sont matures (Fig. 2).

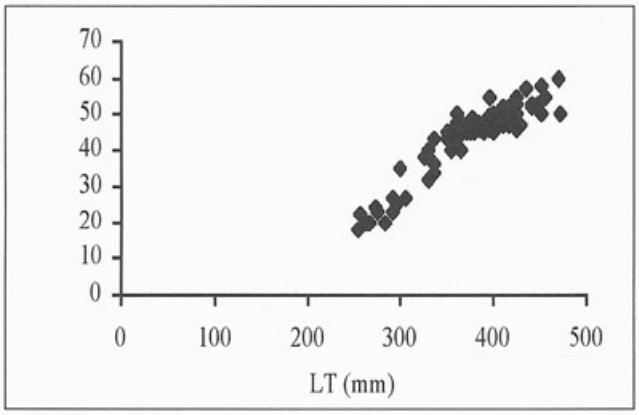


Fig. 1. Croissance relative des ptérygopodes en fonction de la longueur totale.

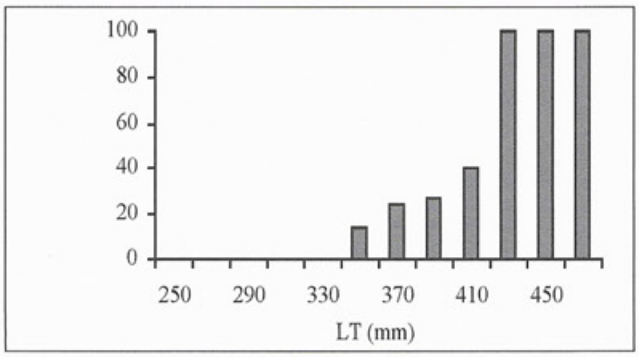


Fig. 2. Evolution du pourcentage de femelles mâtures en fonction de la longueur totale.

Conclusion

Cette étude a montré que *S. canicula* de l'Atlantique arrive à maturité à une taille plus importante que celle enregistrée en Méditerranée (Tab. 1). Ce phénomène de croissance plus rapide en Atlantique qu'en Méditerranée et même sur les côtes nord que dans le golfe de Gabès a été enregistré également pour plusieurs poissons osseux (8).

Tab. 1. Taille à la maturité sexuelle de *S. canicula* dans certaines régions maritimes (LT en millimètre).

Aire géographique	Mâle ($LT_{100\%}$)	Femelles ($LT_{100\%}$)	Références
English channel	580	-	3
Bristol channel	550	650	5
Golfe du Lion	440	480	2
Tunisie (Côtes nord)	400	450	1
Adriatique est	330	400	6
Adriatique sud	437	490	8
Tunisie (Côtes Est et Sud-Est)	400	420	présent travail

Références

1 - Compagno L.J.V., 1984. FAO species catalogue. Vol. 4. Shark of the world. An annotated and illustrated catalogue of shark species known to date. Part 2. Carcharhiniformes. *FAO fish. synopsis.*, (125), 2: 251-655. Rome.

2 - Collenot G., Etude biométrique de la croissance relative des ptérygopodes chez la roussette *Scyliorhinus canicula* (L). *Cah. Biol. Mar.*, 10 : 309-323.

3 - Ellis J.R., et Shakley S.E., 1997. The reproductive biology of *Scyliorhinus canicula* in the Bristol Channel, U.K. *J. Fish Biol.*, 51: 361-372.

4 - Capapé C., 1977. Contribution à la biologie des Scyliorhinidae des côtes tunisiennes I. *Scyliorhinus canicula* (Linné, 1758) : Répartition géographique et bathymétrique, sexualité, reproduction, fécondité. *Bull. Off. natnt. Pêch. Tunisie*, 1: 83-101.

5 - Capapé C., Tomasini J. A., et Boucherau J. L., 1991. Observation sur la biologie de la reproduction de la petite roussette *Scyliorhinus canicula* (Linnaeus, 1758) (Pisces, Scyliorhinidae) du golfe du Lion (France Méridionale). *Ichtyophysiologica Acta*, 14 : 87-109.

6 - Jardas I., 1979. Morphological, biological and ecological characteristics of the lesser spotted dogfish, *Scyloirhinus canicula* (Linnaeus, 1758). Population in the Adriatic sea. *Hvar- Reports Ist Ocean. Split, Jugoslavia*, 4(2-3):3-104.

7 - Ungaro N., Marano G., et Marzano M. C., 2000. Size at sexual maturity of the smallspotted catshark, *Scyliorhinus canicula*, in the Southern Adriatic Sea (Mediterranean sea). Proc. 4th Europ. Elasm. Assoc. Meet., Livorno (Italy), 2000. Vacchi M., La Mesa G., Serena F. and B. Séret, eds. ICRAM, ARPAT & SFI, 2002:171-175.

8 - Bradaï M. N., 2000. Diversité du peuplement ichtyque et contribution à la connaissance des Sparidés du golfe de Gabès. Thèse d'Etat. Univ. Sfax (Tunisie), 600 p.

PRELIMINARY OBSERVATIONS ON THE VARIATIONS IN THE MARINE MACROINFAUNA IN FISHED AND UNFISHED AREAS

Sánchez P. * and Demestre M.

Instituto de Ciencias del Mar- CSIC, Barcelona, Spain - * pilar@icm.csic.es

Abstract

This paper reports the findings of a study conducted in the northwestern Mediterranean to evaluate the differences in the macroinfaunal community in a fishing ground and an unfished zone. Univariate analyses of number of taxa indicated that the infaunal community differs significantly in fishing ground and in the unfished zone. Multivariate analyses revealed that the communities in both fished and unfished areas are also significantly different.

Key words: trawl, sea bed disturbance, macroinfauna

Introduction

The most important demersal mobile gear used in Mediterranean fisheries is the bottom trawl. The towed gears are the most perturbative form of anthropogenic disturbance to benthic habitats. Interesting results have been achieved in 1 and 2. Recently, investigations has began on the impact of the bottom trawl on the sea bed in the Mediterranean (3-5).

This paper reports the preliminary findings of one study conducted in the northwestern Mediterranean to evaluate the effects of bottom trawl on fishing grounds. The aim of this paper is to provide information on the possible differences between fished and unfished areas at the macroinfauna level.

Material and methods

Two zones, one intensively fished at 50 m depth, and other unfished at 60 m depth, were chosen in order to study the differences in their macroinfaunal communities. The study area is located in southern Catalonia (NW Mediterranean), where the fishing fleet of Sant Carles harbour operates. The sea bottom is characterised by a very wide shelf (at some points over 65 km), with a predominance of muddy-sand and mud bottoms, influenced by the Ebro river (6). A total of 23 0,1m^2 van Veen grabs were sampled (11 in the fishing area, and 12 in the unfished area). To establish the minimum area representing the biocenose, cumulative curve was done. After sieving through a 1 mm mesh size, the specimens of each haul were identified and counted. Then, the same calculation was made for the amount of successive cumulative grabs, after the addition of specimens per species was made for every composition of samples. PRIMER statistical software (7) was used to perform multivariate analysis on the community data. A cluster analysis using the Bray-Curtis similarity index calculated on square root transformed data and dendrograms formed using the group average clustering method. The resultant similarity matrices were used to perform non-metric multidimensional scaling (MDS) (8). The non-metric MDS algorithm is an iterative procedure, constructing the MDS plot by successively refining the positions of the points until they satisfy, as closely as possible, the dissimilarity relations between samples.

Results and discussion

The results of minimum area were that 0.54 m^2 is enough to represent this biocenose in both areas.

A total of 69 species or major taxa were collected. The effect of fishing disturbance was already detectable, with significant differences in the number of species, 56 in the fished zone and 63 in the unfished zone (t Student N° taxa = -2.383, p<0.03). The abundance percentage of taxa in the fished area : Polychaeta 39,3%; Sipunculida 1,8%; Echinodermata 3,6%; Crustacea 37,5%; and Mollusca 17,8%; in the unfished area : Polychaeta 36,5%; Sipunculida 1,6%; Echinodermata 3,2%; Crustacea 33,3%; and Mollusca 25,4%. The MDS showing samples in figure 1. Two major groups can be observed. Group f comprises the samples from fishing area and group c samples from unfished area. The samples of unfished and fished areas were clearly grouped in different assemblages. The two sampling sites were clearly distinct (R= 0.617 p= 0.001; ANOSIM one-way). The value of stress (0.19) indicates an excellent representation of the relationship between the samples.

These are preliminary results of the differences between areas intensely exploited by trawlers and areas not trawled due to wrecks or other obstacles.

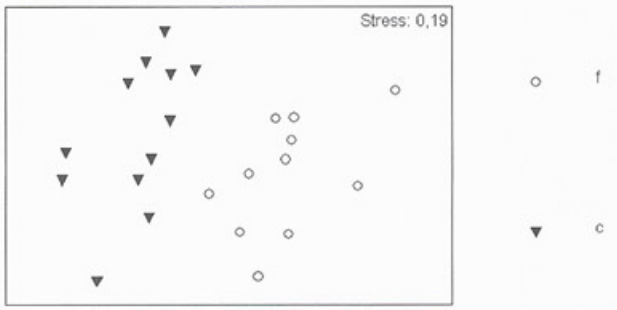


Fig. 1. MDS of samples (fished=f; unfished=c).

Acknowledgements. This paper is a part of the European Project (VFP-QoL CONTRACT Q5RS2002-00787). The authors thank all the participants in the cruise "Veda 1" for their help. We also thank M. R. Porras and Msr S. De Juan for their help in the laboratory.

References

1 - Kaiser M.J. and Spencer, B.E. 1996. The effects of beam-trawl disturbance on infaunal communities in different habitats. *J. Anim. Ecol.*, 65: 348-358.

2 - Jennings, S. and Kaiser M.J. 1998. The effects of fishing on marine ecosystems. *Adv. Mar. Biol.*, 34: 351 p.

3 - Demestre, M., Sanchez, P. and Kaiser, M.J. 2000. The behavioural response of benthic scavengers to otter trawling disturbance in the Mediterranean. Pp. 121-129. *In*: M.J. Kaiser, S.J. de Groot (eds.). The effects of fishing on non-target species and habitats. Blackwell Science, Oxford.

4 - Sánchez, P., Demestre, M., Ramón, M. and Kaiser, M. 2000. The impact of otter trawling on mud communities in the NW Mediterranean. *ICES J. Mar. Scienc.*, 57: 1352-1358.

5 - De Biasi, A.M., Ardizzone, G.D., Biagi, F., De Ranieri, S., Demestre, M., Kaiser, M., Nicoletti, L., Pacciardi, L., Sanchez, P., Sartor, P., Vannucci, A. 2002. Changes at very short time scale: an example from the marine benthic communities. *Assoc. Ital. Oceanol. Limnol.*, 15: 45-51.

6 - Demestre, M., Sánchez, P, and Abello, P. 2000. Demersal fish assemblages of the continental shelf and upper slope of the Catalan coast, NW Mediterranean. *J. Mar. Biol. Assoc. UK,* 80: 981-988.

7 - Clarke, K.R. and Warwick, R.M. 1994. Change in marine communities: an approach to statistical analysis and interpretation, Natural Environment Research Council, Plymouth, UK. 114 p.

8 - Kruskal, J.B. and Wish, M. 1978. Multidimensional scaling. Sage Publications, Beverley Hills, California.

OCCURRENCE OF *CORIS JULIS* (LINNAEUS, 1758) LARVAE IN THE SOUTHERN TUSCAN ARCHIPELAGO

Sartini M. [1], Belcari P. [2] *

[1] Aplysia p.s.c.r.l., Livorno, Italia - aplysia1@libero.it
[2] Dipartimento di Scienze dell'Uomo e dell'Ambiente, Università di Pisa, Italia

Abstract

Distribution, abundance and size structure of *Coris julis* larvae were analysed. Data were collected during three ichthyoplankton cruises carried out in the southern Tuscan Archipelago (northern Tyrrhenian Sea) in 1999 and 2000. *C. julis* larvae were only collected during June, showing a wide distribution on the continental shelf.

Keywords: Ichthyoplankton, larvae, distribution, abundance, northern Tyrrhenian Sea

Introduction

The rainbow wrasse, *Coris julis* (Labridae), is the most common and abundant wrasse in the Mediterranean, especially in its western basin. The species lives on *Posidonia* beds as well as rocky and mixed bottoms, from few meters to 120-150 m depth, but it is more frequent in waters shallower than 50 m (1). It is a by-catch of the inshore trawl and of trap and angling fisheries. Some biological aspects of *C. julis* have not yet deeply investigated, probably because of the lack of commercial value of the species. The aim of this study was to give some information on the abundance, distribution and size structure of *C. julis* larvae collected in the southern Tuscan Archipelago.

Material and methods

In the southern Tuscan Archipelago, northern Tyrrhenian Sea, three ichthyoplankton cruises were carried out in March 1999 and March and June 2000 (2). During each cruise, a minimum of 60 stations were occupied, collecting a total of 210 samples. Larvae were sampled by means of oblique hauls, from near the bottom to the surface. A Bongo net with 60 cm mouth diameter and 500 µm mesh size was used. Sampling methodology followed standard procedures (3). Larvae of *C. julis* were identified according to morphological, morphometric and pigmentation features (4). In addition, the standard length (SL, to the nearest 0.1 mm) was measured for each specimen. Larval abundance was standardised to the volume of filtered water at each station and was expressed as number of larvae/10 m^2 of sea surface (3).

Results and discussion

In the ichthyoplankton survey carried out in June 2000, 113 larvae of *C. julis* were collected, whereas during the cruises of March 1999 and March 2000 no *C. julis* larvae were collected. This is in agreement with existing knowledge of the reproductive period of the species which occurs in late spring-early summer (5).

C. julis larvae presented a wide spatial distribution (Fig. 1). The majority of stations at which they were found were localized between 50 and 200 m, in accordance with the ecological characteristics of the adults. The presence of larvae at stations deeper than 200 m could be related to advection by sea currents in the study area (6).

The maximum abundance of *C. julis* (72 larvae/10 m^2) was recorded below the Island of Elba, near the Island of Pianosa; the minimum abundance (4 larvae/10 m^2) was found at stations located near the Islands of Giglio and Giannutri (Fig. 1).

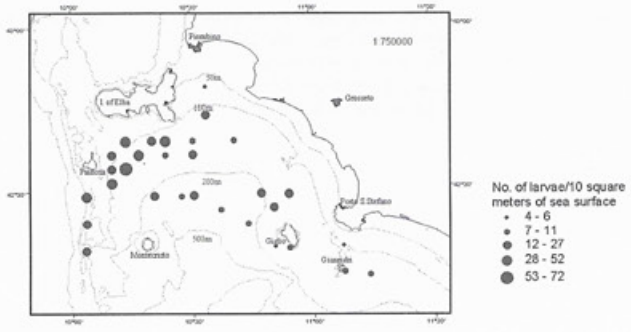


Fig. 1. Distribution and abundance of *C. julis larvae*, expressed as number/10 m^2 of sea surface, estimated for the ichthyoplankton survey of June 2000.

The size of the larvae ranged from 2.04 to 6.56 mm SL (Fig. 2). Most specimens (about 76%) were between 2.5 and 4 mm SL, with a mode at 3.5 mm SL.

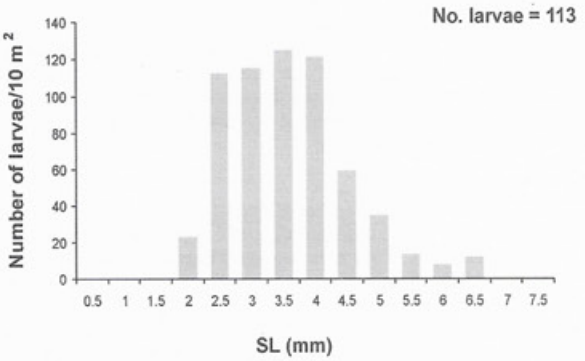


Fig. 2. Size frequency distribution of *C. julis larvae* collected during the ichthyoplankton survey of June 2000.

References

1 - Quignard J.P., Pras A., 1986. Labridae. Pp. 919-942. *In*: Whitehead P.J.P., Bauchot M.-L., Hureau J.C., Nielsen J., Tortonese E. (eds.), Fishes of the North-eastern Atlantic and the Mediterranean. UNESCO, Paris, vol. 2.

2 - Sartini M., 2003. Ittioplancton dell'Arcipelago Toscano meridionale. Ph. D. Thesis, University of Pisa, 233 p.

3 - Smith P.E., Richardson S., 1977. Standard techniques for pelagic fish eggs and larval surveys. *FAO Fish. Tech. Pap.*, No. 175, 100 p.

4 - Spartà A., 1933. Contributo alla conoscenza di uova e larve nei Labridi. IV. Uova e larve di *Julis Giofredi* Risso e *Julis pavo* ottenute da fecondazione artificiale, e stadi post-embrionali raccolti nel plancton. *R. Com. Talassogr. Ital., Mem.* 203, 18 p.

5 - Fiorentino F., 1999. *Coris julis*. *In*: Relini, G., Bertrand, J., Zamboni, A. (eds.), Synthesis of the Knowledge on Bottom Fishery Resources in Central Mediterranean (Italy and Corsica). *Biol. Mar. Medit.*, 6 (suppl. 1): 222-228.

6 - Elliott A.J., 1979. Low-frequency sea level and current fluctuation along the coast of Northwest Italy. *J. Geophys. Res.*, 84: 3752-3760.

CATCH COMPOSITION OF SET NETS USED BY THE SMALL-SCALE FISHERY OF LIVORNO (EASTERN LIGURIAN SEA)

M. Sbrana [1], B. Francesconi [2], I. Rossetti [2 *], P. Sartor [1], S. De Ranieri [1]

[1] Centro Interuniversitario di Biologia Marina ed Ecologia Applicata, Livorno, Italy
[2] Cooperativa di ricerca Aplysia, Livorno, Italy - aplysia1@libero.it

Abstract

Catch composition of three types of set nets used by the small-scale fishery of Livorno (eastern Ligurian Sea) was studied by observations on board of commercial vessels, from January 1999 to December 2000. Standard trammel nets, small mesh size trammel nets and gillnets were studied. Target species and retained by-catch represented the majority of the biomass caught with the two types of trammel nets all year round. Discarding was noticeable for gillnet only in summer and autumn.

Key-words: artisanal fishery, set nets, catch composition, coastal management, Ligurian Sea

Introduction

The small-scale fishery is an important sector of the Livorno fleet; this activity is carried out with different types of set nets, used in seasonal succession according to the main target species and the availability of resources (1, 2). This paper describes the catch composition of these gears, paying particular attention to discards, an important information for an ecological-based management (3). This work was performed whithin a project funded by the Italian Ministero delle Politiche Agricole e Forestali (2).

Material and methods

From January 1999 to December 2000, 49 observations onboard of commercial vessels of the artisanal fleet of Livorno were carried out, considering three types of set nets: standard trammel nets (60-70 mm stretched mesh size of inner panel), trammel nets of smaller mesh sizes (40-45 mm, stretched), locally called "tramaglino", and gillnets (80-85 mm, stretched). The composition of the catch, discards included, was studied without interference in the usual fishing procedures of the crew, especially concerning the sorting operations. For each haul the catch was divided in: target species, retained by-catch, discard of commercial and non-commercial species (3). Discard was determined to the lowest taxonomic level; total weight was recorded for each species caught. Catch per unit of effort (cpue) was estimated, standardising the collected data as kg/5000 m of net per hour of hauling.

Results and discussion

A total of 95 species were caught with trammel nets (59 fishes, 13 molluscs, 19 crustaceans and 4 echinoderms), 111 with "tramaglino" (69 fishes, 10 molluscs, 21 crustaceans, 1 cnidarian and 10 echinoderms) and 68 with gillnets (45 fishes, 11 molluscs, 10 crustaceans and 2 echinoderms).

In terms of weight, the majority of the total catch was composed of commercial species (target species + retained by catch), especially for trammel nets (69 to 84%) and "tramaglino" (91 to 94%), while this percentage was lower for gillnets (51 to 92%). For the latter, noticeable amounts of discards were recorded in summer and autumn (5.0 and 3.1 kg/5000m/h, representing 49 and 34% of the total catch, respectively) (Fig. 1).

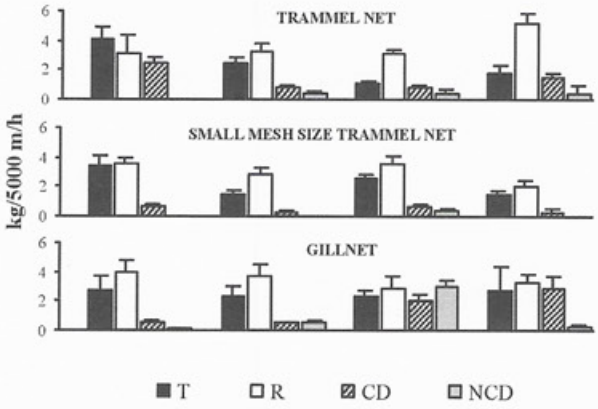


Fig. 1. Seasonal catches per unit of effort (mean cpue + standard error) of set nets used by the artisanal fleet of Livorno. T = Target species; R = Retained by catch; CD = Discard of commercial species; NCD = Discard of non-commercial species.

Table 1 shows the main species per catch category and gear studied. The target species of trammel nets (*Sepia officinalis*, *Solea vulgaris* and *Lithognathus mormyrus*) accounted for 19-42% of the total catch, those of "tramaglino" (*Mullus barbatus*, *Mullus surmuletus* and *S. officinalis*) from 35 to 45% and that of gillnets (*S. vulgaris*) from 22 to 37%. Retained by-catch also had an important contribution, with generally higher cpues than those for the target species (from 2.1 to 5.2 kg/5000m/h compared to 1.5-4.0 kg/5000m/h of the target species, Fig. 1). Important species of this fraction, both in terms of weight and commercial value, were *Raja asterias*, *Umbrina cirrosa*, *Pagellus erythrinus*, *Octopus vulgaris* and *Squilla mantis*.

Table 1. The most important species in biomass of the different fractions of the catch, by gear.

		TRAMMEL NET	SMALL MESH SIZE TRAMMEL NET	GILLNET
	TARGET SPECIES	*L. mormyrus* *S. vulgaris* *S. officinalis*	*M. surmuletus* *M. barbatus* *S. officinalis*	*S. vulgaris*
BY CATCH	RETAINED BY CATCH	*R. asterias* *S. mantis* *U. cirrosa*	*O. vulgaris* *D. annularis* *P. erythrinus*	*R. asterias* *T. lucerna* *S. mantis*
BY CATCH	DISCARD OF COMMERCIAL SPECIES	*Solea vulgaris* *T. mediterraneus* *H. trunculus*	*D.annularis* *M. barbatus* *M. surmuletus*	*S. vulgaris* *M. cephalus* *R. asterias*
BY CATCH	DISCARD OF NON-COMMERCIAL SPECIES	*Pagurus alatus* *P. excavatus* *Liocarcinus vernalis*	*D. arrosor* *M. glacialis* *H. tubulosa*	*D. arrosor* *A. pespelecani* *M. lanata*

Discards, in terms of weight, were mostly composed of commercial species (77 to 97% of total discards) and dominated by fishes, often represented by damaged and unmarketable specimens. Non-commercial species discarded were mostly represented by small-sized species, reflecting the composition of the epibenthic communities inhabiting the exploited fishing grounds.

References

1 - Sbrana M., Reale B., Rossetti I., and Sartor P., 2002. Fishing grounds of the target species exploited by the artisanal fleet of Livorno (eastern Ligurian sea). *Biol. Mar. Medit.*, 9(2): 804-807.

2 - Fabi G., and Sbrana M., 2002. Attrezzi della piccola pesca utilizzati in funzione della successione stagionale e dell'eco-etologia delle specie ittiche in due aree costiere (Tirreno settentrionale e Medio Adriatico). Ministero delle Politiche Agricole e Forestali, Final report, 159 p.

3 - Alverson D.L., Freeberg M.H., Pope J.G., and Murawski S.A., 1994. A global assessment of fisheries bycatch and discards. FAO *Fish. Tech. Pap.*, 339, 233 p.

COMPARING CTENOPHORE SPECIES IN THE BLACK SEA AND THE EASTERN MEDITERRANEAN

Tamara Shiganova [1] *, Julia Bulagakova [1], Epaminondas Christou [2], Ioanna Siokou-Frangou [2]
[1] P.P.Shirshov Institute of oceanology Russian Academy of Sciences, Moscow, Russia - *shiganov @sio.rssi.ru
[2] National Centre for Marine Research, Hellinikon, Athens, Greece

Abstract
The possibility of two Black Sea invaders *Mnemiopsis leidyi* and *Beroe ovata* blooms in the eastern Mediterranean is analyzed. A Comparison between these two species and the indigenous close species *Bolinopsis vitrea* and *Beroe cf. cucumis* is presented.

Key words: Mnemiopsis leidyi, Bolinopsis vitrea, Beroe ovata, Beroe cucumis

While M. leidyi and the indigenous Mediterranean species *Bolinopsis vitrea* Agassiz, 1880, another representative of the ctenophore Order Lobata, occur typically in neritic waters, they rarely overlap (1). *Bolinopsis vitrea* is indigenous to the Mediterranean, but not particularly abundant, although other species of *Bolinopsis* can sometimes reach high densities in other areas (2)

B. vitrea and *M. leidyi* have a similar size range and general body shape, but *B. vitrea* lobes are relatively shorter and they originate about halfway between the mouth and the infundibulum. The estimated relationship in the present study between total length with lobes and wet weight for both species showed that *Bolinopsis* is heavier than *M. leidyi* of equivalent length. Similarly, dry weight is higher for *Bolinopsis* than for *M. leidyi* in the Aegean Sea. Our experiments indicate that *Bolinopsis vitrea* has a lower metabolic and ingestion rate than *M. leidyi* of comparable length, suggesting that *Bolinopsis* is better adapted to the oligotrophic Mediterranean waters. The reproduction rate of *Bolinopsis vitrea* individuals is very weak (12-96 eggs. d^{-1}), probably due to the low ambient prey availability, while *M.leidyi* specimens produced 448 and 440 eggs per day, respectively.

The invasion of *M. leidyi* to the northern Aegean did not elicit any notable effect on behalf of the zooplankton communities, or on mesozooplankton abundance, biomass and community composition. If we compare zooplankton abundance before the *M. leidyi* invasion, this was much higher in most areas of the Black Sea than in the Aegean Sea, which was precisely what favoured the huge *M. leidyi* outbreak in the Black Sea. Thus, low abundance of zooplankton in most areas of the Aegean Sea could act as a limiting factor for *M. leidyi* development. According to our estimations, a population as small as that present cannot graze more than 0.08% of copepod abundance daily, which is negligible.

Among the other preys of both ctenophore species are fish eggs and larvae.

With a big abundance of anchovy eggs and larvae in the Aegean Sea, there seems to no measurable impact of *M. leidyi* and *B. vitrea* on the abundance of anchovy ichthyoplankton in the northern Aegean Sea.

Our experimental data show that conditions of the Aegean Sea can be well tolerated by *M. leidyi*. It can live, feed at a high intensity, and reproduce here. Its eggs develop well, and the percent survival and development of eggs are high (99.7%), but it has a smaller size than in the Black Sea, close to the size of individuals recorded in the Sea of Azov and in the Caspian Sea. Probably this is connected with a suboptimal salinity in the latter places, while in the case of the Aegean Sea, conversely, local salinity may be too high.

Experimental and field observations bring us to the conclusion that the distribution of both *B. vitrea* and *M. leidyi* is regulated to a major degree by prey availability and that the abundance of both species is correlated with the biological productivity of their habitat. In the mostly oligotrophic waters of the Aegean Sea, particularly open waters with low zooplankton density, the development of these carnivorous species is severely limited, and hence, their impact on the biota is virtually nil.

In 1997 another invader ctenophore, *Beroe ovata,* spontaneously appeared in the Black Sea and the Black Sea ecosystem began rapidly to recover (3,4). The question of origin of this species became relevant. First of all scientists presumed that *Beroe ovata* had arrived from Mediterranean Sea. A closer analysis of its morphology led to a revision of its identity, which turned out to be *Beroe ovata* Mayer 1912. It is believed to have been introduced with ship ballast water. Its origin is presumed to be the Atlantic coast of North America, exactly as the previous invader *Mnemiopsis leidyi*. Moreover comparing the new invader genus Beroe with Mediterranean *Beroe ovata* led us to conclude that it is not *Beroe ovata* Chun 1880, but Beroe cf. cucumis Mayer which inhabits the Mediterranean Sea (5).

Representatives of *Beroe* live in the shallows and estuaries of the Mediterranean Sea, and of the tropical and temperate Pacific and Atlantic Oceans. Few species inhabit Arctic Seas (2, 6, 7). All species of beroids are considered to be exclusively feeding on other planktivorous ctenophores. There is often a trophic linkage between *Beroe* species and planktivorous ctenophores. *Beroe* is an important link in pelagic food chains, but before its arrival in the Black Sea, comparatively little was known about its biology. *Beroe* significantly affects the population structure of planktivorous ctenophores and thus indirectly modifies the population dynamics of the zooplankters at lower trophic levels,as clearly demonstrated by *B. ovata* in the Black Sea.

B. ovata spread from the Black Sea to the Sea of Marmara, where it occurs every year during seasonal development of this species (August-November), even it was found near the Dardanelles (per. com. Melek Isinibilir, Istanbul University), most probably *B. ovata* might spread further west to the eastern Mediterranean and overlap with indigenous *B. cf. cucumis*.

Like *M. leidyi* and *B. cf. cucumis* (8, 9), *B. ovata* would not be able reach high density in the eastern Mediterranean due to very low prey (*M.leidyi* and *B. vitrea*) availability. (13) Thus at the moment a bloom of ctenophores – both invaders and indigenous – is not to be expected in the eastern Mediterranean.

References

1 - Kremer, Patricia, Michael R. Reeve and Mary Ann Syms, 1986b The nutritional ecology of the ctenophore *Bolinopsis vitrea*: comparisons with *Mnemiopsis mccradyi* from the same region. *Jour. Plankton Research*, 8: 1197-1208.
2 - Seravin, L.N, 1998. Ctenophora. A. Dobrovol'sky (ed), St.-Petersburg: 1-84.
3 - Vinogradov, M.E., V.V Sapozhnikov, E.A. Shushkina, 1992. The Black Sea ecosystem. Moscow. Russia. Nauka, 112 p.
4 - Shiganova T. A, Musaeva E.I., Bulgakova Yu.V., 2003. Ctenophores invaders *Mnemiopsis leidyi* (A.Agassiz) *Beroe ovata* Mayer 1912, and their effect on the pelagic ecosystem of the northeastern Black Sea. 2003. *Biol. Bull.* N 2.
5 - Seravin, L. N, Shiganova T.A., Luppova N.E., 2002. The history of study of the ctenophore *Beroe ovata* (Ctenophora, Beroida) and some features of the Black Sea representavive's morphology. *Zool. J.,* 81 (10): 1193-1201.
6 - Greve W., Stockner J., Fulton J., 1976. Towards a theory of specialisation in *Beroe* / Ed. Mackie G.O. New York: Plenum Publ. Corp. Pp. 251-253.
7 - Harbison G.R. Madin L.P. & Swanberg N.R. 1978. On the natural history and distribution of oceanic ctenophores. *Deep-Sea Research*, Vol.25: 233-256.
8 - Shiganova, T. A., B. Ozturk, A. Dede, 1994. Distribution of the ichthyo-, jelly- and zooplankton in the Sea of Marmara. *FAO Fisheries report,* 495: 141-145.
9 - Shiganova T. A., Mirzoyan Z. A., Studenikina E. A., Volovik S. P., Siokou-Frangou I., Zervoudaki S., Christou E. D., Skirta A. Y., H. J. Dumont, 2001. The invasion of the ctenophore *Mnemiopsis leidyi* (A.Agassiz) on the Black Sea and on other seas of the Mediterranean basin. *Mar. Biol.,* 431-446.

LENGTH-WEIGHT RELATIONSHIP AND BIOMETRY OF SPRAT, *SPRATTUS SPRATTUS* (LINNAEUS, 1758), IN THE ZRMANJA RIVER ESTUARY (EASTERN ADRIATIC)

Gorenka Sinovčić *, Barbara Zorica, Marijana Franičević and Vanja Čikeš-Keč
Institute of Oceanography and Fisheries, Split, Croatia - * sinovcic@izor.hr

Abstract
A total of 270 specimens of sprat, *Sprattus sprattus* (Linnaeus, 1758), were collected with purse seines from the Zrmanja River estuary (Novigrad Sea) during August 2000 -September 2002. Total length (*TL*) and weight (*W*) ranged from 7.7 to 15.0 cm and 4.03 to 23.05 g, respectively. The estimated length-weight relationship revealed allometric (*b*=2.654) growth.

Keywords: Sprattus sprattus, morphometry, meristic characters, Adriatic Sea

Introduction

Sprat, *Sprattus sprattus* (Linnaeus, 1758), is distributed in costal waters of the eastern Atlantic, the northern Mediterranean and the North Adriatic Sea (1). It is supposed that two subpopulations of sprat are present in the Adriatic Sea (2), based on differences in their morphometry and migrations. In this paper some biometrical parameters of sprat caught in the area of Zrmanja River estuary (Novigrad Sea) are presented.

Materials and Methods

Sprat specimens were caught as by-catch species of purse seiners together with sardine as target species in the Zrmanja River estuary area (Novigrad Sea) from August 2000 to September 2002. The Zrmanja River (69 km long) mouth is located in the central, northern coast of the Novigrad Sea area, forming a highly stratified estuary. All samples were taken at the same location – near the mouth of the Zrmanja River estuary (44°15'N; 15°30'E). All specimens caught were analysed because this species, which was very abundant in this area until 1986, was absent during 1987-1999 and started to appear in August 2000.

Length-weight relationship ($W=aL^b$) was calculated based on 270 specimens whereas six morphometric (total length – *TL*, standard length – *SL*, fork length – *FL*, head length – *HL*, maximum body height – *H* and eye diameter – *Ee*) and five meristic characters (number of rays in dorsal */D/*, pectoral */P/*, ventral */V/* and anal */A/* fins and number of vertebrae */Vert./*) were measured in 33 individuals. All lengths were measured to the nearest mm and weighed to the nearest g. Student's *t*-test was used to compare the estimated *b* value with the theoretical value 3 for isometric growth. Fish robustness was determined using Fulton's condition factor (*K*).

Results

The total length of all analysed specimens ranged from 7.7 to 15.0 cm (9.9 ± 1.1 cm, mean ± *SD*) and weight from 4.03 to 23.05 g (7.60 ± 3.45 g, mean ± *SD*). The morphometric and meristic characters of the 33 are presented in Table 1.

Table 1. Morphometric and meristic characters of 33 sprat specimens caught in the area of the Zrmanja River estuary, August 2000-September 2002.

Characters	Range (min –max, cm)	Mean ± *SD*
Morphometric:		
Total length (*TL*)	9.4–10.5	9.86±0.29
Standard length (*SL*)	8.0–9.2	8.38±0.28
Fork length (*FL*)	8.5–9.8	8.99±0.31
Head length (*HL*)	1.79–2.10	1.94±0.09
Maximum body height (*H*)	1.60–1.98	1.82±0.08
Eye diameter (*Ee*)	0.45–0.55	0.50±0.03
Meristic:		
Number of rays in dorsal fin (*D*)	15-18	16.5±0.71
Number of rays in pectoral fin (*P*)	16-17	16.7±0.45
Number of rays in ventral fin (*V*)	7	7.0±0.00
Number of rays in anal fin (*A*)	16-18	17.4±0.66
Number of vertebrates (*Vert*)	44-48	46.42±0.83

Obtained length-length relationships (*SL/LT, FL/LT, HL/TL, H/TL*) changed significantly (P=0.05) with increase of total length. The only published data we can compare is the data of the vertebrae number (*Vert.*) and portion of head length into total length of this species (3). The other results presented in this paper are the first for this species in the Adriatic Sea. The comparison of the mean vertebrae number (*Vert.*) from this study (46.42±0.83) with that of Zavodnik (3) (47.43±0.11) as well as portion of head length in total sprat length (*%HL*=19.633±0.88 and 18.08±1.03, respectively) indicated significant differences (t-test, P<0.05) between Novigrad Sea and North Adriatic (3).

The length-weight relationship was $W = 0.0168LT^{2.654}$ (n=270, r^2=0.811, SE of slope = 0.003). The slope (*b*=2.654) differed significantly from 3 (*t*-test=4.427, P<0.05), indicating negative allometry.

Fulton's condition factor ranged from 1.108 (length class 7.5 cm) to 0.006 (length class 15.0 cm) with a mean value of 0.769, indicating that smaller individuals were more robust than larger ones.

Reference

1 - Whitehead, P. J. P., 1985. FAO species catalogue. Clupeoid fishes of the world. Part 1. *FAO Fish. Synop.*, 7(125), 303 p.
2 - Zavodnik D., 1974. Jadranska papalina (*Sprattus sprattus* L.) biologija i ribolov/Adriatic sprat (*Sprattus sprattus* L.) – biology and fisheries. *Acta Adriat.*, 16(26): 435-440 (in Croatian, English summary).
3 - Zavodnik, D. and Zavodnik, N., 1967. Observations on the biometry and numerical characteristics in sprat, *Sprattus sprattus*, in the northern Adriatic. *Thalassia Jugosl.*, 3(1-6): 183-194.

EPIPELAGIC MESOZOOPLANKTON AND COPEPOD GRAZING ALONG AN EAST-WEST TRANSECT IN THE MEDITERRANEAN SEA

Ioanna Siokou-Frangou
Hellenic Centre for Marine Research, Anavyssos, Greece

Abstract

An increasing east-west trend of mesozooplankton biomass and abundance was detected in the Mediterranean Sea during June 1999. However, species composition did not show any significant differences. Samples collected from cyclonic gyres were distinguished for their increased biomass, abundance and grazing impact on autotrophic production.

Key-words: mesozooplankton, grazing, Mediterranean

Introduction

A eastwards gradient of increasing oligotrophy is well established in the Mediterranean Sea (1). Mesozooplankton abundance, biomass, species composition and copepod grazing on autotrophs were studied in the epipelagial during trans- Mediterranean cruise (EU-project MATER).

Methods

Mesozooplankton samples were collected during June 1999 at 9 stations along an east-west transect in the epipelagial (to depth of 100m) by a WP-2 net (200μm). Samples were collected at midday and midnight for the estimation of copepod grazing. The gut fluorescence of two size fractions (<500μm and >500μm) of copepods was measured and ingestion rates were estimated (2).

Results and discussion

Total zooplankton abundance values increased from east (M1=93 ind m^{-3}) to west (M9=898 ind m^{-3}, Figure 1). Biomass values (dry weight) presented the same trend, varying from 1.09 mg m^{-3} (M1) to 4.16 mg m^{-3} (M9). Samples collected within the Cretan (M4) and Rhodos (M2) cyclonic gyres were characterized by high mesozooplankton abundance and biomass compared with other samples in the eastern Mediterranean Sea; increased abundance values were observed during previous studies in the Rhodos gyre (3, 4). Copepods were the dominant group, representing 56% (M8) to 91% (M9) of the zooplanktonic community. *Clausocalanus* copepodites, *Farranula rostrata*, *Oithona* copepodites, *Oncaea media*, *Oithona plumifera*, *Mecynocera clausi*, *Calocalanus* spp., *Corycaeus* spp., *Oithona setigera* were the most abundant taxa over all stations. Some species exhibited differentiated distribution patterns: *F. rostrata* and *Corycaeus* spp. presented an east-west decreasing trend; *Oithona* copepodites, *O. setigera* and *M. clausi* were more abundant in the central part. *Clausocalanus pergens* dominated station M9, a fact probably related to the lower temperature compared to the eastern basin (Theocharis, pers.comm.). Similar zooplankton abundance and species composition were found in the Ionian Sea in April-May 1999 by Mazzocchi *et al.* (5) The abundance of appendicularians and of *Oncaea* spp was significant at stations M2 and M4, suggesting feeding relationships among these taxa (5). Station M8 was characterized by the significant presence of chaetognaths, siphonophors and the low relative abundance of copepods, implying a grazing control by the former taxa. The copepods' gut pigment concentrations varied between 0.042 ng chl-α cop^{-1} (<500 μm at M7-day) and 1.39 ng chl-α cop^{-1} (>500 μm at M8-night). Ingestion rates were calculated to be 1.8-35.9 ng chl-α cop^{-1} d^{-1}.

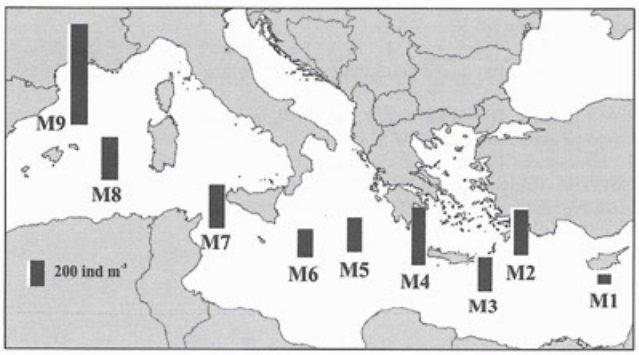


Fig. 1. Mesozooplankton abundance distribution in the 0-100 m layer during June 1999.

Although primary production values (measured during the same cruise) have revealed an increasing east-west trend (O. Gotsis-Skretas and K. Pagou, pers.comm.), the potential grazing pressure of copepods over the >1.2 μm fraction of primary production did not reveal any clear trend. The estimated consumed portion of the autotrophic production was very low at stations M6 and M7 (less than 10%) and high at station M4 (35%). This strong grazing impact is related both to high ingestion rates and to high copepod abundance relatively to the available primary production. It is worth noting that the abundance of ciliates at stations M2 and M4 was lower than that of the neighbouring stations (6) probably due to a top-down control by copepods.

Our results confirm that the mesozooplankton abundance and biomass differ among the basins of the Meditterranean Sea. The hydrological features seem to play an important role for the pelagic food web within the very oligotrophic eastern basin.

References

1 - Turley C.M., Bianchi M., Christaki, U., Conan P., Harris J.R.W., Psarra S., Ruddy G. Stutt E.D., Tselepides, T. and Van Wambeke, F. 2000. Relationship between primary producers and bacteria in an oligotrophic sea-the Mediterranean and biogeochemical implications. *Mar. Ecol. Progr. Ser.* 193: 11-18.

2 - Bamstedt,U., Gifford, D.J., Irigoien, X., Atkinson, A. and Roman, M. 2000. Feeding. In: ICES Zooplankton Methodology Manual, pp. 297-399.

3 - Mazzocchi, M.G., Christou, E.D., Fragopoulu, N. and Siokou-Frangou, I., 1997. Mesozooplankton distribution from Sicily to Cyprus (Eastern Mediterranean). I. General aspects. *Oceanologica Acta* 20(3): 521-535.

4 - Christou,E.D., Siokou-Frangou,I., Mazzocchi,M.G. and Aguzzi, L., 1998. Mesozooplankton abundance in the Eastern Mediterranean during spring 1992. *Rapp. Comm. int mer Médit.* 35(2): 410-411.

5 - Mazzochi, M.G., Nervegna, D., D'Elia G., Di Capua, I., Aguzzi, L. and Boldrin A., in press. Spring mesozooplankton communities in the epipelagic Ionian Sea in relation to the Eastern Mediterranean Transient. *J. Geophys. Res.*

6 - Pitta, P. Giannakourou, A and Christaki, U., 2001. Planktonic ciliates in the oligotrophic Mediterranean Sea: longitudinal trends of standing stocks, distributions and analysis of food vacuole contents. *Aquat. Microb. Ecol.* 24: 297-311.

PSELIODINIUM VAUBANII – AN ORGANISM INTRODUCED INTO THE ADRIATIC SEA BY BALLAST WATERS?

Sanda Skejić, Živana Ninčević-Gladan * and Ivona Marasović
Institute of Oceanography and Fisheries, Split, Croatia

Abstract

The dinoflagellate *Pseliodinium vaubanii* was first recorded from the Adriatic Sea in the vicinity of the River Po estuary, in 1978. Subsequently it was recorded from a number of bays and estuaries along the eastern Adriatic coast. It is assumed that *Pseliodinium vaubanii* was introduced into the Adriatic Sea with ballast waters. Even though the studies of Jacques and Soyer (2) showed this species to occur under vertically stable conditions of the water column, we recorded it under conditions of markedly non-homogeneous water column.

Keywords: Pseliodinium vaubanii, Adriatic, ballast waters

Material and methods

The phytoplankton communities near shellfish farms along the eastern Adriatic coast were analysed over one year (August 2002 through August 2003). The samples were collected from surface and bottom layers by Niskin bottles and plankton net (mesh size 20 µm) at monthly intervals. The temperature and salinity were measured by YSI-63 CTD sonde. The phytoplankton community was identified using Olympus IX 50 inverted microscope (3). *Pseliodinium vaubanii* Was common in our samples. We analysed the environmental conditions under which this species occurs.

Introduction

Pseliodinium vaubanii is first described by Sournia (4) from Nosy-Be, Madagascar. It was first recoded in the Mediterranean in the Gulf of Lion (2). In the Adriatic Sea the species was first recorded from the vicinity of the Po estuary in the northwestern Adriatic (the largest number of ships from all over the world take this route), and subsequently from the Šibenik harbour in the River Krka estuary, from Ploče harbour near the River Neretva estuary and from Kaštela Bay near the Jadro River estuary (1).

Results and discussion

Even though the species is widely distributed over all the Adriatic coastal waters, its abundance is markedly low everywhere.

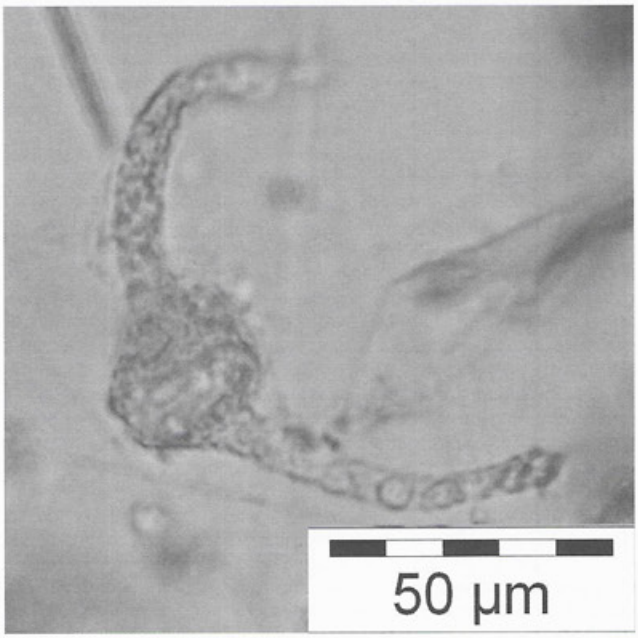
The phytoplankton of the Adriatic Sea, particularly of its northern and central parts, has been well studied. Therefore it could hardly be assumed that a conspicuous species such as *Pseliodinium vaubanii* could be overlooked. Because *P. vaubanii* was reported from harbours, with an increased eutrophication level, due primarily to river run-offs and human activities, we assume it is an alien species. It is known to occur at the bottom of homogenous water column, with salinities 37.65 to 38.20 psu, and assuming that temperature below 15° C could be a limiting factor (2).

Our records show that *P. vaubanii* may occur in markedly non-homogeneous water column, even though all the records refer to bottom layers with considerably more stable conditions. As to the salinity range, our results mostly agree with those of Jacques and Soyer, even though both slightly higher and slightly lower salinities were recorded on several occasions (Tab 1), however the species may have a considerably broader temperature range. On several occasions the temperature was much lower than 15° C (Tab 1), which may be indicative of the fact that salinity is more crucial for this species than temperature. This has also been confirmed by the fact that, irrespective of temperature, this organism, almost as a rule, occurs in bottom layers which have typically martime salinity, as compared to the brackish surface layers.

Pseliodinium vaubanii seems to prefer eutrophic environments, having settled in the eutrophic eastern Adriatic coast, regadless of whether the eutrophication is of natural or anthropogenic origin (shellfish farms and harbours).

Table 1. Temperature and salinity values at the investigated stations.

MONTH	SITE	Temperature (°C)		Salinity (psu)	
		Surface	Bottom	Surface	Bottom
Aug. 2002	Kastela	24,1	18,6	36,9	38,5
Nov. 2002	Sibenik1	16,2	19,8	11,2	38,4
	Sibenik2	16,0	19,2	10,7	38,5
	Bistrina	15,4	17,4	36,3	37,5
Feb. 2003	Sibenik2	6,8	13,2	13,6	38,2
March 2003	Peruzula	11,5	9,6	25,4	38,1
	Usko	10,8	11,5	36,5	37,3
June 2003	Solina	24,5	18,5	38,2	38,1
	Sibenik1	26,0	17,0	21,7	38,6
	Prdelj	26,0	14,9	32,9	38,4
July 2003	Prdelj	26,0	18,3	33,9	36,5
	Solaris	25,7	25,6	38,7	38,7
August 2003	Sibenik2	24,6	18,8	33,1	38,3
	Sibenik3	24,1	18,3	33,6	38,5
	Peruzula	27,5	23,3	36,3	38,4
	Prdelj	25,8	20,5	35,8	36,7



References

1 - Marasovic I., 1983. Records of new phytoplynkton species in the Adriatic. *Notes* No 52. : 1-6.

2 - Jacques G., and Soyer M., 1977. New observations on *Pseliodinium vaubanii* (Sournia) a free planktonic dinoflagellatae. *Vie Milieu*, A. 27 (1): 83- 90.

3 - Utermöhl H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton Methodik. *Mitt. int. Ver. Limnol.*, **9**: 1-38.

4 - Sournia A., 1973. Une période de poussées phytoplanctoniques près de Nosy-Be (Madagascar) en 1971.I. Espèces rares ou nouvelles du phytoplancton. *Cah. ORSTOM,* sér. Océanogr.,10 (2): 151-159.

PARASITIC DINOFLAGELLATES IN MEDITERRANEAN ZOOPLANKTON

Alf Skovgaard * and Enric Saiz

Institut de Ciències del Mar (CMIMA - CSIC), Barcelona, Catalunya, Spain - * skovgaard@icm.csic.es, enric@icm.csic.es

Abstract

We investigated the occurrence of parasitic dinoflagellates in zooplankton (copepods and appendicularians) off Barcelona, Spain. The most common species were the intestinal parasites *Blastodinium* spp. found in the copepod genera *Oncaea*, *Corycaeus*, *Oithona* and *Paracalanus*. However, also the coelomic parasite *Syndinium* was relatively common in *Paracalanus*. The ectoparasite *Oodinium pouchetii* occasionally infested large proportions of appendicularians.

Keywords: Dinoflagellate, Parasite, Copepod, Blastodinium, Syndinium

A number of dinoflagellates are parasites of marine zooplankton organisms (1) and, at times, these parasites may contribute significantly to the mortality of copepod populations (2, 3). However, the profusion of parasitism and its impact on zooplankton population dynamics has received little attention and is not very well understood.

To study the prevalence and possible impact of dinoflagellate parasites, we collected zooplankton weekly or biweekly off Port Olímpic, Barcelona, by taking vertical net tows with 53 and 100 µm plankton nets. Live animal were observed qualitatively within 2-5 hours after sampling and, in addition, samples fixed in formaldehyde were studied quantitatively for the prevalence of parasitized zooplankton organisms.

Blastodinium spp. could be detected in live copepods as large greenish or brownish bodies in the gut of infected animals (Figs 1-3). In fixed animals, infection with *Blastodinium* was less evident due to the lack of colour as a diagnostic tool. Based on the host species and the size and shape of the parasites (1), we were able to identify at least 3 *Blastodinium* species: *B. mangini* Chatton (including the variety *B. mangini* var. *oncaea* Chatton), *B. contortum* Chatton and *B. oviforme* Chatton. *Syndinium turbo* Chatton could be detected equally well in live and fixed animals (*P. parvus*) since this parasite made its host conspicuously dilated, dark and opaque (2, 3). The detection of *Oodinium* on appendicularians was straightforward, since these are ectoparasites and form characteristic cysts attached the epithelium of the host. When infected copepods were kept in seawater in the laboratory, sporulation always occurred within 1-2 days and free-swimming parasite zoospores could then be observed. This indicates that only the final developmental stages of the parasite life cycles within its copepod hosts were detected. New methods, therefore, need to be applied in order to gain more knowledge on the total infection frequencies and, thereby, the effect of dinoflagellate parasites on their copepod hosts.

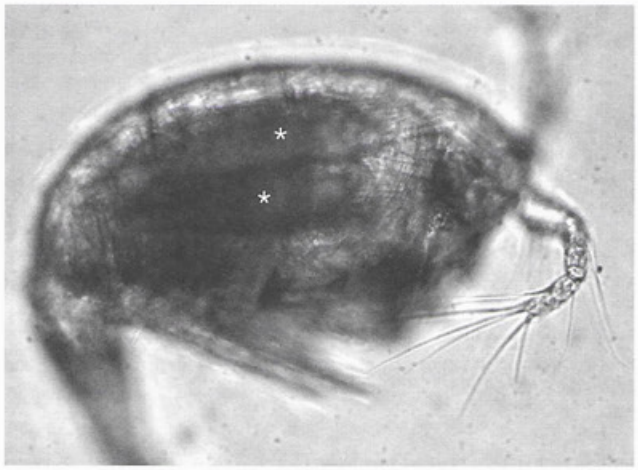


Fig. 1. *Oncaea* sp. female infected with two individuals of *Blastodinium mangini* var. *oncaea* (asterisks). Live specimen.



Fig. 2. *Paracalanus parvus* female infected with *Blastodinium contortum*. Live specimen.

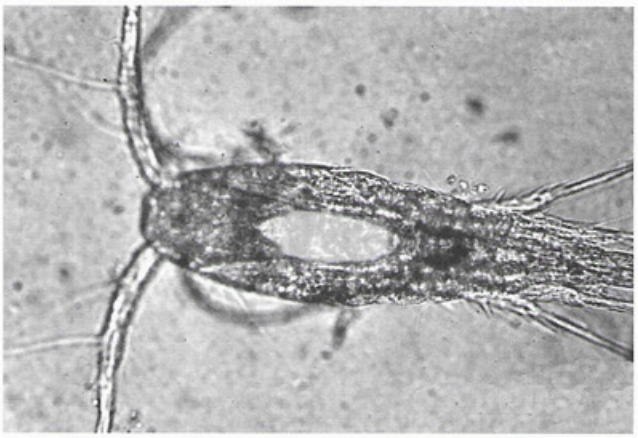


Fig. 3. *Oithona nana* infected with *Blastodinium oviforme*. Live specimen viewed in eipfluorescent light. Fluorescence of *Blastodinium* chlorophyll is seen as bright ovoid body.

References

1 - Chatton, È., 1920. Les Péridiniens parasites: morphologie, reproduction, éthologie. *Arch. Zool. Exp. Gen.*, 59: 1-475.

2 - Ianora, A., Scotto di Carlo, B., Mazzocchi, M. G., and Mascellaro, P., 1990. Histomorhological changes in the reproductive condition of parasitized marine planktonic copepods. *J. Plank. Res.*, 12: 249-258.

3 - Kimmerer, W. J., and McKinnon, A. D., 1990. High mortality in a copepod population caused by a parasitic dinoflagellate. *Mar. Biol.*, 107: 449-452.

FISHING OF THE COMMON SOLE, SOLEA SOLEA (LINNAEUS, 1758) IN THE EASTERN ADRIATIC SEA

Soldo A. *, Cetinić P., Dulčić J., Jardas I., Kraljević M., Pallaoro A., Matić Skoko S.
Institute of Oceanography and Fisheries, Split, Croatia - * soldo@izor.hr

Abstract

Common sole *Solea solea* (Linnaeus, 1758), is one of the most important commercial species in the Eastern Adriatic Sea. It is widely distributed throughout sandy and muddy bottoms of whole Adriatic, but its greatest occurrence is in the northern part. A total of 2.798 specimens of the common sole were caught by trammel nets in the period December 2002 – February 2003. Total length (TL) ranged from 20.0 to 39.8 cm (mean = 29.38 cm, SD = 2.49) and age from 2-7 years, with the 2- and 3-year old individuals dominating the samples (87.7 %).

Keywords: common sole, trammel net, fishing, total length, age

Introduction

The common sole, *Solea solea* (Linnaeus, 1758) is a demersal fish species preferring muddy and sandy bottoms. It occurs also in estuaries or even in the lower parts of the rivers. Juveniles frequently appear near shores, while adults can be found even at depths of 250 m. Spawning starts offshore at the end of autumn or early in winter (1). It is one of the most important commercial species in the Adriatic, especially in its northern part, which is the main fishing area of the species caught by scallop dredges, bottom trawls, gillnets and trammel nets. The later are the main fishing gears for the species and according to the Croatian fishery legislation their use is prohibited during the period 1st of June - 1st of September.

Material and methods

Samples were collected from the western coasts of Istrian peninsula (eastern part of the Northern Adriatic), using commercial fishermen, at depths of 20 - 40 m, during the period from December 2002 through February 2003. Trammel nets were of twisted multifilament polyamide, with mesh sizes of 80 and 320 mm (stretched mesh) in the inner and outer panel, respectively. Generally, a series of trammel nets used were consisted of 18-20 single, 18 m long, nets of 1 m height. For each specimen the total length (TL, to the nearest mm) and weight (W, to the nearest g) were measured. Age was determined by reading otoliths.

Results and discussion

During the investigated period a total of 4989 specimens of fish and other marine organisms were caught by trammel nets. Overall, 49 different species were recorded (40 fish, 3 cephalopods, 5 crustaceans and 1 shellfish). 2798 individuals of common sole were caught representing 70.9 and 70.4% of the total catch by number and weight, respectively. The second most abundant fish species was *Merluccius merluccius* (4.0% of the total catch by number and 3.0% by weight). Other sole species, *Solea kleini*, *Solea nasuta* and *Solea impar* were caught sporadically. Cuttlefish, *Sepia officinalis,* consisted 7.1% of the total catch by number and 11.7% by weight. *Squilla mantis* was the dominant crustacean species (7.9% and 2.4% by number and weight, respectively). Weight of caught common sole specimens ranged from 62 to 592 g (W ± SD = 228.9 ± 76.92 g). The total length of common sole ranged from 20.0 to 39.8 cm (Fig. 1). The average length (29.38 ± 2.493 cm) was higher then that reported for the same species caught by gillnets in the western parts of the Northern Adriatic (2). The age of common sole specimens were 2 to 7 years old (Fig. 2). The 2- and 3-years old classes were the most abundant (87.7%). The comparison of these results to those from gillnets, suggests that trammel nets of 80 mm mesh size are much more selective than 64-68 mm mesh size gillnets. Moreover, gillnet research reported large percentages of specimens under the minimum legal size of 20 cm (9-30% depending on season), while in trammel nets such small specimens were not found. An explanation could be that gillnets used at the western parts of the Northern Adriatic are characterized by small height (2-2.5 m) and very low buoyancy of floats, that allow gillnets to lay on the bottom and therefore catch common sole in a manner similar to trammel nets, but with considerably smaller mesh sizes.

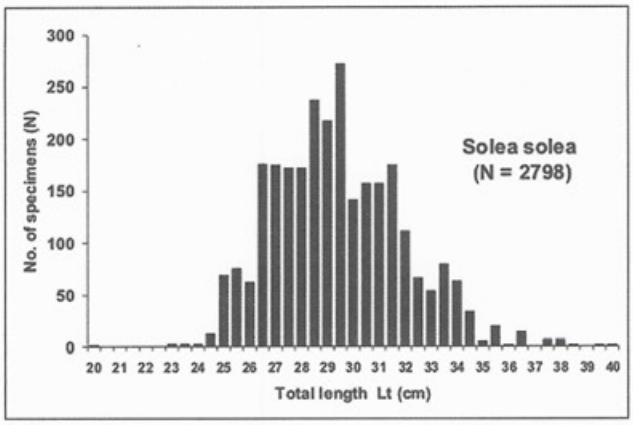


Fig. 1. Total length frequency distribution of *Solea solea* (Istrian Peninsula), December 2002 - February 2003.

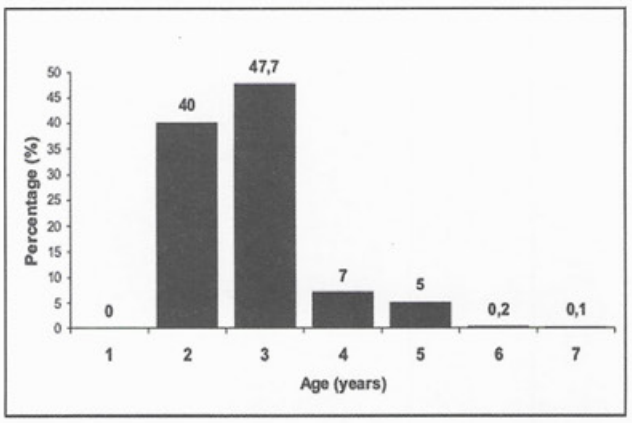


Fig. 2. Age composition of *Solea solea* (Istrian Peninsula), December 2002 - February 2003.

References

1 - Jardas I., 1996. Jadranska ihtiofauna. Školska knjiga d.d., Zagreb, 536 p.

2 - Grati F., Fabi G., Lucchetti A. and Consoli P., 2002. Analisi delle catture di *Solea vulgaris* Quensel, 1806 effettuate con reti ad imbrocco in Adriatico settentrionale. *Biol. Mar. Medit.,* 9 (1): 154 - 160.

CONDITION AND FECUNDITY OF RED MULLET OVER MUDDY AND "CORALLIGENE" SUBSTRATA

S. Somarakis [1, 2 *], Ch. Stamataki [2], A. Machias [2], N. Papadopoulou [2], C. Smith [2], I. Karakassis [2]

[1] University of Patras, Department of Biology, Patra, Greece - * somarak@upatras.gr

[2] Institute of Marine Biology of Crete, Iraklio, Crete, Greece

Abstract

We compared somatic, gonadal and hepatic condition as well as batch fecundity of red mullet (*Mullus barbatus*) between two sites differing in substratum type. The first site had muddy substratum, whereas the second site was covered by dense patches of calcareous algae and associated biogenic structures ("coralligene"). The results suggested that red mullet was in superior condition over coralligene, where fish had significantly ($P<0.05$) higher hepatic or somatic mass. Batch fecundity did not differ ($P>0.05$) between sites.

Keywords: Mullus barbatus, condition, fecundity, coralligene

Introduction

The red mullet, *Mullus barbatus*, is one of the most important species for the Mediterranean fisheries. It is abundant throughout the continental shelf, over both muddy and coarser substrata, although it shows maximum abundance and frequency of occurrence over muddy bottoms (1).

In the present contribution we present preliminary results of the comparison of somatic condition, organ condition and fecundity of red mullet between muddy and coralline algae substrata. The latter comprise important fishing sites for local small-scale fisheries (2).

Materials and methods

Three replicate hauls were taken at each of two sites of similar depth (70-90 m) in the South Evoikos Gulf (Aegean Sea) using an otter trawl with a cod-end bag liner of 28 mm stretched mesh-size. The first site had muddy substratum (90% silt and clay) whereas the other one was considerably coarser (89% sand and gravel) and dominated by dense patches of biogenic structures related to colony-forming calcareous algae of the class Rhodophycae ("coralligene" [3], "tragana" in Greek). The substratum types were determined by grain size analysis and side scan sonar tows over the trawl path.

A sample of red mullets was randomly selected from each haul and fixed in 10% buffered formalin solution. In the laboratory, the fish were measured (total length [TL], 1mm; total weight [TW], 0.01g; eviscerated weight [EW], 0.01g), sexed and their gonads and liver dissected and weighted (gonad weight [GW], 0.0001g, hepatic weight [LW], 0.0001g). Samples from the gonads were subsequently dehydrated and embedded in paraffin. Sections (4-6 µm) were cut and stained with hematoxylin and eosin. The hydrated oocyte method was used for batch fecundity measurements (4).

For each site, we modeled GW, LW and batch fecundity (FEC) on EW as well as EW on TL and FEC on GW using the allometric equation: $Y=aX^b\exp(\varepsilon)$. In all cases, this simple model was more efficient in terms of residuals and explanation of the variation than other models. Analysis of covariance (ANCOVA) was used to test for between-site differences in the log-log relationships between variables. Slopes were tested first using a model that included an interaction term. If the interaction term was not significant (i.e. slopes were not significantly different between sites), then the y-intercepts were tested.

Results and conclusion

Histological analysis of the gonads revealed that 99 and 100% of the analysed females and males were in the hydrated and spermatogenic stage, respectively. Non-hydrated females were not used in the subsequent analyses.

The calculated parameters of the allometric relationships for each site and sex are given in Table 1. The ANCOVA results indicated that, for both sexes, the LW-on-GW relationship had higher intercept in the coralligene site (females: $P<0.05$, males: $P<0.0001$). The EW-on-TL relationship for females had also higher intercept in the coralligene site ($P<0.001$). No significant ($P>0.05$) differences between sites were found for the fecundity relationships (FEC-on-EW and FEC-on-GW).

These preliminary results suggest that red mullet was in superior condition in the coralligene site, where the fish had, on average, higher hepatic or somatic mass. This superior condition did not seem to affect batch fecundity of mature females. The biological and functional complexity of submarine coralligene (2) is likely to provide superior feeding conditions for red mullets and other fishes. Unpublished results from a diet analysis study seem to corroborate this hypothesis; higher stomach contents weight was observed in the diet of *M. barbatus* over coralligene sites with the main prey taxa being decapods and small crustaceans which are thought to be of higher nutritional value and energy content [5].

Table 1. Parameters of the allometric functions ($Y=aX^b$) between gonad weight (GW) and eviscerated weight (EW), liver weight (LW) and eviscerated weight, eviscerated weight and total length (TL), batch fecundity (FEC) and eviscerated weight, and batch fecundity and gonad weight. n: sample size, r^2: coefficient of determination, a,b: parameters of the allometric model.

Relationship	Sex	Substratum	a	b	r^2	n
GW-EW	Females	Mud	0.103	0.993	0.850	55
		Coralligene	0.048	1.176	0.854	48
LW-EW		Mud	0.049	0.791	0.733	55
		Coralligene	0.026	0.991	0.746	48
EW-TL		Mud	$4\,10^{-6}$	3.196	0.976	55
		Coralligene	$3\,10^{-6}$	3.216	0.968	48
FEC-EW		Mud	136.42	1.002	0.749	55
		Coralligene	57.40	1.203	0.771	48
FEC-GW		Mud	1398.4	0.991	0.855	55
		Coralligene	1305.1	1.011	0.882	48
GW-EW	Males	Mud	0.025	0.943	0.543	81
		Coralligene	0.053	0.718	0.206	59
LW-EW		Mud	0.037	0.61	0.506	81
		Coralligene	0.026	0.0772	0.559	59
EW-TL		Mud	$2\,10^{-6}$	3.373	0.960	81
		Coralligene	$5\,10^{-6}$	3.126	0.922	59

References

1 - Lombarte A., Recasens L., Gonzalez M., and de Sola L.G., 2000. Spatial segregation of two species of Mullidae in relation to habitat. *Mar. Ecol. Progr. Ser.*, 206: 239-249.

2 - Georgiadis M., Papatheodorou G., Katselis G., Tzanatos E., Ramfos A., Vavoulis D., and Koutsikopoulos C., 2001. Morphological characteristics and distribution of "coralligene" fishing grounds (Rhodophyceae) in the area of Cyclades. Proceedings of the 10th Panhellenic Conference of Ichthyologists, pp. 333-336.

3 - Bonsence D.W.J., 1985. The "Coralligene" of the Mediterranean – a recent analogue for the Tertiary coralline algal limestones. Pp. 216-225. *In*: Toomey D.E., and Nitecki M.H. (eds), Paleoalgology: Contemporary research and applications.

4 - Maraveya E., Somarakis S., and Machias A., 2001. Batch fecundity of anchovy in the NE Aegean Sea. *Rapp. Comm. int. Mer Médit.*, 36: 299.

5 - Norrbin F., Bamstedt U., 1984. Energy contents in benthic and planktonic invertebrates of Kosterfjorden, Sweden. A comparison of energetic strategies in marine organism groups. *Ophelia*, 23: 47-64.

DONNÉES RÉCENTES SUR L'AIRE DE RÉPARTITION DE L'ESPÈCE INVASIVE *PINCTADA RADIATA* DANS LES ÎLES KERKENNAH (TUNISIE)

Emna Soufi-Kechaou * et Nejla Aloui-Bejaoui

Institut National Agronomique de Tunisie, Tunis Mahrajène-Tunisie - * emnasoufi@lycos.com, bejaoui.nejla@inat.agrinet.tn

Résumé

L'espèce lessepsienne *Pinctada radiata* présente un intérêt écologique majeur et s'est acclimatée pour former des populations denses dans l'archipel des Kerkennah. Sa répartition sur les côtes Est de l'îlot Chergui est mise en évidence dans le présent travail. Elle est variable et dépend de certains facteurs du milieu. Sa densité comparée à celle de *Pinna nobilis,* bivalve endémique de la Méditerranée est étudiée et permet de prédire une compétition entre les deux espèces.

Mots-clé: Iles Kerkennah, Pinctada radiata, Pinna nobilis, espèce invasive

Introduction

L'huître perlière *Pinctada radiata* est l'un des premiers mollusques bivalves exotiques signalés en Méditerranée après la construction du canal de Suez. D'origine Indo-Pacifique, il a été mentionné pour la première fois dans le Golfe de Gabès en 1891 (1). Depuis, cette espèce présente une densité exceptionnelle dans l'archipel des Kerkennah situé sur les côtes sud-est de la Tunisie. Ce même milieu est caractérisé par la présence du bivalve endémique de la Méditerranée *Pinna nobilis,* espèce protégée et bioindicatrice, et de ce fait d'intérêt écologique majeur en Méditerranée.

Un seul travail a été réalisé en 1993 sur la biologie de ces deux espèces dans les îles Kerkennah (2). La présente étude se propose d'apporter de nouvelles données sur l'écologie de *Pinctada radiata,* dans l'objectif de contribuer au dégagement de signes de compétition spatiale et trophique entre cette espèce et *Pinna nobilis*.

Matériel et méthodes

Une campagne de prospection a été effectuée à l'Est de l'îlot Chergui. Les limites de l'aire d'observation, prises en coordonnées UTM sont donnés par les quatre points suivants: (32 S)

$\begin{pmatrix} x = 0706330 \\ y = 3856050 \end{pmatrix}$ et $\begin{pmatrix} x = 07108070 \\ y = 3855454 \end{pmatrix}$ du côté nord et

$\begin{pmatrix} x = 0698619 \\ y = 3839669 \end{pmatrix}$ et $\begin{pmatrix} x = 0700644 \\ y = 3838779 \end{pmatrix}$ du côté sud de la partie prospectée.

Les prélèvements de *Pinctada radiata* ont été réalisés au niveau de deux stations, choisies en fonction de l'absence (station 1) ou de la présence de *Pinna nobilis* (station 1). Un échantillonnage mensuel d'une trentaine d'individus de *Pinctada radiata* entre juin et septembre 2003 a été réalisé dans le but de mesurer les paramètres de croissance. Les prélèvements ont été réalisés par plongée à des profondeurs de 1,8 m (station 1) et 1,2 m (station 2). Les paramètres du milieu: température, salinité, O_2 dissous, MES, Chl a et MOP sont également évalués.

Résultats

Pinctada radiata se répartit de manière très inégale dans la zone prospectée. En effet, les densités relatives varient de 0 à 109,85/m^2. Les densités dans la partie Nord de la zone sont plus importantes que celles de la partie Sud. Concernant *Pinna nobilis*, les densités relatives varient de 0,22 à 7,6/m^2.Dans les endroits où il y a peu ou pas de *Pinctada radiata,* nous trouvons la plus forte densité de Pinna (7,6 /m^2) avec une taille moyenne de 21,56 cm +/- 4,64 et une taille maximale de 30 cm. Par contre, dans les zones où il y a de fortes densités de *Pinctada radiata*, *Pinna nobilis* se fait rare avec un individu tous les 10 m^2 et des tailles moyennes de 13,59 cm +/- 2,86. Les longueurs moyennes de *Pinctada radiata* dans la station 1 varient de 32,71 +/- 10,6 à 43,65 +/- 13,2. Quant à la station 2, ces tailles varient de 28,74+/- 12,65 à 41,10 +/- 8,47.

Discussion et conclusion

La topographie sous-marine dans les îles Kerkennah caractérisée par l'alternance de vasières, de hauts fonds et de chenaux (3), autorise la distribution préférentielle de *Pinctada radiata* dans les endroits où l'apport en éléments nutritifs est important. Nos résultats mettent en évidence une densité relativement importante dans les deux stations. Nous avons relevé une densité moyenne significativement plus importante dans la station 2: 167 individus /m^2 par rapport à la station 1: 103,33 / m^2.

En outre, la température du milieu d'étude est fortement influencée, par celle de l'air vue la faible profondeur. Les premiers résultats dans nos deux stations mettent en évidence des valeurs comprises entre 25,7°C au mois de juin et 31,8° C au mois d'août. Ainsi, nous avons constaté des mortalités exceptionnelles au mois de septembre suite à la période caniculaire qui s'est étendue entre juin et août 2003. En effet, des études menées au laboratoire (4) montent qu'à partir de 31°C le taux de survie de *Pinctada radiata* diminue notablement.

Par ailleurs, les différences par rapport aux tailles et aux densités, trouvées au sein des deux lots de *Pinctada radiata,* ainsi que pour ceux de *Pinna nobilis*, laissent penser qu'il existe bien une compétition d'ordre trophique et géographique que nous comptons développer par des études complémentaires.

Références

1 - Bouchon-Brandley M. Et Berthoule A., 1891. Les pêches maritimes en Algérie et en Tunisie. Ministère des travaux publics en Tunisie. Vol. 20, n. 3. Pp. 95-95. Paris.

2 - Tlig-Zouari S., 1993. Contribution à l'étude écobiologique de deux espèces de mollusques lamellibranches *Pinctada radiata* et *Pinna nobilis* de îles Kerkennah. Th. Doc. Fac Sci. Tunis. 215 p.

3 - Amari A., 1984. Contribution à la connaissance hydrologique et sédimentologique de la plateforme des Kerkennah. Th. 3e cycle. Univ. Tunis, 263 pages.

4 - Britt N., 2000. The use of bivalves in the past and aspects of the ecology of the pearl oyster, *Pinctada radiata,* in the rocky shore of Haifa. RIMS newsletter. Report n. 27: 56-67. Univ. Haifa. Leon Recanati institue for maritime studies.

CHARACTERISTICS OF THE GROWTH OF THE ANCHOVY *ENGRAULIS ENCRASICOLIS* DURING A COMPLETE LIFE CYCLE

Sami Souissi
Station Marine, Université des Sciences et Technologies de Lille, CNRS-UMR 8013 ELICO, Wimereux, France
Sami.Souissi@univ-lille1.fr

Abstract

This paper presents the general form of the growth curve in length as a function of age of the anchovy *Engraulis encrasicolus*. This study is a compilation of several data from the literature concerning the life cycle from yolk-sac larvae to adults. Numerical tools were used to fit such heterogeneous data set and to assess the growth rate.

Keywords: Life cycle, growth, anchovy

Introduction

The biology of the anchovy *E. encrasicolis* has been studied to understand the role of this short living species (4-5 years) in the western Mediterranean ecosystems and to improve its management [1,2]. To improve management of these stocks, the life cycle strategy of *E. encrasicolus* should be better understood [2]. In the NW Mediterranean the spawning areas are localised in the most productive planktonic zones [1]. The demographic and growth processes during the early life stages are crucial for recruitment. However, only few studies have examined the demographic and growth processes of fishes during their ontogeny. The aim of this paper is to present the growth curve in length as a function of age from yolk-sac larvae to the last adult age-class. This analysis is a first step necessary before building complete life cycle models including demography and growth processes.

Methods

The age/length tables for larval, post-larval, pre-adults and adult phases were obtained from several studies realised in the Adriatic, the western Mediterranean and also in the Bay of Biscay [2]. Larvae were aged by means of daily growth increments in the otoliths. By putting all data of adults together a precision of 6 months was obtained. Most standard techniques of fitting empirical models cannot be used for such heterogeneous data. We used an alternative technique based on spline functions in order to fit the complete growth function. This procedure developed under Matlab Software is very flexible and may allow obtaining either integration or derivative of the obtained function [3].

Results and discussion

Figure 1A shows the shape of the growth curve of *E. encrasicolus* from larvae (<4 mm) to last age-class (170-200 mm). The length of metamorphosis (30 mm) is reached rapidly after one month. The general pattern of the variation of the specific growth rate as a function of length shows a like-hyperbolic curve (Figure 1C). This strategy of high growth rate during the first year and a first maturity around 110 mm may be explained by the high mortality encountered during this phase. The absence of clear relationship between stock and recruitment of these clupeid species is another reason for focusing on the complete life cycle processes. For a congeneric species *E. mordax*, Peterman *et al.* [4] used 13-year data of abundances of the first three stages: eggs, larvae (4-5 days) and early juveniles (19 days). They argued that the absence of correlations between these abundances and the number of recruits (1 year) was related to high variability (CV=171%) of the survival rate between 19 days and one year.

The results showed here represent a first step towards modelling of the growth rate of anchovy during the complete life cycle. To explain variability in the data, a bioenergetic model including the effects of environmental factors should be developed. Such a model may allow possible interactions between the environment, the recruitment and population dynamics to be better assessed.

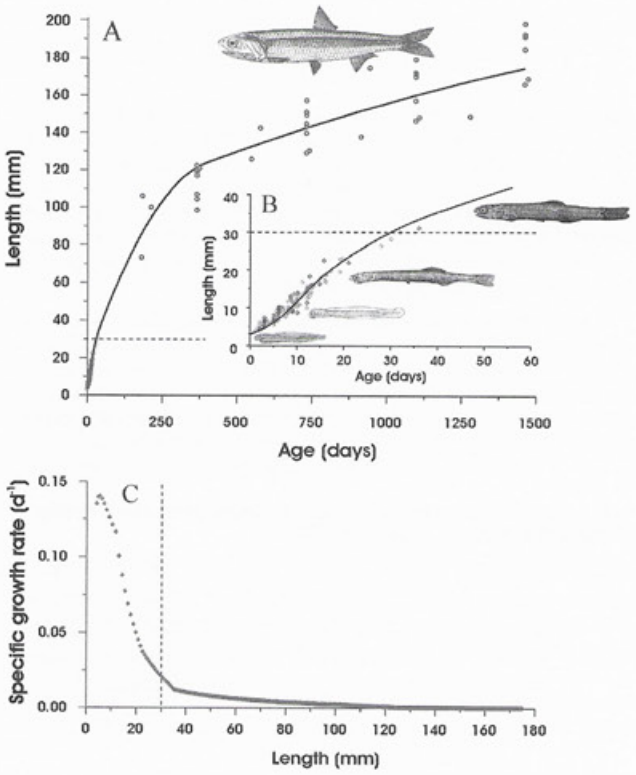


Fig. 1. A) Growth function of the anchovy *E. encrasicolus* during the complete life cycle. Symbols correspond to a compilation of the data from the literature [2]. Solid line is obtained by using the stepwise method of fitting based on spline functions. B) A zoom for the growth function during the first two months. C) Variation of the specific growth rate (d^{-1}) as a function of length of individuals. Discontinuous lines in all panels show the length of metamorphosis of this species.

References

1 - García A., and Palomera I., 1996. Anchovy early life history and its relation to its surrounding environment in the Western Mediterranean Basin. *Sci. Mar.*, 60: 155-166.

2 - Souissi S., 1998. Modélisation du cycle de vie d'un poisson : Conséquences pour la gestion des ressources exploitées. Application à l'étude de l'interaction entre les populations de copépodes et la population d'anchois. Thèse de doctorat, Université Pierre et Marie Curie, Paris VI., 416 p. (+annexes, 187 p.).

3 - Bernard O., and Souissi S., 1998. Qualitative behavior of stage-structured populations: application to structural validation. *J. Math. Biol.*, 37: 291-308.

4 - Peterman R.M., Bradford M.J., Lo N.C.H., and Methot R.D., 1988. Contribution of early life stages to interannual variability in recruitment of northern anchovy (*Engraulis mordax*). *Can. J. Fish. Aquat. Sci.*, 45: 8-16.

IMPACT DES FACTEURS ENVIRONNEMENTAUX SUR LA STRUCTURATION DU ZOOPLANCTON D'UNE SALINE MÉDITERRANÉENNE : LA SALINE DE SFAX (TUNISIE)

Néji Toumi [1], Habib Ayadi [1], Jean-François Carrias [2], Khaled Medhioub [3], Mekki Boukhriss [4], Abderrahman Bouaïn [1] et Télesphore Sime-Ngando [2]

[1] Laboratoire d'Ecologie Planctonique, Faculté des Sciences de Sfax, Faculté des Sciences de Sfax, Tunisie
* n.toumi@voila.fr, Habib.Ayadi@fss.rnu.tn
[2] Laboratoire de Biologie des Protistes, Université Blaise Pascal (Clermont II), UMR CNRS, Aubière, France
[3] Laboratoire d'Environnement, IPEIS, Sfax, Tunisie
[4] Laboratoire d'Ecologie Végétale, Faculté des sciences de Sfax, Tunisie

Résumé

Le zooplancton de la saline de Sfax (Tunisie) a été étudié suivant un cycle biannuel. Les résultats montrent que dans les premiers bassins la dominance est partagée entre les copépodes et les rotifères. Ces deux groupes régressent dans les bassins sursalés laissant se développer des espèces plus euryhalines telles que le cilié *Fabrea salina* et le crustacé phyllopode *Artemia salina*.

Mots clés : saline, salinité, zooplancton, peuplement

Introduction

Il est actuellement admis que les milieux côtiers, notamment ceux situés en zone tempérée, font aujourd'hui l'objet d'une gestion relativement adéquate. Rares sont cependant les études scientifiques concernant les zones côtières humides en général, et les milieux saumâtres et les marais salants en particulier (1). Cela est particulièrement vrai pour la côte méditerranéenne où de tels milieux constituent généralement des écosystèmes à forte productivité biologique et de grande importance écologique et sociale (2, 3).

La présente étude est menée sur une saline méditerranéenne, la saline de Sfax (côte Centre-Est de la Tunisie, environ 36°N et 11°E). Pour réaliser cette étude, 6 stations d'échantillonnage, correspondant à 6 bassins de salinité différentes (A1, A5, A16, C21, M1 et M2) ont été choisies dans le cadre de cette étude. Ces bassins montrent un gradient croissant de salinité (Tableau 1) et permettent ainsi d'envisager l'impact de ce facteur sur la distribution du peuplement zooplanctonique.

Table 1. Valeurs moyennes (± SD) des principaux paramètres abiotiques des bassins d'étude de la saline de Sfax.

Paramètres	A1	A5	A16	C21	M1	M2
Salinité (‰)	42,3 ± 1,31	48,2 ± 3,81	75,9 ± 3,45	85,6 ± 7,08	155,9 ± 6,00	177,7 ± 8,57
pH	7,43 ± 0,53	8,00 ± 0,27	8,04 ± 0,24	8,1 ± 0,2	7,70 ± 0,14	7,96 ± 0,22
T(°c)	20,2 ± 6,57	21,7 ± 6,61	21,2 ± 6,9	21,8 ± 6,79	24,7 ± 6,90	23,0,2 ± 6,35
MES (mg.l^{-1})	93,85 ± 82,83	129,78 ± 90,75	112,04 ± 95,44	190,56 ± 140,71	185,59 ± 192,86	352,22 ± 312,22

Résultats et discussions

Le tableau 1 montre l'évolution des paramètres physico-chimiques des saumures au niveau des différents bassins d'étude. La salinité du milieu augmente progressivement depuis la station A1 (42‰) jusqu'à la station M2 (salinité moyenne 180‰). En moyenne, la température augmente légèrement avec la salinité des bassins (Tableau 1). Les valeurs de pH montrent de faibles variations entre les bassins d'étude. La turbidité des saumures liée à la teneur en matières en suspension (MES) montre des valeurs croissantes en fonction de la salinité, cela peut s'expliquer par la dégradation du matériel biologique au fur et à mesure de l'augmentation de la salinité.

Le zooplancton de la saline de Sfax est composé par les groupes suivants : crustacés copépodes, rotifères, protozoaires ciliés, le phyllopode *Artemia* ainsi que d'autres formes larvaires (annélides et cirripèdes surtout) désignés dans notre étude par le terme "autre zooplancton". La densité du zooplancton dans les quatre premiers bassins est relativement faible (Fig. 1), les groupes dominants sont principalement les copépodes au niveau des deux stations A1 et A5 et les rotifères pour les stations A16 et C21. Dans deux dernières stations M1 et M2 le zooplancton de la saline est formé essentiellement par le groupe des protozoaires ciliés et le crustacé *Artemia*. Ceci est conforme avec les résultats du test ANOVA. En effet, la salinité a un effet négatif marqué sur l'abondance des copépodes des rotifères et du groupe "autre zooplancton" alors que l'effet inverse est observé pour *Artemia*.

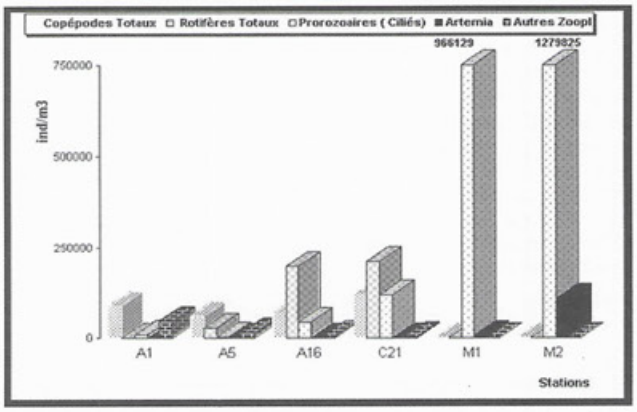


Fig. 1. Abondance moyenne des groupes zooplanctoniques dans les 6 bassins d'étude.

Références

1 - Davis J.S., 2000. Structure, function and management of the biological system for seasonal solar saltworks. *Global Nest: the Int. J.*, 2(3): 217-226.

2 - Kinne O., 1971. Salinity – invertebrates. Pp. 821- 995. In: O. Kinne (ed.), Marine Ecology, vol 2: environmental factors. Wiley Interscience, London.

3 - Quignard J.P., 1984. Les caractéristiques biologiques et environnementales des lagunes en tant que base biologique d'aménagement des pêcheries. *Etudes et Revues*, 61(1): 3-38.

CARACTERISATION MERISTIQUE DE L'ATHERINE DES ILES KERKENNAH (TUNISIE)

M. Trabelsi [1] *, E. Faure [2], J.-P. Quignard [3], M. Boussaid [4] et F. Maamouri [1]

[1] Laboratoire de Biologie et Parasitologie aquatique, Faculté des Sciences, Tunis, Tunisie - * atherina2002@yahoo.fr
[2] Laboratoire Systématique Evolutive, Université de Provence, Marseille, France
[3] Laboratoire d'Ichthyologie, Université Montpellier II, Montpellier, France
[4] Institut National des Sciences Appliquées et de Technologie, Tunis, Tunisie

Résumé

L'analyse de 9 caractères méristiques chez des Athérines de Kerkennah a permis de discriminer cette population. Comparée à *A. boyeri* et *A. punctata,* l'Athérine de Kerkennah se distingue par les valeurs individuelles et moyennes les plus basses pour les caractères vertèbres, écailles en ligne longitudinale, branchiospines et rayons aux nageoires pectorales.

Mots clés: Athérines, Kerkennah, Caractères méristiques

Introduction

Les caractères méristiques ont été, et sont encore, pris en considération en taxinomie des Poissons pour les identifier et les ranger dans une classification. Déterminés génétiquement, ces caractères peuvent, parfois, être modulés par l'environnement: c'est la «plasticité phénotypique». Les principaux facteurs naturels jouant un rôle dans ce domaine sont la température, la concentration en O_2 et CO_2, la salinité et l'intensité lumineuse. Les caractères méristiques les plus sensibles à ces facteurs, donc les plus variables, sont le nombre de vertèbres, des écailles et de rayons aux nageoires (1, 2).

Le présent travail analyse les caractères méristiques des Athérines de Kerkennah et les compare aux données obtenues chez *A. punctata* et *A. boyeri* (3).

Matériel et méthodes

Pour réaliser cette étude nous avons prélevé:

- 100 Athérines en Tunisie (Kerkennah (K)),
- 400 *A. punctata* en Tunisie (Cap Zébib (Z) - Monastir (J)) et en Corse (Pinarello (N) - Lavezzi (O)),
- 700 *A. boyeri* en Tunisie (Tabarka (R) - Hergla (H) - Monastir (M) - Mahdia (F); en Corse (Pinarello (I)) et au Languedoc (Sète (S) - Palavas (A)).

Pour chaque individu, nous avons compté le nombre de vertèbres (VE), des écailles en ligne longitudinale (EC), de branchiospines supérieure (BS), inférieure (BI) et totale (BT = BS+BI) et de rayons aux nageoires dorsales (D1, D2), anale (AN) et pectorales (PE).

Pour une meilleure estimation des divergences, nous avons procédé à l'Analyse Canonique Discriminante (A.C.D.) traitant, simultanément, tous les caractères et échantillons analysés (4).

Résultats

Pour les Athérines étudiées, nous présentons ci-dessous les valeurs minimale, modale et maximale pour chacun des neuf caractères méristiques considérés.

Athérine de Kerkennah

VE = (39) 40 (42). **EC** = (39) 40 (42). **BS** = (6) 7 (8). **BI** = (18) 19 (21). **BT** = (24) 26 (29).
PE = I + (13) 13 (15). **D1** = (5) 7 (9). **D2** = I + (9) 11 (14). **AN** = I + (12) 14 (15).

Atherina punctata:

VE = (41) 43 (46). **EC** = (41) 43 (46). **BS** = (7) 8 (9). **BI** = (19) 21 (24). **BT** = (26) 29 (33).
PE = I + (13) 14 (17). **D1** = (VI) VII (VIII). **D2** = I + (10) 11 (12). **AN** = I + (11) 13 (15).

Atherina boyeri:

VE = (43) 45 (48). **EC** = (43) 46 (48).**BS** = (8) 9 (11). **BI** = (24) 27 (30). **BT** = (32) 37 (41).
PE = I + (13) 15 (17). **D1** = (6) 8 (10). **D2** = I + (9) 11 (13). **AN** = I + (12) 13 (16).

Pour ce qui concerne les deux premiers axes absorbent 97,24% de l'inertie globale. L'axe 1 (valeur propre = 16,0381, absorption = 93,45%) est corrélé aux caractères VE-EC-BS-BI-BT-PE-D1. L'axe 2 (valeur propre = 0,6501, absorption = 3,79%) est défini par D2.

A. boyeri, *A. punctata* et l'Athérine de Kerkennah se séparent nettement selon l'axe 1 (Fig. 1).

– *A. boyeri* se caractérise par les nombres individuels et moyens les plus élevés pour les caractères VE-EC-BS-BI-BT-PE-D1.

– *A. punctata* et l'Athérine de Kerkennah présentent des valeurs plus basses pour VE-EC-BS-BI-BT-PE-D1. Dans ce groupe, les Athérines de Kerkennah se singularisent par les nombres les plus bas.

Discussions et conclusions

Les résultats obtenus montrent l'importance des caractères VE-EC-BS-BI-BT-PE dans la discrimination des Athérines de Kerkennah. Ces Athérines occupent une place bien particulière complètement indépendante de *A. punctata* et *A. boyeri*. Les faibles moyennes vertébrales sont



Fig. 1. ACD des caraxtères méristiques de l'Athérine de Kerkennah, *A. punctata* et *A. boyeri*.

reliées à des températures et des salinités élevées (5). Des travaux d'hydrologie réalisés à Kerkennah (6) mettent en évidence la présence de fortes valeurs de température et de salinité, ces relevées peuvent être les éléments d'explication à nos observations. Nos résultats, concernant l'isolement de la population de Kerkennah de celles du proche continent (*A. boyeri* et *A. punctata*), confortent ceux rapportés sur les Sardines des îles de Majorque, Corse, Sardaigne et Sicile (7) et sur les Sardinelles (*Sardinella aurita*) des Baléares et de Rhodes (8).

Références

1 - Jordan D. S., 1892. Relations of temperature to vertebrae among fishes. *Proc. U. S. Nat. Mus.*, 14: 107-120.

2 - Helfman G. S., Colette B. B. et Facey D. E., 1997. The Diversity of Fishes. Blackwell Science, 528 p.

3 - Trabelsi M., Faure E., Quignard J.-P., Boussaïd M., Focant B. et Maamouri F., 2002. *Atherina punctata* and *Atherina lagunae* (Pisces, Atherinidae), new species found in Mediterranean Sea. 1. Biometric investigations of three Atherinid species. *C. R. Acad. Sci.* Paris, Life Sciences, (325): 967-975.

4 - Sas, 1990. SAS user's guide: SAS STAT, SAS BASIC. Versio 6, fourth edition. SAS incl, Box 8000. Cary, NC 27512-8000, Cary; NC: SAS Institut Inc.

5 - Kiener A. et Spillmann C.J., 1969. Contributions à l'étude systématique et écologique des Athérines des côtes françaises. *Mém. Mus. Hist. nat. Paris*, nouv. sér., Sér. *A, Zool.*, 40 (2): 33 - 74.

6 - Amari A., 1984. Contribution à la connaissance hydrologique et sédimentologique de la plateforme des Kerkennah. Thèse 3 ème Cycle, Université de Tunis, 263 p.

7 - Larraneta M. G., 1968. Unités de stock de la sardine de la Méditerranée occidentale et de l'Adriatique. *Etudes et Revues C.G.P.M. - FAO, Rome*, 33: 54 p.

8 - Ben Tuvia A., 1960. Synopsis of biological data on *Sardinella aurita* of the mediterranean sea and other waters. *FAO Fisheries Synopsis*, 14: 26 p.

PARASITISME ET ANOMALIE DE CALCIFICATION DE LA COQUILLE OBSERVES CHEZ LA PALOURDE EUROPEENNE *RUDITAPES DECUSSATUS* PRELEVEES DANS LA REGION DE SFAX (TUNISIE)

Trigui El-Menif N. [1] *, Gargouri Ben Abdallah L. [2] et Le Pennec M. [3]

[1] Université de Carthage, Faculté des Sciences de Bizerte, Département de Biologie, Laboratoire d'hydrobiologie marine, Tunisie
[2] Université du nord, Faculté des Sciences de Tunis, Département de Biologie, Laboratoire de Parasitologie, Campus Universitaire, Tunisie
[3] Institut Universitaire Européen de la Mer, Université de Bretagne Occidentale, site Technopôle Brest IroisePlouzané, France

Résumé

Des observations macroscopique et microscopique de palourdes *Ruditapes decussatus* (L) prélevées de janvier à décembre 2002 dans quatre stations de la région de Sfax: Hagouna, Sidi Mansour, Port de pêche de Sfax et Gargour révèlent la présence d'une anomalie coquillière affectant la partie postérieure des valves et d'un ensemble de parasites au niveau des siphons, du manteau, de la gonade et de la glande digestive (sporocystes et cercaires libres de *Cercaria plumosa*, de métacercaires de Gymnophallidae, de protozoaires; de mixosporidies et microsporidies et de copépodes). Sur coupes semi-fines et ultra-fines, le manteau des individus affectés par la perturbation coquillière montre deux parasites. Le premier, formé de cellules circulaires groupées dans des lacunes constituant des ensembles de différentes formes. Le second, rare, proche du genre *Stoecharthrum*. C'est un parasite à paroi épaisse et à structure interne lamellaire, de 80 à 180 µm de longueur et de 40 à 80 µm de largeur.

Mots clés: Mollusque bivalve, Ruditapes decussatus, perturbation coquillière, parasitisme

Introduction

La palourde *Ruditapes decussatus* est présente sur le littoral tunisien à une densité atteignant 90 individus/m^2 (Gargour et Port de Sfax). La production moyenne annuelle est de 1200 t dont 90% sont exportés vers l'Europe.

Matériel et méthodes

Des prélèvements saisonniers de 100 à 150 palourdes ont été effectués durant l'année 2002. Les stations étudiées se situent dans la région de Sfax (Fig. 1): il s'agit de Hagouna, Sidi Mansour, du Port de pêche et de Gargour. Une fois au laboratoire, les échantillons sont examinés macroscopiquement et microscopiquement. Les individus parasités et/ou présentant une anomalie coquillière sont dénombrés et conservés pour analyse. Des portions du manteau sont fixées au glutaraldéhyde et à l'acide osmique et des coupes semi-fines et ultra-fines sont réalisées pour des observations en microscopie photonique et électronique à transmission.

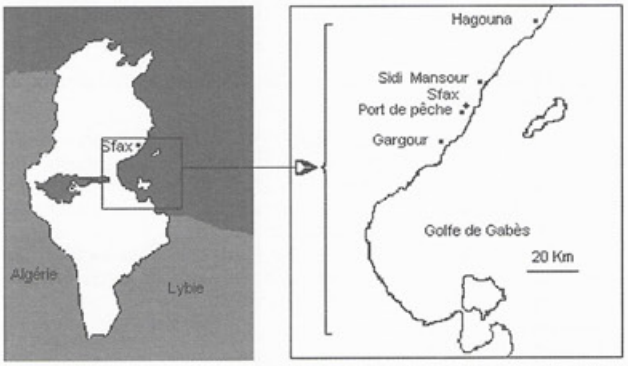


Fig. 1. Carte de Tunisie indiquant les 4 stations de prélèvement des palourdes.

Résultats

Les perturbations affectant la coquille prennent naissance du côté interne des valves, au niveau de la sortie des siphons, avant de s'extérioriser. Elles entraînent progressivement des perforations, empêchant la coquille de se fermer hermétiquement. Le taux moyen d'individus affectés est élevé au Port (3,5 à 5,6%). A Sidi Mansour et Gargour le taux varie de 2,3 à 3%, alors qu'à Hagouna, aucun cas n'est observé.

Les observations microscopiques de la chair de palourdes prélevées dans le Port révèlent la présence de parasites dans les gonades, les siphons, le manteau et la glande digestive. Il s'agit de sporocystes et cercaires de *Cercaria plumosa*, de métacercaires de Gymnophallidae et de protozoaires (mixosporidies et microsporidies). Des copépodes ont été observés, sans qu'il soit possible, pour l'instant, de les identifier. Les taux de parasitisme enregistrés étant de 13.85% en été, 19,81% en automne, 12,94% en hiver et 11,75% au printemps.

Les observations des coupes semi-fines et ultra-fines du manteau des palourdes affectées par des anomalies de calcification, révèlent deux types de parasites. Le premier se présente sous la forme d'unités cellulaires, de 12 à 18 µm de diamètre, à vacuole centrale volumineuse repoussant le cytoplasme et le noyau à la périphérie. Ces cellules semblent se diviser par clivage formant une structure globale sans forme particulièrement définie. Le deuxième parasite, de 80 à 180 µm de longueur et de 40 à 80 µm de largeur, montre une paroi épaisse et une structure interne lamellaire.

Discussion et conclusion

Les différentes observations des anomalies de calcification touchant la coquille révèlent une similitude avec celles provoquées par la bactérie, *Vibrio tapetis*, chez *Ruditapes philippinarum* (1). Les parasites affectant les tissus internes des palourdes sont nombreux et les taux les plus élevés sont relevés chez les individus du Port. Ceci peut vraisemblablement s'expliquer par l'enrichissement de ce milieu en matières organiques provenant des rejets. Les hydrocarbures peuvent avoir un impact car les résultats obtenus sur la teneur de ces composés totaux dans les tissus des bivalves se traduisent par des valeurs plus élevées dans les stations du Port et de Gargour.

Concernant certaines formes pathogènes présentes dans les tissus de la palourde portugaise, (2) ont montré l'existence d'une parasitose affectant le tissu conjonctif des branchies et des gonades et dont la similitude est grande avec celle révélée dans notre étude. Pour ces auteurs, le parasite serait proche de *Perkinsus marinus* dont la position taxonomique est controversée. Selon (3) ce serait un Dinoflagéllé. L'autre parasite, rare chez les bivalves, semble proche du genre *Stoecharthrum* rencontré chez *Lucinoma borealis minor* (4). C'est un Mésozoaire dont le cycle évolutif comprend un stade asexué parasite: le plasmode.

Ces résultats préliminaires montrent que divers agents pathogènes peuvent affecter la palourde, à des taux variant de 10 à 20%. L'intérêt économique de cette espèce en Tunisie nécessite une étude approfondie en vue d'identifier les pathogènes et déterminer leur impact sur certains tissus.

Références

1 - Paillard C., Percelay L., Le Pennec M. et Le Picard D., 1989. Origine pathogène de « l'anneau brun » chez *Tapes philippinarum* (Mollusque, bivalve). *C. R. Acad. Sci. Paris*, T. 309, S. III: 235-241.

2 - Comps M. et Chagot D., 1987. Une parasitose nouvelle chez la palourde *Ruditapes decussatus* (L.). *C. R. Acad. Sci. Paris*, T. 304, S. III: 41-44.

3 - Murrell A., Kleeman S. R., Barker S. C ; and Lester R. J. G., 2002. Synonymy of *Perkinsus olseni* Lester & Davis, 1981 and *Perkinsus atlanticus* Azevedo, 1989 and an update on the phylogenetic position of the genus *Perkinsus*. *Bull. Eur. Ass. Fish. Pathol.*, 22: 258-265.

4 - Monnat J. Y., 1970. Introduction à l'étude de la reproduction chez *Lucinoma borealis* (Linné) (Bivalvia, Lucinacea), Thèse 3ème cycle, Université de Bretagne Occidentale, Brest, 82 p.

SPAWNING PATTERN OF ROUND SARDINELLA, *SARDINELLA AURITA* VALENCIENNES, 1847, IN RELATION TO SEA SURFACE TEMPERATURE (NORTHERN AEGEAN SEA, GREECE)

A.C. Tsikliras [1, 2]

[1] Aristotle University of Thessaloniki, School of Biology, Department of Zoology, laboratory of Ichthyology, Thessaloniki, Greece
[2] Fisheries Research Institute, NAGREF, Nea Peramos, Kavala, Greece - atsik@bio.auth.gr

Abstract

Mean monthly gonadosomatic index was calculated for both sexes of round sardinella *Sardinella aurita* Valenciennes, 1847 in northern Aegean Sea (September 2000-August 2002). Gonad development was synchronous for both sexes and significantly correlated ($r>0.50$, $P<0.01$) to sea surface temperature. The sharp temperature increase in spring seems to determine the onset of round sardinella spawning.

Keywords: round sardinella, spawning, SST, northern Aegean Sea

Introduction

Round sardinella, *Sardinella aurita* Valenciennes, 1847 (Pisces, Clupeidae) is a stenothermic and stenohaline pelagic, shoaling fish of the subtropical zone (1-3). The breeding pattern of round sardinella has been characterized as an extremely complex phenomenon (3), studied in several areas of its distribution (4-7) including the southern Mediterranean Sea (8, 9). Besides an early work (10), there are no data on its reproduction in Greek waters. The aim of the present work is to identify the effect of sea surface temperature on the spawning pattern of round sardinella.

Materials and Methods

Samples were collected onboard the commercial purse seine fleet for two complete years (September 2000-August 2002) in Kavala Gulf, northern Aegean Sea. The mean gonadosomatic index [GSI=(gonad weight)/(total weight)×100] was calculated on a monthly basis, separately for the two sexes. Sea surface temperature (SST, °C) was recorded monthly using a CTD probe.

Results

The monthly mean GSI showed synchronous gonad maturation for the two sexes and a short spawning season in early summer (Fig. 1). The onset of reproduction varied between the two study years with a time lag of a month observed in gonad development and maturation in 2002. The reproductive activity of round sardinella begun in May or June. Mean monthly SST was 0.5 to 1°C higher during the first study year (mean: 18.15, range: 10.07-27.41) compared to the second one (mean: 17.67, range: 9.62-26.51). Significant cross correlation between GSI and SST was found for lag=1 month:

$GSI_{f,t}=-0.94+0.11SST_{t-1}$ ($r=0.54$, $n=24$, $P=0.007$),
$GSI_{m,t}= -1.88+0.16SST_{t-1}$ ($r=0.57$, $n=24$, $P=0.003$).

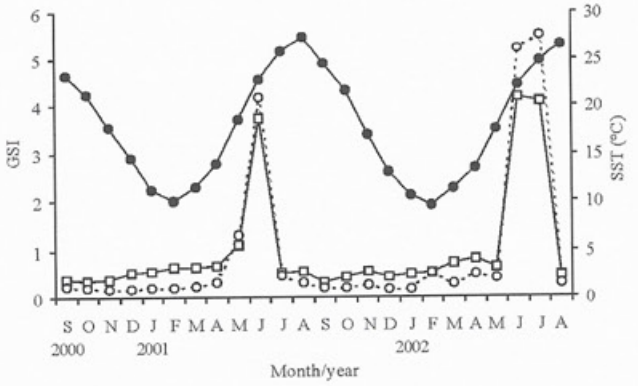


Fig. 1. Monthly variation of SST (solid circles, °C), and GSI values for female (open squares) and male (open circles) round sardinella, northern Aegean Sea (September 2000-August 2002).

Discussion

In general, the cues that trigger gonad development and maturation are environmental, often linked to temperature and daylength variations (11). The process of gonad maturation and spawning may be delayed due to unfavourable environmental conditions (7). In contrast, early maturation may also occur due to extremely favourable conditions. Indeed, the unusual high winter temperatures in northern Aegean Sea during the first year of the study may have caused favourable conditions for round sardinella that triggered the gonad development earlier in May. Positive relationships between spawning and temperature for round sardinella have been reported for other Mediterranean areas (6, 9, 12) as for the Aegean Sea.

Permanent low water temperatures may completely inhibit round sardinella's spawning and even prevent its distribution (3), an effect that has been reported for other fishes (e.g. 11). In southern Mediterranean, round sardinella's gonad maturation begins when temperature reaches 20°C (13). A threshold seems also to exist in the northern Aegean, at around 20-22°C with the sharp temperature increase in spring setting the signal for gonad development and maturation.

References

1 - Longhurst A.R., and Pauly D., 1987. Ecology of Tropical Oceans. Academic Press, San Diego.

2 - Fréon P. and Misund O.A., 1999. Dynamics of Pelagic Fish Distribution and Behaviour: Effects on Fisheries and Stock Assessment. Blackwell Fishing News Books, London.

3 - Whitehead P.J.P., 1985. FAO Species catalogue. Clupeoid Fishes of the world: An annotated and illustrated catalogue of the herrings, sardines, pilchards, sprats, chads, anchovies and wolf-herrings. *FAO Fish. Syn.*, 125.

4 - Cury P., and Fontana A., 1988. Compétition et stratégies démographiques comparées de deux espèces de sardinelles (*Sardinella aurita* et *Sardinella maderensis*) des côtes ouest-africaines. *Aquat. Living Resour.*, 1: 165-180.

5 - Fréon P., El Khattabi M., Mendoza J., and Guzman R., 1997. Unexpected reproductive strategy of *Sardinella aurita* off the coast of Venezuela. *Mar. Biol.*, 128: 363-372.

6 - Ettahiri O., Berraho Am., Vidy G., Ramdani M., and Do Chi T., 2003. Observation on the spawning of Sardina and Sardinella off the south Moroccan Atlantic coast (21-26°N). *Fish. Res.*, 60: 207-222.

7 - Quaatey S.N.K., and Maravelias C.D., 1999. Maturity and spawning pattern of *Sardinella aurita* in relation to water temperature and zooplankton abundance off Ghana, West Africa. *J. Appl. Ichthyol.*, 15: 63-69.

8 - Wassef E., Ezzat A., Hashem T., and Faltas S., 1985. Sardine fishery by purse-seine on the Egyptian Mediterranean coast. *Mar. Ecol. Prog. Ser.*, 26: 11-18.

9 - Bensahla Talet A., Mortet Y., and Tomasini J.A., 1988. Relations masse-longueur, sex-ratio et reproduction (saison de ponte, fécondités) de *Sardinella aurita* (Val. 1847) des côtes oranaises (Algérie). *Rapp. Comm. int. Mer Médit.*, 31 (2): V-II 14.

10 - Ananiades C.I., 1952. Quelques considérations biométriques sur l'allache (*Sardinella aurita* C. V.) des eaux grecques. *Prak. Hell. Hydrobiol. Instit.*, 5: 5-45.

11 - Jobling M., 1995. Environmental Biology of Fishes. Chapman & Hall, London.

12 - Palomera I. and Sabatés A., 1990. Co-occurrence of *Engraulis encrasicolus* and *Sardinella aurita* eggs and larvae in the northwestern Mediterranean. *Scient. Mar.*, 54: 61-67.

13 - Ben Tuvia A., 1960. Fluctuations in the stock of *Sardinella aurita* and its dependence on temperature and rain. *FAO Fish. Biol. Synop.*, 14: 287-312.

ASPECTS OF REPRODUCTIVE BIOLOGY OF FEMALE ROUND SARDINELLA, *SARDINELLA AURITA*, IN NORTHERN AEGEAN SEA (GREECE)

A.C. Tsikliras [1, 2 *] and E. Antonopoulou [1]

[1] Aristotle University, School of Biology, Department of Zoology, Thessaloniki, Greece, - * atsik@bio.auth.gr
[2] Fisheries Research Institute, NAGREF, Nea Peramos, Kavala, Greece

Abstract

Fecundity and size at maturity are presented for female round sardinella, *Sardinella aurita*, in northern Aegean Sea. The length at first maturity (TL) was 168 mm. Females produced on average 20,976 oocytes (range: 9,700-72,700, SD=7,741). Absolute fecundity increased exponentially with total body length ($F= 0.0949 \times TL^{4.223}$) and weight ($F= 511.19 \times W^{1.022}$).

Keywords: round sardinella, fecundity, size-at-maturity, northern Mediterranean, Aegean

Introduction

Round sardinella, *Sardinella aurita* Valenciennes, 1847 (Pisces, Clupeidae) is a pelagic shoaling fish of tropical and subtropical distribution (1). Although its reproduction has been studied in the southern Mediterranean Sea (2, 3), there are no data for the northern part of the sea, its northern boundary distribution. This work presents data on female fecundity, its relationship to length and weight and female size at maturity.

Materials and methods

Samples were collected with beach and purse seiners between September 2000 and August 2001, in Kavala Gulf, northern Aegean Sea. Total female fecundity (F) was estimated for 105 fish using the volumetric method (4). The relationships between mean total fecundity per size class and total length (TL, mm) or weight (W, 0.01 g) were studied using the exponential equation $F= ax^b$, where x is either TL or W. Size at first maturity (L_{m50}) was estimated using the logistic model (5, 6).

Results and discussion

The length frequency distribution of the specimens used for fecundity estimates is shown in figure 1. The L_{m50} was found to be 168.33 mm (95% confidence limits: 165.30 – 171.01). Each spawning female produced an average of 20,976 (SD=7,741) oocytes, ranging between 9,700 and 72,700 oocytes, and 445 (SD=98) oocytes per g of W. Mean absolute fecundity increased exponentially with TL and W:

$F= 0.0949 \times TL^{4.223}$ ($r^2= 0.91$, n=8, $P<0.01$)
$F= 511.19 \times W^{1.022}$ ($r^2= 0.92$, n=8, $P<0.01$).

Absolute fecundity of round sardinella exhibited high variability among individuals of the same size, which is the result of the synergetic effects of genetic differences among the females and environmental factors (7). Although our estimates were within the range reported so far (8, 3), they were close to the lower limit. This might be attributed to the fact that the maximum TL of the North Aegean population is lower compared to those off northwest African (8) and southern Mediterranean (3). The positive correlation of fecundity with size has been reported for round sardinella populations in the Mediterranean and eastern Atlantic (8, 3).

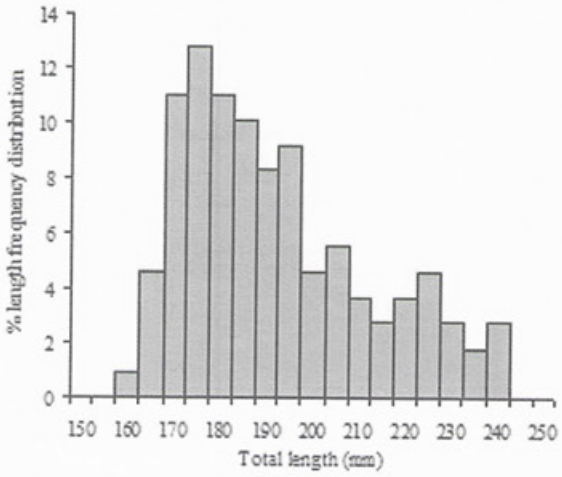


Fig. 1. Length frequency distribution of the round sardinella specimens used for fecundity estimates.

References

1 - Longhurst A.R., and Pauly D., 1987. Ecology of Tropical Oceans. Academic Press, San Diego.
2 - Wassef E., Ezzat A., Hashem T., and Faltas S., 1985. Sardine fishery by purse-seine on the Egyptian Mediterranean coast. *Mar. Ecol. Prog. Ser.*, 26: 11-18.
3 - Bensahla Talet A., Mortet Y., and Tomasini J.A., 1988. Relations masse-longueur, sex-ratio et reproduction (saison de ponte, fécondités) de *Sardinella aurita* (Val. 1847) des cotes oranaises (Algérie). *Rapp. Comm. Int. Mer Médit.*, 31 (2): V-II 14.
4 - Bagenal, T.B. and Braum, E., 1978. Eggs and early life history. Pp. 165-201. In: T.B. Bagenal (ed.), Methods for Assessment of Fish Production in Freshwaters. Oxford: Blackwell Scientific Publications.
5 - Echeverria, T.W., 1987. Thirty-four species of California rockfishes: maturity and seasonality of reproduction. *Fish. Bull.*, 85: 229-250.
6 - Petrakis, G. and Stergiou K.I., 1997. Size selectivity of diamond and square mesh codends for four commercial Mediterranean fish species. *ICES J. Mar. Sci.*, 54: 13-23.
7 - Wootton, R.J., 1998. Ecology of Teleost Fishes. 2nd edition, Kluwer Academic PublishersFish and Fisheries Series 24, Dordrecht, The Netherlands.
8 - Pham-Thuoc and Szypuła J., 1973. Biological characteristic of gilt sardine *Sardinella aurita* Cuv. Et Val. 1847 from northwest African Coast. *Acta Ichthyol. Piscat.*, 3: 19-37.

SHORT-TERM INVESTIGATION OF THE FISH COMMUNITY IN MALI STON BAY RESERVATION, CROATIA, SOUTHERN ADRIATIC

Pero Tutman *, Nikša Glavić, Valter Kožul, Boško Skaramuca

Institute of Oceanography and Fisheries, Laboratory for Ecology and Aquaculture, Dubrovnik, Croatia - * pero.tutman@mailcity.com

Abstract

A short-term study of the coastal fish community was conducted from May till August 2003 in the special reservate in Mali Ston Bay (southern Adriatic, Croatia), using a 25 m long beach seine. A total of 4038 fish specimens, belonging to 14 families and 28 species were caught. Atherinidae (88,18%) dominated the catch: *Atherina boyeri* (81,87%) was the most numerous, while *A. hepsetus* (6,31%), *Gobius genioporus* (2,15%), *Mullus barbatus* (1,95%) and *M. surmuletus* (1,11%) comprised 11,52% in total. The remaining species contributed less than 0,3% of the catch. Most species were present as juveniles. The overall value of richness (D) was 3,25, diversity (H) values were 0,94 and evenness (J) was 0,11. Our preliminary results provide a contribution to the knowledge of the fish assemblage of the Mali Ston Bay.

Key words: fish, biodiversity, Mali Ston Bay, Adriatic

Introduction

Mali Ston Bay is an unpolluted area suitable for the cultivation of the European oyster and Mediterranean mussel. The tradition of oyster and mussel farming in this Bay is centuried old, and it is one of the few areas famous for successful cultivation and fast growth of oysters and mussels. Although there is considerable research on the plankton and shellfish populations, the fish assemblage of Mali Ston Bay is scarcely known (1). The present study provides preliminary data on the fish assemblage in the special reservate in Mali Ston Bay, southern Adriatic.

Matherial and methods

Mali Ston Bay is located between the coast and the peninsula of Pelješac. The waters of the Bay are affected by freshwater discharged by the Neretva river, underground springs and occasional abundant rainfall. The greatest part of Mali Ston Bay was proclaimed as a special reservation at 2002. Sampling was conducted from May till August 2003, in several sites. The sampling sites were mostly on muddy, or sandy-muddy bottoms with rocky boulders and parts overgrown with *Zoostera sp*. To depths of 2 m. Fish samples were collected with beach seine, 25 m long and 5 m high at the central part with central bag. The mesh size was 8 mm at outer wings, and 4 mm at central part of the net. Collected material was kept on ice and brought to the laboratory for identification. Species were identified according to (2) and (3). The community structure was specified by species richness (D), diversity (H) and eveness (J)(4-6).

Results

A total of 4038 fish specimens werecollected, belonging to 14 families and 28 species. The most abundant were members of family Atherinidae with 88,18% of the catch. *Atherina boyeri* (81,87%) was the most numerous, while *A. hepsetus* (6,31%), *Gobius genioporus* (2,15%), *Mullus barbatus* (1,95%) and *M. surmuletus* (1,11%) comprised 11,52% in total. The remaining species contributed less than 0,3% of the catch. The greatest number of species (24) and individuals (1694) was caught in May, while the smallest number of individuals (489) was caught in August. Most species were present as juveniles. The overall value of richness (D) was 3,25, ranging from 2,40 in June to 3,09 in May. The values of diversity (H) was from 0,49 in June to 1,03 in August with an overall value of 0,94. Evenness (J) values were from 0,04 in May to 0,17 in June, with an overall value of 0,11.

Discussion

The taxonomic composition of fishes reported in Mali Ston Bay differs from other protected areas in the Mediterranean (7-9). The difference may stem from different geographical and geomorphological features of the Bay. Mali Ston Bay is semi-closed, with relatively little water exchange and the mostly mud bottom. The low abundance of some species, for example *Diplodus* spp. (except *D. annularis*) could be attributed to the paucity of microhabitats suitable for the settlement of these species. The absence of juvenile stages of *Dicentrarchus labrax* and *Sparus aurata*, typical brackish-water species, possibbly means that this reservate would not act as an spawning and nursery center for these species, but somwhere outside of its border, possible in nearby Neretva river estuary. *Atherina boyeri* made a signifficant contribution to the overall number of individuals of the assemblage as the frequent species of brackish-water ecosystems (10). Similar results were obtained for shallow coves in the middle Adriatic (11). The values of diversity, richness and eveness are slightly lower than values obtained in other bays and estuaries (12-14). This difference may stem from the lower number of species related to the number of individuals. The data collected in this study provides preliminary knowledge of the fish assemblage of the special reservate in Mali Ston Bay.

References

1 - Jardas I., Jukić S., Kačić J., Regner S., Sinovčić G., 1981. Ribarstveno-biološka istraživanja šireg područja Malostonskog zaljeva. Pp. 175-202. *In:* Pozar H. (ed:), Zbornik radova «Malostonski zaljev, prirodna podloga i društveno valoriziranje».

2 - Jardas I., 1996. Jadranska ihtiofauna. Školska knjiga. Zagreb, 533 p.

3 - Šoljan T., 1965. Ribe Jadrana. Zavod za izdavanje udžbenika. 451 p.

4 - Margalef R., 1968. Perspectives in Ecology Theory. Univ. Of Chicago, Press Chicago, 111 p.

5 - Shannon C.E., Weaver C., 1949. The matematical theory of communication. Univ. Of III. Press. Urbana, III., 117 p.

6 - Pielou E.C., 1966. Shannon's formula as measure of species diversity: its use and misuse. *Amer. Naturalist*, 100: 463-465.

7 - Bell J.D., 1983. Effects of depth and marine reserve fishing restrictions on the structure of a rocky reef fishing assemblage in the north-western Mediterranean sea. *J. Appl. Ecol.*, 20: 357-369.

8 - Garcia-Rubies A., Zabala M., 1990. Effects of total fishing prohibition on the rocky fish assemblage of Medes Islands marine reserve (NW Mediterranean). *Sci. Mar.*, 54(4): 317-328.

9 - Vacchi M., Bussotti S., Guidetti P., La Mesa G., 1998. Study of the coastal fish assemblage in the marine reserve of the Ustica Island (southern Tyrrhenian Sea). *Ital. J. Zool.*, 65, *suppl.*: 281-286.

10 - Quignard J.P., Pras A., 1984. Atherinidae. Pp. 1207-1210. *In:* Whitehead P.J.P., Bauchot M., Hureau J.C., Nielsen J., Tortonese E. (eds.), Fishes of the North-Eastern Atlantic and the Mediterranean. Paris, UNESCO.

11 - Dulcic J., Matic S., Kraljevic M., 2002. Shallow coves as nurseries for non-resident fish: a case study in the eastern middle Adriatic. *J. Mar. Biol. Ass. U.K.*, 82: 991-993.

12 - Dulcic J., Kraljevic M., Grbec B., Pallaoro A., 1997. Composition and temporal fluctuations of inshore juvenile fish populations in the Kornati Archipelago, eastern-middle Adriatic. *Mar. Biol.*, 129: 267-277.

13 - Dulcic J., Kraljevic M., Kozul V., Skaramuca B., 1998. Composition of juvenile fish populations in the Donji Molunat Bay, southern Adriatic (summer aspect). *Rapp. Comm. Int. Mer Médit.*, 35(2): 424-425.

14 - Tutman P., Glavic N., Kozul V., Glamuzina B., Skaramuca B., 2001. Structure of juvenile fish assemblage in Lopud Bay, Island of Lopud, south-east Adriatic Sea. *Rapp. Comm. Int. Mer Médit.*, 36: 333.

TYPOLOGY OF GREEK SMALL-SCALE FISHERIES BASED ON SOCIAL, ECONOMICAL AND BIOLOGICAL ELEMENTS

E. Tzanatos [1] *, Y. Vlatsiotis [1], L. Papaharisis [2], G. Katselis [3], E. Dimitriou [4], C. Koutsikopoulos [1]

[1] Department of Biology, University of Patras, Patra, Greece - * marlab@upatras.gr
[2] NIREUS S.A., Athens, Greece
[3] Technological Educational Institution of Messolonghi, Messolonghi, Greece
[4] Aquaculture Centre of Acheloos, Neohori, Greece

Abstract

A survey for the identification of the characteristics of Greek small-scale fisheries was conducted in 121 ports of 18 prefectures of Greece. The results showed the traditional, family-dependent and locally varying character of small-scale fisheries. Three groups of fishermen according to their dependence on fisheries were identified. Fishing activity exhibited a seasonal pattern. The identified complexity of small-scale fisheries should be taken into account for management implementation.

Keywords: small-scale fisheries, fishermen, typology, Greece

Introduction

Small-scale coastal fisheries comprise an important part of Greek fisheries in terms of landings, vessels and manpower [1, 2]. Overfishing problems have forced the European Union to reduce fishing effort through reduction in the number of fishermen and vessels [3]. The biological, economical and social characteristics of the system "small-scale fisheries" should be examined in order to optimize the management strategy and facilitate measure implementation.

Methodology

A total of 549 interviews of small-scale fishermen were conducted in 121 ports from 18 out of the 40 coastal prefectures of Greece. In order to obtain a representative sample of the Greek fishermen population, Greek prefectures were stratified according to the number of fishermen and the dependence on fisheries, the latter indicated by the total number of fishermen per population.

Results and discussion

Most Greek small-scale fishermen (64.6%) follow the family profession. The internal migration is low (85.7% and 68.8% live in the prefecture and in the place of their birth, respectively), while 65.5% are either illiterate or have attended preliminary school. The 61.3% working with other people on-board, work with members of their family. All these characteristics imply a closed, traditional system where measure implementation could be difficult.

Small-scale fishermen were categorised in 3 groups, according to their dependence on fisheries (Fig. 1). Group A: Dependence mainly on fishing, Group B: Dependence both on fishing and other sources and Group C: Dependence on other sources of income. These groups exhibited differences with respect to the total days of activity, income, vessel technical characteristics and level and means of information. Bearing in mind that current management policies aim towards reducing the number of fishermen, these groups should be treated differently in the licensing procedure in order to control fishing effort while at the same time minimizing social injustice.

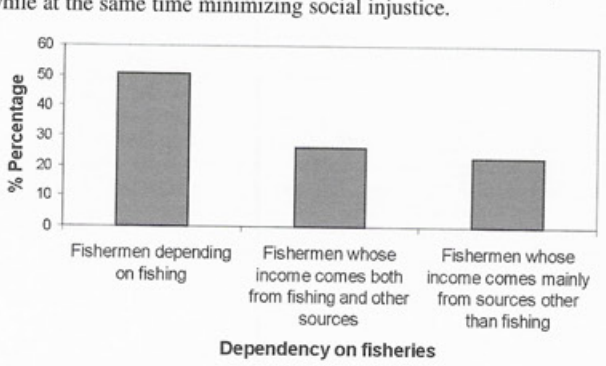


Fig. 1. Groups of fishermen according to their dependency on fisheries and estimated percentages for Greece.

The fishing activity exhibited a seasonal pattern with a peak in summer months (Table 1). Analysis of variance of monthly activity showed a significant difference between the 3 fishermen groups formerly identified (all P-values<0.01). Even though fishing pressure from small-scale fisheries is difficult to be monitored, it is bound to follow this seasonal pattern. This pattern varies among different areas of Greece.

Table 1. Mean and standard deviation of monthly days of activity of fishermen engaged in the Greek small-scale fisheries and of the three groups of fishermen identified according to their dependence on fisheries.

Month	Total	Group A	Group B	Group C
January	12.9±7.2	14.6±6.6	11.4±7.1	8.1±6.4
February	13.9±7.4	15.6±6.8	12.3±6.9	9.0±7.1
March	16.4±7.0	18.1±6.1	15.3±6.3	11.0±7.8
April	18.3±7.0	20.1±5.9	17.1±6.4	12.7±8.0
May	19.9±7.1	21.6±6.1	18.9±6.3	13.7±8.5
June	20.6±7.0	22.4±5.7	19.0±7.2	15.0±8.3
July	20.7±7.0	22.5±5.6	18.9±7.4	15.0±8.0
August	19.4±7.4	20.8±6.5	18.2±7.7	14.9±8.4
September	19.7±7.3	21.4±6.3	18.1±7.5	14.4±7.7
October	18.4±7.1	20.1±6.3	17.1±6.1	12.5±7.3
November	15.9±7.2	17.6±6.4	14.4±6.4	10.2±7.7
December	13.3±7.2	14.8±6.5	12.1±7.0	8.4±6.8

A total of 18 different fishing gears (e.g. nets, longlines, beach seines, trolling lines) and 62 target species (e.g. *Mullus surmuletus, Pagellus erythrinus, Diplodus vulgaris, Boops boops*) were recorded during the survey, exhibiting intense seasonal and local variability. The latter is related to the type of the ecosystem (e.g. presence of lagoons, open sea), the biology of the target species and the existing legal prohibitions for gear use. The large number and combinations of gear and target species demonstrate the multispecies-multigear character of the Greek small-scale fisheries. The combination of these data along with activity records will result to the identification of the most important métiers [4, 5], the latter being a useful tool for fisheries management.

References

1 - Stergiou K. I., Christou E. D., Georgopoulos D., Zenetos A., and Souvermezoglou C., 1990. The Hellenic Seas: Physics, chemistry, biology and fisheries, *Oceanogr. Mar. Biol. An. Rev.*, 35: 415-538.

2 - Anonymous, 2003. Common Fisheries Register, Ministry of Agriculture, Athens, Greece.

3 - Anonymous, 2001. Green Paper on the future of the Common Fisheries Policy, 40 p., Brussels.

4 - Mesnil B., and Shepherd J. G. 1990. A hybrid age- and length-structured model for assessing regulatory measures in multiple-species, multiple-fleet fisheries, *J. Cons. Int. Explor. Mer*, 47: 115-132.

5 - Ulrich C., Gascuel D., Dunn M. R., Le Gallic B., and Dintheer C., 2001. Estimation of technical interactions due to the competition for resource in a mixed-species fishery, and the typology of fleets and metiers in the English Channel, *Aquat. Livin. Resour.*, 14: 267-281.

GROWTH PARAMETERS OF THE MOST ABUNDANT PANDALID SHRIMPS (DECAPODA: CARIDEA) FROM THE NORTHERN AEGEAN SEA

D. Vafidis *, P.K. Leontarakis, A. Dailianis and A. Kallianiotis

Fisheries Research Institute, N.AG.RE.F., Nea Peramos, Kavala, Greece - *.dvafidis@otenet.gr

Abstract

Length-weight relationships and von Bertalanffy growth parameters were estimated for the five most abundant deep-water pandalid shrimps (*Chlorotocus crassicornis* A. Costa, 1871; *Plesionika antigai* Zariquiey-Alvarez, 1955; *P. giglioli* Senna, 1903; *P. heterocarpus* A. Costa, 1871 and *P. martia* A. Milne-Edwards, 1883) caught in the northern Aegean Sea.

Keywords: Pandalidae; length-weight relationship; growth; Aegean Sea

Introduction

Several pandalid shrimps are distributed along the Mediterranean continental shelf and slope. Although their biology has been thoroughly studied in western Mediterranean, little is known on their growth in the eastern Mediterranean. The present study provides preliminary information on the length-weight relationships and growth parameters of the five most-abundant pandalids of the northern Aegean Sea.

Materials and methods

Samples were collected during a 4-year MEDITS survey, preserved in 10% formaldehyde solution and carapace length (CL, to the nearest 0.01 mm) and total weight (TW, to the nearest 0.01 g) were measured. Sex was identified by the presence or absence of the male appendage on the second pair of pleopods. Appropriate parametric and non-parametric statistical tests were used to compare mean CLs between sexes. Length-weight relationships were determined using linear regressions and $\log_{10}$-transformed data, and analysis of covariance (ANCOVA) was used to identify differences in slope values between sexes. *t*-tests (H_0=3) with a confidence level of ±95% (a=0.05) were also performed to determine the allometry of the relationships. Standard von Bertalanffy growth curves were fitted to the length-frequency data for both sexes using ELEFAN I.

Results and discussion

Length frequency distributions are presented in Figure 1. A comparison of the mean CLs between sexes showed that females of *P. giglioli*, *P. heterocarpus* and *P. martia* reached a significantly (P<0.05) larger size than males, whereas no significant (P>0.05) difference existed in *C. crassicornis* and *P. antigai*. Length-weight relationships (Table 1) showed isometric growth and negative allometries in males and females respectively of *P. antigai* and *P. martia*. In *P. heterocarpus and C. crassicornis*, weight increased relatively slower than length in both sexes. Weight increased isometrically to length in *P. giglioli*. Length-weight relationships are instrumental in prescribing life habits of deepwater decapod crustaceans [1, 2]. Our results generally agree with those from the western Mediterranean [2] and are characteristic of nectobenthic species of moderate locomotory ability. The von Bertalanffy growth parameters (Table 1) showed distinct growth patterns between sexes in all species, as female generally reached larger L_{inf}s and had higher *K*. This is apparent for *P. martia* and *P. heterocarpus* from the northwestern [2] and central [3] Mediterranean, although growth parameters notably differ between different geographical regions. Results of the present study should be interpreted under the limitations regarding sampling of nectobenthic species using bottom trawling.

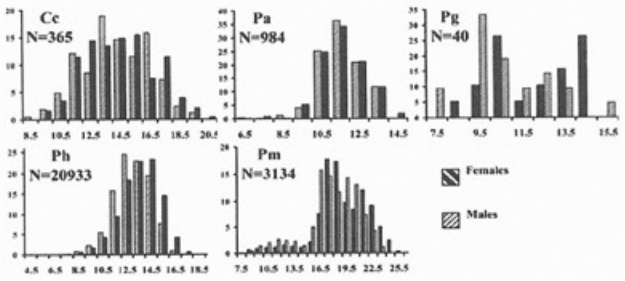


Fig. 1. Length-frequency distributions for the five most-abundant pandalids from the northern Aegean Sea. Abbreviations: Cc= *C. crassicornis*, Pa= *P. antigai*, Pg= *P. giglioli*, Ph= *P. heterocarpus*, Pm= *P. martia*.

Table 1. Descriptive statistics of carapace length (mm), length-weight relationships and von Bertalanffy growth parameters for the five most-abundant pandalids from the northern Aegean Sea (abbreviations of species names as in Fig. 1, += significant difference between intercepts (*a*) in the length-weight relationship, *= significant difference between slopes (*b*) and ns= no significant difference between sexes, P<0.001 for all regressions).

	Sex	N	Min-Max	Mean	Allometric equation	r^2	L_{inf} mm	K y^{-1}	t_o y
Cc+	F+M	365	9.0-20.2	14.4			17.3	0.48	-0.31
	F	201	9.6-20.2	14.4	$TW=3.3*CL^{2.8}$	0.90	19.0	0.40	-0.30
	M	164	9.0-19.4	14.3	$TW=5.9*CL^{2.8}$	0.90	17.4	0.48	-0.27
Pa*	F+M	944	6.5-15.2	11.6			12.7	0.73	-0.11
	F	560	6.9-15.2	11.6	$TW=4.8*CL^{3.0}$	0.81	13.9	0.98	-0.79
	M	384	6.5-13.9	11.5	$TW=11.0*CL^{2.}$	0.82	12.7	0.68	-0.27
Pg ns	F+M	40	7.7-15.3	11.4	$TW=17.0*CL^{2.}$	0.93	-	-	-
Ph*	F+M	20933	6.1-18.2	13.4			15.6	1.09	-0.31
	F	9468	6.3-18.2	13.6	$TW=12.6*CL^{2.}$	0.91	17.8	1.45	-0.17
	M	11465	6.1-17.6	13.0	$TW=41.7*CL^{2.}$	0.90	16.1	1.17	-0.28
Pm*	F+M	3134	7.5-26.2	18.5			24.0	0.73	-0.79
	F	1643	7.5-26.2	19.0	$TW=4.7*CL^{3.0}$	0.96	23.7	0.71	-0.74
	M	1491	7.8-26.1	17.9	$TW=6.8*CL^{2.8}$	0.97	23.0	0.58	-0.19

References

1 - Cartes J.E., 1993. Diets of deep-water pandalid shrimps on the Western Mediterranean slope. *Mar. Ecol. Progr. Ser.*, 96: 49-61.

2 - Company J.B. and Sardà F., 2000. Growth parameters of deep-water decapod crustaceans in the Northwestern Mediterranean Sea: a comparative approach. *Mar. Biol.*, 136: 79-90.

3 - Maiorano P., D'Onghia G., Capezzuto F. and Sion L., 2002. Life-history traits of *Plesionika martia* (Decapoda: Caridea) from the eastern-central Mediterranean Sea. *Mar. Biol.*, 141(3): 527-539.

THE AGE AND GROWTH OF JUVENILE DOLPHINFISH *(CORYPHAENA HIPPURUS)* IN EASTERN MEDITERRANEAN WATERS

V. Vassilopoulou, P. Bekas and G. Christides *
National Centre for Marine Research, Athens, Greece

Abstract

The age of juvenile dolphinfish collected in Greek waters was determined from counting sagittal daily increments. 65 to 168 increments were counted on the sagittae of males with total lengths ranging between 430 and 717 mm, and 72 to 157 increments on the sagittae of females, with total lengths ranging between 426 and 695 mm. The von Bertalanffy growth parameters were also estimated.

Keywords: daily rings, dolphinfish, Aegean Sea

Introduction

The dolphinfish (*Coryphaena hippurus*) is an epipelagic species distributed worldwide in all tropical and temperate oceans. In the Mediterranean, juveniles of the species are caught from late August to early December, using mainly the fish aggregating device (FAD) technique. Dolphinfish appears to grow very quickly and the maximum life span in central-western Atlantic reaches four years (1). In the present study, data on the age and growth of juvenile dolphinfish from Greek waters are provided.

Material and methods

In 2002, fish sampling was conducted on monthly basis at sites where floating FADs, constructed with palm leaves, were moored. The otoliths were removed and preserved following Panella's method (2). For age readings, the sagittae were used, which were embedded in heat hardening implex resin, in order to obtain a transversal section. Sequential grinding was performed and final polishing was accomplished using a 0.3 alumina paste. Age readings were made under a light microscope, coupled to a high-resolution video camera and monitor system, following standard procedures (3). Growth increments (i.e. sagittae rings) were assumed to be formed on a daily basis and counted from the core to the tip of the rostrum at x 400. The relationship between total length (TL) and daily increments was determined with a linear regression of length on number of rings. Age-length data were modelled using the von Bertalanffy growth equation, and the growth performance index (4) was estimated.

Results and discussion

Dolphinfish ranged in length between 426 and 717 mm, with the bulk of the stock being comprised by specimens of 520-620 mm (Fig. 1). The mean TL of females was significantly (t-test, $P<0.05$) smaller than that of males. Most of the largest specimens (>650 mm) collected in the study area were males. The age range determined from sagittal interpretation was 65-168 increments for males, having a corresponding TL range of 430-717 mm, and 72-157 increments for females, having a corresponding TL range of 426-695 mm. The parameters of the linear regressions of sagittal rings on TL are shown in Table 1, and those of the von Bertalanffy growth equation, along with the growth performance index, in Table 2. Similar results were obtained for the species in western Mediterranean waters (5).

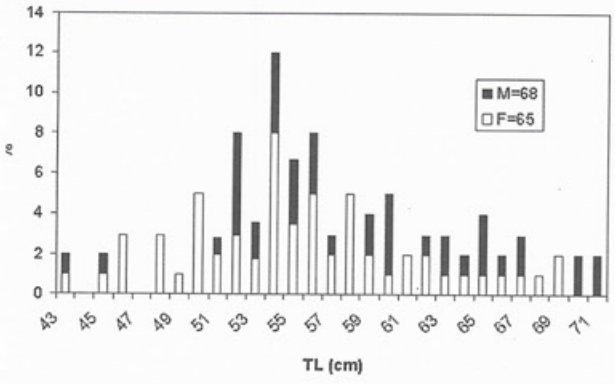


Fig. 1. Length frequency distribution of dolphinfish collected around FADs in Greek waters.

Table 1. Summary of results for linear regressions of sagittal rings on total lengths.
(r=coefficient of correlation, n=number of fish).

	Slope	(SE)	Intercept	(SE)	r	n
All fish	3.03	(0.15)	258.13	(15.62)	0.83	133
Males	2.86	(0.20)	267.92	(23.96)	0.85	68
Females	3.49	(0.29)	211.92	(31.12)	0.77	65

Table 2. Von Bertalanffy growth curve parameters for dolphinfish from Greek waters. Standard errors of estimates are in brackets. Φ: growth performance index.

	L_∞ (mm)	K (yr^{-1})	t_o (yr)	Φ
Female	1190.3	1.89	-0.093	6.4
	(219.9)	(0.69)	(0.043)	
Male	1069.1	2.05	-0.084	6.3
	(62.5)	(0.37)	(0.021)	
All fish	989.1	1.92	-0.087	6.2
	(146.5)	(0.57)	(0.037)	

References

1 - Uchiyama, J., Burch, R. K. and Kraul, S., 1986. Growth of the dolphins *Coryphaena hippurus* and *C. equiselis* in Hawaiian waters, as determined by daily increments on otoliths. *Fish. Bull.*, 84(1): 186-191.

2 - Panella, G., 1980. Methods of preparing fish sagittae for the study of growth patterns. Pp. 619-624. In: D.C. Rhoades, R. A. Lutz (eds.), Skeletal growth of aquatic organisms: biological records of environmental change. Plenum Press, New York.

3 - Morales-Nin, B., 1992. Determination of growth in bony fishes from otolith microstructure. *FAO Fish. Tech. Tech. Pap.*, 322: 51pp.

4 - Munro, J. L. and Pauly, D., 1983. A simple method for comparing the growth of fishes and invertebrates. *Fishbyte*, 1: 5-6.

5 - Massuti, E.., Morales-Nin, B. and Moranta, J., 1999. Otolith microstructure, age and growth pattern of dolphin, *Coryphaena hippurus*, in the western Mediterranean. *Fish. Bull. (U.S.)*, 97(4): 891-899.

RECURRENT BLOOMS OF *ALEXANDRIUM CATENELLA* IN MEDITERRANEAN CONFINED WATERS

Magda Vila [1] *, Mercedes Masó [1], Esther Garcés [1], Nagore Sampedro [1], Isabel Bravo [2], Antonella Luglié [3], Kees van Lenning [1], Silvia Anglés [1], Blanca Puig [1] and Jordi Camp [1]

[1] Institut Ciències del Mar, Barcelona, Spain - *magda@icm.csic.es
[2] Instituto Español de Oceanografía, Vigo, Spain
[3] Dipartamento Botanica ed Ecologia Vegetale, Sassari, Italy

Abstract

Paralytic Shellfish Poisoning (PSP) events related to phytoplankton blooms have increased worldwide. In the Mediterranean Sea, species belonging to the genus *Alexandrium* are chiefly associated with PSP events, and *A. catenella* is one of its most toxic. Before *A. catenella* had been detected in the Mediterranean Sea, that species was related to productive, cold upwelling regimes. However, in the Mediterranean Sea, *A. catenella* blooms are often localised phenomena that occur in enriched and confined coastal waters (harbours, bays). An intensive study was carried out during a huge bloom of this species in the Tarragona harbour in 2002.

Keywords: Harmful Algal Blooms, Alexandrium catenella, harbours, Paralytic shellfish poisoning, dinoflagellate

The most widespread *Alexandrium* that can be detected in the Mediterranean Sea is *A. minutum*. This species was first described in the Alexandria harbour (1), but it was thirty years later when that species was reported to be linked to toxicity in Mediterranean waters (2). Since then, numerous PSP outbreaks caused by *A. minutum* have been detected in the Mediterranean Sea. *A. minutum* was the unique *Alexandrium* species related to toxic events in the Mediterranean Sea for several years. It is important to mention that *A. minutum* blooms have always been described as localised phenomena related to harbours and lagoons (see 3 for revision). In the summer of 1998 the first widespread PSP event in the Mediterranean Sea occurred along the Catalan coast (100 Km affected) and it was caused by *A. catenella*. In the summer of 1999 a similar event took place again (4).

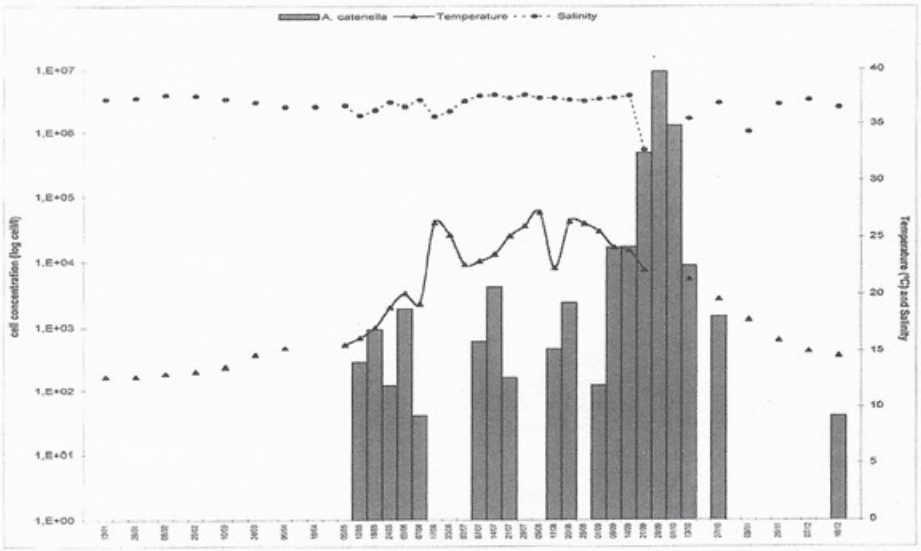
Along the southern Catalan Coast, *A. catenella* showed a clear seasonal pattern, being detected in several harbours from May to October. In 2002, a huge bloom of that species occurred in the Tarragona harbour (max. $9x10^6$ cells·l^{-1}, end September) at 22°C, producing a reddish-brown discoloration of the waters. The Tarragona harbour is one of the biggest harbours in the Mediterranean (4,5 km long; 600m to 2Km wide) with considerable commercial and fishing activities. This harbour receives freshwater inflows from the Francolí river. The river discharge is situated near the mouth harbour (inside side). *A. catenella* blooms have taken place there yearly, at least since 1998.

In 2002, *A. catenella* moderated cell densities (<10^4 cells·l^{-1}) were detected in the Tarragona harbour from mid-May, but it started blooming at the end of September (Fig. 1). It coincided with a salinity decrease (32) and with a high nutrient load (nitrate, ammonium, silicate and orthophosphate peaks of 40, 18, 37 and 1.8 µM, respectively). The nearly monospecific outbreak of *A. catenella* in Tarragona was intensively studied according to space and time. The bloom was followed every 3-4 days at 3 stations. In addition, a cruise was carried out when the organism rose to 10^6 cells·l^{-1}. The cruise consisted in a transect (6 stations from the most confined parts of the harbour to the mouth) which was repeated three times during that day: in the morning (9:00-10:30h, GMT), at midday (13:30-15:15) and at noon (16:30-18:00). CTD casts were performed at each station and samples were taken every metre from the surface to a depth of 10m. *A. catenella* (total cell number and cells per chain), chlorophyll and total inorganic nutrients were analysed. Pigments and PSP toxins were analysed by HPLC at surface level during the midday transect. Sediment samples were taken by scuba diver 8 months later (April 2003) to study the potential seedbeds.

The horizontal spatial variability of the organism was linked to the water confinement. The highest concentrations of *A. catenella* were detected in the inner part of the harbour (around $6{\cdot}10^6$ cells·l^{-1}) and diminished in the mouth (10^4-10^5 cells·l^{-1}). That pattern remained the same the whole day. The vertical distribution was characterised by a thick layer of 6m that contained the bulk of the population. A clear vertical pattern associated to temporal variability was not observed, except for the inner stations. In the three cruises, the average number of single cells was high (about 75%). The relative number of chains increased according to depth and proximity to the mouth of the harbour. Results of the sediment sampling could explain the recurrence blooms of *A. catenella* (max. conc. 3480 cysts·cm^{-3} of wet surface sediment).

Results indicate that the *A. catenella* blooms in the Mediterranean Sea are small-scale phenomena, related to confined waters and originated by autochthonous seedbeds. Nevertheless, exportation of cells to open waters could cause widespread PSP events. For instance, during the same year an *A. catenella* bloom occurred in the Olbia harbour (Sardinia, Italy). Unexpectedly, at the end of the bloom, the highest densities were detected out of the harbour area (max. $4{\cdot}10^4$ cells·l^{-1}). This distribution could probably be due to cell exportation and accumulation. Comparative studies between the two affected sites (Tarragona and Olbia harbour) are carried out.

This study was performed within the frame of the EU project STRATEGY (EVK3-CT-2001-00046).



References

1 - Halim Y., 1960. *Alexandrium minutum*, nov. gen. nov. sp. dinoflagellé provocant des eaux rouges. *Vie Milieu*, 11: 102-105.

2 - Delgado M., Estrada M., Camp J., Fernández J.V., Santmartí M., and Lletí C., 1990. Development of a toxic *Alexandrium minutum* Halim (Dinophyceae) bloom in the harbour of Sant Carles de la Rápita (Ebro Delta, northwestern Mediterranean). *Scien. Mar.* 54(1): 1-7.

3 - Vila M., Camp J., Garcés E., Masó M., and Delgado M., 2001. High resolution spatio-temporal detection of potentially harmful dinoflagellates in confined waters of the NW Mediterranean. *J. Plankton Res.* 23(5): 497-514.

4 - Vila M., Garcés E., Masó M., and Camp J., 2001. Is the distribution of the toxic dinoflagellate *Alexandrium catenella* expanding along the NW Mediterranean coast? *Mar. Ecol. Prog. Ser.* 222: 73-83.

INITIAL PHASE OF THE INTRAOVARIAN SPERM STORAGE OF *HELICOLENUS DACTYLOPTERUS*

Sílvia Vila *, Maria Sàbat, Marta Muñoz and Margarida Casadevall

Àrea de Zoologia, Departament de Ciències Ambientals, Universitat de Girona, Campus Montilivi, Girona, Spain

* silvia.vila@udg.es, maria.sabat@udg.es, marta.munyoz@udg.es, margarida.casadevall@udg.es

Abstract

Sperm storage crypts located within the ovaries of *Helicolenus dactylopterus* were analysed during the first phase of this storage. Electron and optical microscope observations showed some degree of organization of the stored spermatozoa. Besides, desmosomic unions among cryptal cells denoted the isolation of spermatozoa inside the crypts and were probably related to the protection of these cells from the immune system of the female.The retainment of an important portion of cytoplasm by the spermatozoa at the beginning of the storage could be explained as an initial source of nutrients while there is not nutritional supply from the female.

Key words: Helicolenus dactylopterus, sperm storage, histology, ultrastructure

The bluemouth rockfish, *Helicolenus dactylopterus*, is a zygoparous oviparous species with internal fertilization. Females present specialized structures known as crypts where the spermatozoa are stored and mantained viable for periods up to 10 months, from April and May onwards. When spawning starts, between January and February, the spermatozoa stored in the crypts must be reactivated, with subsequent fertilization of mature eggs (1).

We found that *Helicolenus dacctylopterus* shows the most complex structures for sperm storage than those previously described in viviparous species within the same family (2-3). Thus, in this species spermatozoa remain grouped within differentiated structures instead of floating freely like in *Alcichthys alcicornis* (3) or singly adhered to the ovarian epithelium as found in viviparous species like *Sebastes taczanowskii* that retain spermatozoa adhered to the epithelium of the ovigerous lamella or wrapped in its microvilli. The prolonged time period during which spermatozoa must reside in the ovary may offer an explanation about the existence of these specialised storage crypts.

The aim of this paper is to analyze the structure and ultrastructure of these intraovarian crypts during the initial period of storage. From June onwards there is a marked increment of testicular activity (4), thus our work has been focused on two fresh samples caught in July (Palamós, Costa Brava, northwest Mediterranean), when the crypts are full of "new" spermatozoa.

In both cases several portions of the central ovarian area were analysed. Small pieces of ovary were fixed in glutaraldehyde (2.5%)-paraformaldehyde (2%) mixture in a 0.1 M cacodylate buffer.

Spermatozoa storage structures are located very near the muscular-connective rachis of the gonad, at the base of the interlamellar gaps (5). The cryptal epithelial cells present a nucleus with some strongly condensed heterochromatin, a lot of free ribosomes, vesicles and RER, and this is a clear evidence of important protein synthesis.

We also observed an enormous quantity of desmosomal unions among the cryptal cells (Fig. 1), forming thus a continuous cellular layer that surrounds the crypt cavity, probably related to the protection of the spermatozoa from the immune system of the female which stores them (3). Lining the epithelial cells there are some cells of different morphology, with a nucleus slightly extended and much more electrodense.

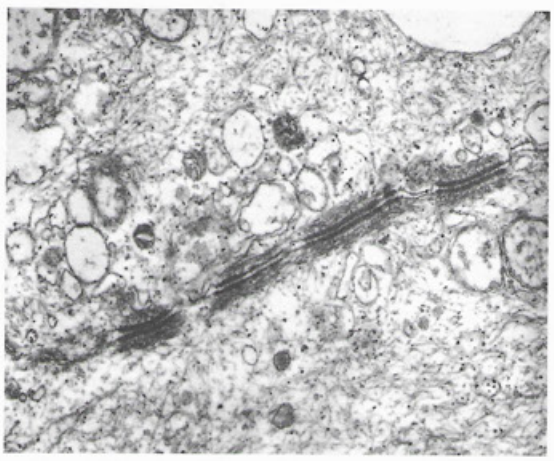


Fig. 1. Transmission electron micrograph showing desmosomal unions among cryptal epithelial cells.

Our observations through the optical microscope suggested some organization of the male gametes located in the crypts, a fact that later was corroborated by the transmission electronic microscope. We can clearly see that these organizations are not due to the existence of a separate membrane like the ones which surround spermatozeugmata.(6), but the spermatozoa are arranged in some kind of bundles seemingly independent one from one another.

An outstanding fact is that the spermatozoa remaining inside the crypts keep an important portion of cytoplasm (Fig. 2), in which we can observe many mitochondria, vacuola and tiny granules. A possible explanation could be that this cytoplasm represents an initial reserve of nutrients for spermatozoa at the beginning of the storage period, while later there would be evidence of a supply of nutritional substances from the female towards the male sexual cells, a fact that we aim to confirm in further studies.

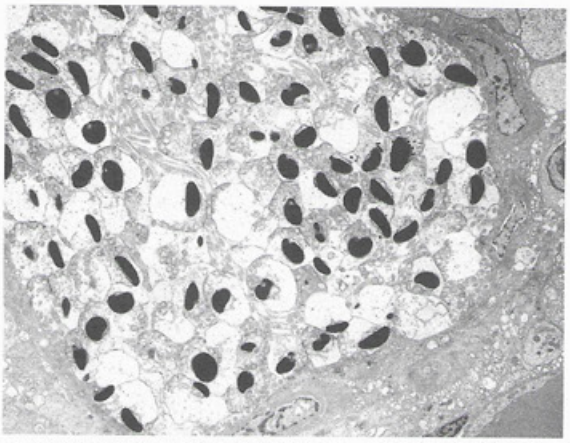


Fig. 2. Intraovarian sperm storage crypts. Electron microscopy view showing a sperm bundle surrounded by cryptal epithelial cells.

References

1 - Muñoz M., Casadevall M., Bonet S.,1999. Annual reproductive cycle of *Helicolenus dactylopterus dactylopterus* (Teleostei: Scorpaeniformes) with special reference to the ovaries sperm storage. *J. Mar. Biol. Ass. UK.* 79:521-529.

2 - Moser, H.G. 1967. Seasonal histological changes in the gonads of *Sebastodes paucispinis* Ayres, an ovoviviparous teleost (family Scorpaenidae). *J. Morphol.* 123: 329-354.

3 - Koya Y., Munehara H.,and Takano K., 1997. Sperm storage and degradation in the ovary of a marine copulating sculpin, *Alcichthys alcicornis* (Teleostei: Scorpaeniformes): role of intercellular junctions between inner ovarian epithelial cells. *J Morphol.* 233: 153-163.

4 - Muñoz, M. and M. Casadevall 2002. Reproductive indices and fecundity of *Helicolenus dactylopterus dactylopterus* (Teleostei: Scorpaenidae) in the Catalan Sea (western Mediterranean). *J. Mar. Biol. Ass. U.K.* 82: 995-1000.

5 - Muñoz M., Casadevall M., Bonet S.,and Quagio-Grassiotto I., 2000. Sperm storage structures in the ovary of *Helicolenus dactylopterus dactylopterus* (Teleostei: Scorpaeniformes): an ultrastructural study. *Environmental Biology of Fishes*. Kluwer Academic Publ., Netherlands. 58: 53-59.

6 - Downing, A. L. and J. R. Burns (1995). Testis morphology and spermatozeugma formation in three genera of viviparous halfbeaks: *Nomorhamphus, Dermogenys,* and *Hemirhamphodon* (Teleostei: Hemiramphidae). *Journal of Morphology*. 225: 329-343.

THE DIET OF *ASTROPECTEN IRREGULARIS PENTACHANTUS* (DELLE CHIAJE, 1825) FROM THE CENTRAL MEDITERRANEAN SEA

Alberto Villari [1], Paola Rinelli [2] and Daniela Giordano [2 *]

[1] Via Villa Contino, 30-98124 Messina, Italy
[2] IAMC-CNR, Section of Messina, Italy

Abstract

A study of stomach contents of *Astropecten irr. pentachantus* collected at depth of 160 m on the muddy-sandy bottom, in the southern Tyrrhenian Sea (Central Mediterranean), found that their diet was dominated by the gastropod *Eulimella acicula* (Philippi, 1836) and the bivalve *Corbula gibba* (Olivi,1792).

Key words: Mollusca, Asteroidea, Mediterranean Sea

Introduction

The feeding habits of the Asteroidea have been extensively studied (1-4), and it was noted that gastropods and bivalves form a major part of the diet of *Astropecten aranciacus* (5). We studied the malacofauna (6, 7) in the stomach contents of *Astropecten irr. pentachantus* collected in the southern Tyrrhenian Sea (Central Mediterranean).

The samples for this study, part of a MEDITS project funded by the European Community, were collected by trawl, in the Gulf of Patti (Sicily), in 1995, at depths between 50 and 100 m. To verify the bottom homogenity and the biocenosis bounderies, two sediment samples, were taken, using a Van Veen Grab, at the beginning and at the end of each haul. The biocenosis that characterized the study area were: Vases Terrigenes Cotieres (VTC), of the Fonds Detritiques du Large (DL) and that of the Vases Bathyales (VB).

Materials and methods

A total of 199 specimens of *Astropecten irregularis pentachantus* were collected from trawl fishery discards. The sampling stations were distributed by applying a stratified sampling scheme with a simple random pattern inside each stratum. The stratification parameter adopted was depth, with the following bathymetric limits: 10, 50, 100, 200, 500 and 800 m. The specimens were sorted, identified and preserved in a solution of hypochlorite of sodium (15%). The stomach contents of 60 specimens were analysed.

Tab. 1. Specimens found in the stomach of *Astropecten irregularis pentachantus*.

GASTEROPODS	number	%
Cerithidium submammillatum (De Rayneval & Ponzi, 1852)	21	7,72
Alvania testae (Aradas e Maggiore, 1844)	10	3,67
Obtusella macilenta (Monterosato, 1880)	8	2,94
Hyalea vitrea (Montagu, 1803)	3	1,1
Aporrhais serresianus (Michaud, 1828)	5	1,83
Turritella communis Risso, 1826	15	5,51
Mangelia costulata (Blainville, 1829)	1	0,33
Mangelia tenuicostata (Brugnone, 1868)	2	0,73
Bela brakistoma (Philippi, 1844)	19	6,98
Chrisallida obtusa (Brown,1827)	33	12,13
Odostomia conoidea (Brocchi, 1814)	15	5,51
Odostomia scalaris MacGillivray, 1843	1	0,36
Liostomia afzelii Warén, 1991	1	0,36
Eulimella acicula (Philippi, 1836)	48	17,64
Turbonilla acutissima Monterosato, 1884	26	9,55
Acteon semistriatus (Basterot, 1825)	3	1,1
Pyrunculus minutissimus (Monterosato, 1878 ex H. Martin)	1	0,36
BIVALVIA	number	%
Nuculoma tenuis (Montagu, 1808)	12	4,41
Bathyarca grenophia (Risso, 1826)	1	0,36
Acanthocardia aculeata (Linne, 1758)	6	2,2
Parvicardium minimum (Philippi, 1836)	5	1,83
Corbula gibba (Olivi, 1792)	35	12,86
Kelliella abissicola (Forbes, 1844)	1	0,36

Results and discussion

The list of prey species found in the stomach contents of the *A. irr. pentachantus* is shown in the table 1. A total of 270 specimens of molluscs were identified with 17 species of gastropods (210 specimens), and 6 species of bivalves (60 specimens).

It is interesting that two specimens of *Acteon semistriatus* (Basterot, 1825) were collected, as the species was only recently reported in Sicilian waters (8). Although the biology of the Pyramidellidae was studied extensively, and it is known that some species are parasitic on echinoderms and molluscs, their trophic ralations are still little known.

Chrysallida obtusa [= intersticta] is an ectoparasite of oysters (9), although occasionally found where oysters are normally absent, indicating it might parasitize other hosts (10). In the past *C. Obtusa* were considered rare, while in this case the percentage is high.

The dominant prey items recorded from *A. irr. pentachantus* in this study were the gastropods *Eulimella acicula, Chrisallida obtusa* and *Turbonilla acutissima*, and the bivalve *Corbula gibba.*

Eulimella acicula is widely distributed in the Mediterranean, to depth of 400 m and is frequently found in stomach contents of *A. irregularis*. However, the presence of *Corbula gibba* may indicate environmental instability (11).

References

1 - Tortonese E.,1949. Distribution bathimétrique des Echinodermes et particulièrement des espèces méditerranéennes. *Bull. Ist. Ocean.* Monaco, *47* (956), 16 p.
2 - Tortonese E., 1965. Echinodermata Fauna d'Italia. Edizioni Calderini. 6. Bologna.
3 - Aege C.M., 1970. Feeding Biology of the Sea Star *Astropecten irregularis* Pennant. *Ophelia,* 8: 1-134.
4 - Lawrence J., 1987. A functional biology of Echinoderms. Peter Calow eds. 340 p.
5 - Llabres Fiol R., Mediano Gil I., 1980. Estudio del contenido gastrico de la estrella de arena (*Astropecten aranciacus* L.) en la bahia de Alcudia (Mallorca). Com. Prim. Congr. Nac Malac., 67-74. Madrid
6 - Di Geronimo I., 1974. Molluschi bentonici in sedimenti recenti batiali e abissali dello Ionio. *Conchiglie,10* (7- 8):133-172.
7 - Di Geronimo I., and Panetta P., 1973. La malacofauna batiale del golfo di Taranto. *Conchiglie, 9* (5-6) 69-122,3 tav.
8 - Palazzi S., and Villari A., 2000. Molluschi e Brachiopodi delle grotte sottomarine del taorminese. *La Conchiglia Annuario 2000,* pp 1-56.
9 - Cole H.A., and Hancock D A., 1955. *Odostomia* as a pest of oysters and mussels. *J. Mar. Biol. Assoc. U.K.*, 34: 25-31.
10 - Rasmusen E., 1973. Systematics and ecology of the Isefjord marine fauna (Denmark). *Ophelia*, 11: 1-495.
11 - Di Geronimo I., Robba E. 1987. The structure of benthic communities in relation to basin stability. The lithosphere in Italy, Advances in Earth Science Research. *Acc. Naz. Lincei*, 277-284.

ON THE BIOLOGY OF ADRIATIC SOLE, *SOLEA IMPAR* BENNET, 1831 (PISCES; SOLEIDAE), OFF THE SW COAST OF SICILY

S. Vitale *, L. Cannizzaro, G. Bono, A.M. Beltrano, P. Rizzo, A. Milazzo

Istituto di ricerche sulle Risorse Marine e l'Ambiente, IRMA-CNR, sez. dell'Istituto per l'Ambiente Marino Costiero (IAMC), Mazara del Vallo (TP), Italy - servit00@hotmail.com

Abstract

The age and growth, weight-length relationship and sexual maturity of Adriatic sole, *Solea impar* Bennett, 1831 were studied for 283 specimens caught in 2002 off the south-west coast of Sicily. Age was determined from reading 230 otoliths. The growth parameters estimated by sex were: L_∞= 234.62 mm, K= 0.29 yr^{-1}, t_0=-2.39 yr for females and L_∞= 223.81 mm, K= 0.25 yr^{-1}, t_0=-3.14 yr for males. The parameters of the weight-length relationship were: a= $2*10^{-6}$, b=3.269 and a=$8*10^{-6}$, b=3.011 ($W=aL^b$) for females and males, respectively.

Key-words: Solea impar, age, growth, sexual maturity, Sicily

Introduction

The Adriatic sole, *Solea impar* Bennett, 1831 is a target species of the Sicilian artisanal fishery. It inhabits sandy and muddy bottoms at a depth of 30-100 m (1). Data on its biology are scarce (2-3). This study provides data on the age, growth, length-weight relationship and maturity of the Adriatic sole off the SW coast of Sicily.

Materials and methods

A sample of 283 specimens was collected from the landings in the port of Selinunte (SW coast of Sicily), during 2002. All specimens were measured to half cm below and weighted to the nearest g. Otoliths were viewed through a binocular microscope under reflected light. They were read by two readers three times, results were compared and questionable readings discarded. A total of 230 pairs of otoliths were read. The Von Bertalanffy equation (4) was used to calculate growth parameters using the least square method. Moreover, the parameters of the weight-length relationship ($W=aL^b$) were estimated. For each fish, gonads were weighed and a macroscopic scale was used (5) to distinguish the maturity stages. The gonadosomatic index (GSI=100 X (gonad weight/somatic weight) was calculated.

Results and discussion

Although the landings of the artisanal fishery were monitored all year round, the Adriatic sole was caught only from March to July. The length frequency distribution showed that total length (TL) ranged between 132 and 223 mm, with females being larger than males ($\overline{TL}_{females}$=174 mm, SE=1.57; $\overline{TL}_{males}$=159 mm, SE=1.18). The result of Kolmogorov-Smirnov test showed significant differences in the length distribution between males and females, $D^*_{(0.01)}$=0.22<D=0.45. As showed elsewhere (6), the weight-length relationship indicated a positive allometric growth for both sexes: $W=2X10^{-6}TL^{3.269}$ (R^2=0.92) and $W=8X10^{-6}TL^{3,011}$ (R^2=0.86) for females and males, respectively. The growth parameters were L_∞= 223.81 mm, K= 0.25 yr^{-1}, t_0=-3.14 yr (R^2=0.81) for males and L_∞= 234.62 mm, K= 0.29 yr^{-1}, t_0=-2.39 yr (R^2=0.90) for females. All specimens caught were at the maximum maturity stage (IV) and GSI values followed a similar pattern for both sexes being higher in April-June ($\overline{GSI}_{march}$=3.12 SE=0.53; $\overline{GSI}_{april}$=4.46 SE= 0.54; $\overline{GSI}_{may}$=4.39 SE=0.35; $\overline{GSI}_{june}$=4.04 SE=0.46; $\overline{GSI}_{july}$=1.11 SE=3.46). This indicates a prolonged spawning season, as also shown in other studies (7).

The growth parameters of Adriatic sole in the south-west coast of Sicily were smaller than those estimated off the west coast of Brittany (8). Such a difference could be directly or indirectly related to the environmental conditions as well as fishing intensity in the two areas. It must be pointed out that juveniles (0 age group) were not caught in the waters off SW Sicily.

The results of our investigation on the biology of Adriatic sole, the lack of juveniles in our sample and of catches in cold seasons, allow to formulate the following hypotheses: (a) the sandy bottoms with a depth of 5-20 m, where the artisanal fishery works, are the spawning area for Adriatic sole; (b) The return in the shallow water of the mature Adriatic sole at the beginning of the spawning period, shows that inshore movement exists.

References

1 - Quéro J.C., Desoutter M., Lagardére F., 1986. Soleidae. 3. Pp. 1319. *In*: Whitehead P.J.P., Bauchot M.L., Hureau J.C. Nielsen J. Tortonese E. (eds.), Fishes of the North-Eastern Atlantic and Metiderranean. Unesco, Paris.

2 - Sorbe J.C., 1973. Ecologie et éthologie alimentaire de l'ichthyofaune chalutable du plateau continental sud Gascogne. 125. Thèse Univ. Aix-Marseille. 125 p.

3 - Alayse J. P., and Deniel C., 1986. Comparaison du complexe des soles-poles de Bretagne (*Solea lascaris* et *S. impar*) avec *S. impar* du golfe du Lion : polymorphisme enzymatique et scalimétrie. *Océanis*, 12: 345-356.

4 - Sparre P., Ursin E., Venema S.C., 1989. Estimation of growth parameters. Pp. 57-77. *In*: Introduction to tropical fish stock assessment. Fao Fish. Tech. Pap., 306/1, Rome.

5 - Holden M.J., and Raitt D.F.S., 1974. Part 2. Methods of recourse investigation and their application. Pp. 127-135. *In*: Manual of fisheries science. Fao Fish. Tech. Pap., 115, (Revision 1), Rome.

6 - Abd El Missih S., 1984. Contribution à la connaissance des Soléidés (Poissons Téléostéens) du Golfe du Lion. Systématique, écobiologie. Thèse Univ. Montpellier. 311 p.

7 - Deniel C., 1989. Comparative study of sexual cycles, oogenesis and spawning of two Soleidae, *Solea lascaris* (Risso, 1810) and *Solea impar* (Bennet,1831), on the western coast of Brittany. *J. Fish Biol.*, 35: 49-58.

8 - Deniel C., 1990. Comparative study of growth of flatfishes on the west coast of Brittany. *J. Fish Biol.*, 37: 149-166.

ZOOPLANKTON STUDIES IN THE BOKA KOTORSKA BAY DURING 2002 - CHAETOGNATHA

Vera Vukanić *and Dušan Vukanić
Institute of marine biology, Laboratory of Zooplankton Ecology, Kotor, Serbia and Monenegro
* vukanic@cg.yu, v_vukanic@yahoo.com

Abstract

During 2002 a systematical ecological research of zooplankton was carried out in Boka Kotorska Bay in monthly intervals, including measurements of basic parameters (T°C, Sal‰, pH, O_2, transparency by Secchi plate, color of the sea with Forel scale I–XXI). Special attention was paid to biodiversity, dynamic, abundance and distribution of the zooplankton. In this paper we present the hydrographic data of Boka Kotorska Bay, together with data on the presence, abundance and distribution of the eight species of the chaetognatha genus *Sagitta* found there: *S. minima, S. enflata, S. setoza, S. friderici, S. lyra, S. serratodentata, S. hexaptera* and *S. bipunctata.*

Key words: Boka Kotorska, hydrography, abundance, Chaetognatha

Introduction

The Boka Kotorska Bay is under a strong influence of freshwater influx, as well as pronounced oscillations of hydrographic factors. The chaetognatha of Boka Kotorska Bay are barely known, based on a short-duration study (January to May) in the inner part of the Bay of Kotor [1]. Four species of the genus *Sagitta* were found: *S. enflata, S. setoza, S. serratodentata, S. minima*, and numerous juvenile stages in March. During 2002, monthly measurements of hydrographic parameters were conducted, and zooplankton samples collected. This paper deals with the data concerning the presence and distribution of the chaetognatha genus *Sagitta*.

Material and methods

Our observations were based on the analysis of zooplankton samples collected monthly during 2002, in three shallow stations near the sea farming areas (P–M, P–O and P–IBM), and 4 stations in the middle of each small bay within Boka Kotorska (P–1, P–2, P–3, P–4 or Kotor, Risan, Tivat and Hercegnovi bays, respectively) (Fig. 1). Zooplankton was collected with Nansen net (100 and 150 microns). Contemporaneously we measured T°C, Sal‰, pH, O_2, transparency by Secchi plate, color of the sea with Forel scale I–XXI. The presence and abundance of Chaetognatha was analyzed in all samples.



Fig 1. Research plan of stations in Boka Kotorska Bay.

Results and discussion

Temperature - Maximum temperature on the surface of the seawater was 27.7% in July, minimum 8.2% in February.

Salinity - The salinity in the shallow sea near the Institute (P-IBM) in September amounted to 2,30%, the lowest value ever recorded in the Bay. At that time the sea was at Forel VI, and the whole Gulf was of light yellow-green color. Due to abundant rains throughout 2002, intensive inflow of fresh waters was recorded. Maximum salinity in July was (P_1-K) 37.90% and 38.11% (P_4-HN). Oxygen saturation was from 80% to 141%, Ph from 7.94 to 8.4, and transparency from 6 to 10m according to Secchi.

Boka Kotorska Bay has all characteristics of closed coastal waters of the East Adriatic. Zooplankton is mainly characterized by euritherm and eurihaline species, as well as open-sea species that enter into the Bay from the deep waters of the southern Adriatic and soon die.

In the course of the analyses of the representative samples and examination of complete samples, we identified eight species: *S. minima, S. enflata, S. setoza, S. friderici, S. lyra, S. serratodentata, S. hexaptera, S. bipunctata*, and many juvenile forms whose number increased from the inner waters of the Boka Kotorska Bay towards the open sea. At the Station P_4-HN in the total population Chaetognatha reached 96,6%.

S. friderici, S.lyra, S. hexaptera and *S. bipunctata* are recorded in the Boka Kotorska Bay for the first time. They were found in a small number by the end of the summer, and again in the autumn. We found a great number of *S. friderici* at P_1-K in August (4300 No.-ind/m^2), and a smaller number in September, but none in other months.

Table 1. Average value of abundance of *Chaetognatha* in the stations in the Boka Kotorska Bay during 2002.

STAT.	P_1-K		P_2-R		P_3-T		P_4-HN	
PROF.	30-0m		30-0m		30-0m		30-0m	
SPECIES	No.ind/m^2	%	No.ind/m^2	%	No.ind/m^2	%	No.ind/m^2	%
Sagitta minima	58	4,3	75	8,7	25	2,2	25	1,3
Sagitta enflata	8	0,6	17	2	r		r	
Sagitta setoza	183	13,7	100	11,6	100	8,6	33	1,7
Sagitta friderici	375	28	-		8	0,7	r	
Sagitta lyra	50	37,3	r		41	3,5	8	0,4
Sagitta serratodentata	r		-		r		-	
Sagitta hexaptera	33	2,5	r		8	0,7	-	
Sagitta bipunctata	r		r		-		-	
Chaetogn. juv.sp.	633	47,2	667	77,7	975	84,2	1867	96,6
TOTAL	1340		859		1157		1933	

References

1 - Benović, A. and V. Onofri, 1983. Contribution to the knowledge of net-zooplankton of the Bay of Kotor. *Studia Marina,* 13-14: 119-125.
2 - Furnestin, M.L., 1957. Chaetognathes et Zooplancton du secuteur Atlantique Marocain. Rev. Trav. Inst. Pêche marit. Paris, 21, 1 et 2, 366 p.
3 - Gamulin,T. et E.Ghirardelli, 1983. Les Chaetognathes de la mer Adriatique. *Rapp. Comm. int. Mer Médit.,* 28 : 9.

ZOOPLANKTON COMMUNITY STRUCTURE AND DISTRIBUTION IN THE BAY OF VILLEFRANCHE-SUR-MER USING THE ZOOSCAN DIGITAL IMAGING SYSTEM

Caroline Warembourg *, Lars Stemmann, Stéphane Gasparini, Laure Mousseau, Frédéric Ibanez, Gabriel Gorsky

Observatoire Océanologique, LOV - UMR 7093, Station Zoologique, Villefranche-sur-Mer, France

* waremb@obs-vlfr.fr, stemmann@obs-vlfr.fr, gasparini@obs-vlfr.fr, mousseau@obs-vlfr.fr, ibanez@obs-vlfr.fr, gorsky@obs-vlfr.fr

Abstract

The mesozooplankton (>200 µm) abundances and biomass spectra were studied in a 8-years time-series in the coastal zone of the North Ligurian Sea using a new image analysis system. Preliminary results show a clear seasonal cycle of both abundance and biomass structure of the zooplankton community. These are related to changes in zooplankton biodiversity and phytoplankton biomass.

Keywords : zooplankton, biomass spectrum, image analysis

Zooplankton plays a central role in aquatic ecosystems relative to phytoplankton and higher trophic levels (1). It is a biological indicator of environmental changes (2) or human impacts on marine systems. Within the french program SOMLIT, we have followed the temporal variability of coastal mesozooplankton with environmental changes in a 8-years time-series. Weekly samples of zooplankton collected by a WPII net (200 µm of mesh size) between 1995 and 2003 in the bay of Villefranche-sur-Mer (North-western Mediterranean) were analysed by the ZOOSCAN. This new system is a low-cost imaging device which allows rapid, exhaustive and non-destructive enumeration and measurements of mesozooplankton and micronekton (3). It permits to describe the biodiversity and size of the zooplankton community by measuring 38 morphometric attributes for each individual with an automated identification. In our study, slopes of the biomass spectra (4) are calculated for the mesozooplankton community (450 to 1550 µm in Equivalent Spherical Diameter) on 273 samples (more than 300 000 individuals measured).

The zooplankton abundance shows a seasonal cycle over the eight years (Fig. 1). Abundances are higher in winter-spring period (500-7000 ind.m^{-3}) than during the summer-autumn period (35-2500 ind.m^{-3}). The results show a high inter-annual variability with the highest abundances between 1999 and 2001. The zooplankton seasonal cycle generally follows the chlorophyll *a* cycle. The slope of the biomass spectrum provides an informative measure of the structure of the plankton community. The temporal distribution of the calculated slopes (Fig. 2) also exhibits a seasonal pattern : 1) a steep spectrum characterized by a high negative slope (in winter and spring) indicates the dominance of organisms with a low biomass, 2) a flat spectrum with a less negative slope (in summer and fall) implies a higher proportion of larger organisms. During the year 2002, the Shannon diversity index (calculated only on the abundance of copepods manually identificated) shows that copepods' biodiversity was lower in winter-spring during the phytoplankton bloom than during the rest of the year (Fig. 3). This suggests a relationship between the biomass structure and the biodiversity. In November 2002, the spatial structure of the zooplankton community was also analysed on a transect from the South French coast to the central Ligurian Sea. The slopes of the biomass spectra are steeper in the open sea than in the coastal area. At that time of the year, chlorophyll *a* concentrations are higher in the open sea as a result of well established upwelling (5).

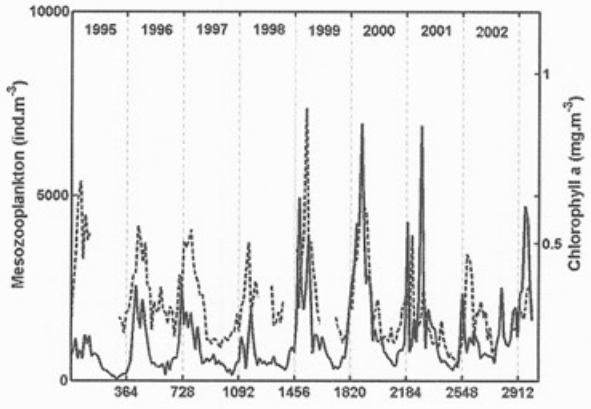


Fig. 1. Temporal distributions of the biweekly mesozooplankton abundance (continuous line) and chlorophyll *a* (dashed line).

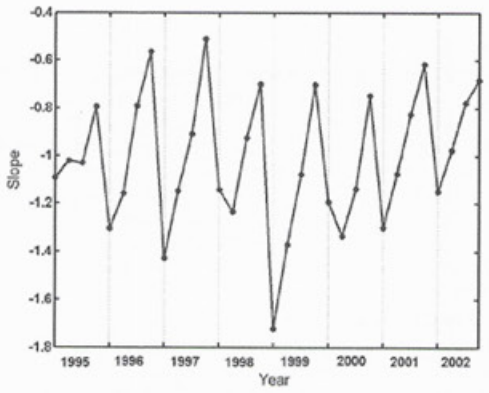


Fig. 2. Temporal distribution of biomass spectra slope from 1995-2002.

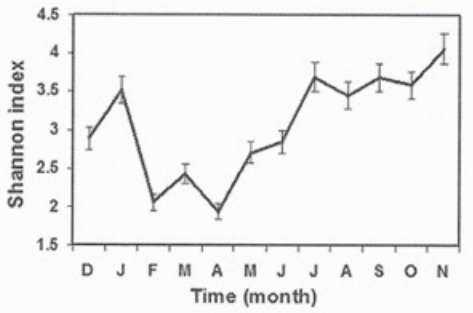


Fig. 3. Monthly variation of the copepods Shannon index during the year 2002.

These preliminary results obtained by the ZOOSCAN reveal some temporal and spatial patterns of the zooplankton community structure which can be associated with changes in zooplankton diversity and phytoplankton biomass. The next step will be the taxonomic identification of all organisms by the ZOOSCAN, in order (1) to evaluate the link between biodiversity and biomass spectra, (2) to describe the relationship between zooplankton (biodiversity and biomass) and environmental factors (phytoplankton, nutrients, detritic particles, temperature, salinity).

References

1 - Banse K., 1995. Zooplankton: pivotal role in the control of ocean production. *ICES J. Mar. Sci.*, 52: 265-277.

2 - Beaugrand G., Reid P.C., Ibanez F., Lindley J.A., and Edwards M., 2002. Reorganization of North Atlantic marine copepod biodiversity and climate. *Science*, 296: 1692-1194.

3 - Grosjean P., Picheral M., Warembourg C., and Gorsky G., *accepted.* Enumeration, measurement and identification of net zooplankton samples using the ZOOSCAN digital imaging system. *ICES J. Mar. Sci.*

4 - Platt T., and Denman K., 1977. Organization in the pelagic ecosystem. *Helgol. Meeresunters.*, 30: 575-581.

5 - Sournia A., Brylinski J.-M., Dallot S., Le Corre P., Leveau M., Prieur L., and Froget C., 1990. Fronts hydrologiques au large des côtes françaises : Les sites ateliers du programme Frontal. *Oceanol. Acta.*, 13(4) : 413-438.

REPRODUCTIVE BIOLOGY OF *DIPLODUS VULGARIS* IN EGYPTIAN WATERS

Magda. I. Zaki *, M.Abdallah, F. Abou-Zaid and S. Salem

* National Institute of Oceanography and Fisheries, Kaet Bay, Alexandria, Egypt - * DrMagdaZaki@ hotmail.com

Abstract

The monthly distribution of the different sexual maturity stages for *Diplodus vulgaris* and gonado somatic index indicated that the spawning season extended from November to February with a peak in December. The analysis of egg diameter distribution during the spawning season indicated that this *species* characterized by a prolonged rather than a fractional spawning. The absolute fecundity ranged from 16,552 to 79,807 eggs for mean total length ranging between 15.5 and 20.4 cm

Key words: Diplodus vulgaris ; Reproductive Biology; Sparidae

Introduction

It is well known that the gonads in fish show a seasonal variation which however might vary from one species to another, as well as within the same species in different geographic localities in response to environmental factors which affect the physiological activity of the fish(1). This study presents data on maturity stages, length at first maturity, gonado somatic index, egg diameter, and fecundity of *Diplodus vulgaris* collected off the Egyptian coast of the Mediterranean Sea.

Material and methods

Diplodus vulgaris were collected monthly from Kayed Bay, Alexandria, Egypt. The total length (TL), gutted weight (W) and gonad weight (GW) to nearest mg, sex and maturity stages were recorded (2). Length at first sexual maturity is the length at which 50% of the fish reached sexual maturity. Gonadosomatic index (GSI) is calculated as the percentage of the gonad weight to the gutted weight. Egg diameter was measured. Estimation of fecundity was based on counting the mature yolked and ripe eggs in the ripe ovaries during the spawning season. The absolute and relative fecundity was calculated (3).

Result and discussion

Monthly distribution of maturity stages: Immature fish were found throughout the year, with their highest proportions between February and June (63.64% for females and 44.44% - for males). Between August and July, however, most of the fish matured (86.67% of females and 66.67% of males)

In October, fish from the nearly ripe stage represented by 11.76 % for females and 15.38% for males then increased to a peak (29.41% for females and 30.77% for males) in November and decreased at the end of December. Spawning fish were detected during November to February. The spent stage was detected form February to May for females and from February to April.

Fish with immature gonads were regarded as immature, and those with maturation, nearly ripe, spawning and spent stage gonads were considered as mature individuals. Females of TL < 14 cm and males of TL<13 cm were immature. Larger fish showed an increase in the frequency of mature specimens, and all females and males larger than 17.9 cm were fully mature with no significant difference (4).

The GSI started to increase in November (1.56 and 1.54 for females and males, respectively) and reached a maximum in December (5.63 and 2.21 for females and males, respectively) (Fig. 1). The female GSI was higher than that of males; but both displayed nearly the same cyclic trend during the period of study. These results indicated that the spawning season extended from November to February with a peak in December.

The ripe female had three batches of ova. The first one included eggs with a diameter ranging from 0.1 to 0.4 mm. These were immature eggs found in all the examined ovaries during the spawning season. The second batch included the mature; yolky; eggs with a diameter ranging from 0.4 to 0.8 mm. Finally the third batch included the ripe ovulated eggs of diameters ranging from 0.8 to 1.26 mm.

The ovaries sampled at the end of November with a GSI of 2.86 showed that the immature; mature egg ratio 1.9:1. The ovaries at the beginning of December (GSI=5.00) had immature eggs representing 20% and mature eggs representing 80% of the total number of eggs. At the end of December the GSI increased to maximum value, 11.67, with the three batches of eggs; representing 17.2%, 42.6% and 40.2% of the total number of eggs, respectively.

In January, GSI decreased to 3.49. The ovaries had immature eggs. During February the GSI decreased to 3.57. In early March the ovaries were at the spent stage (containing only immature eggs).

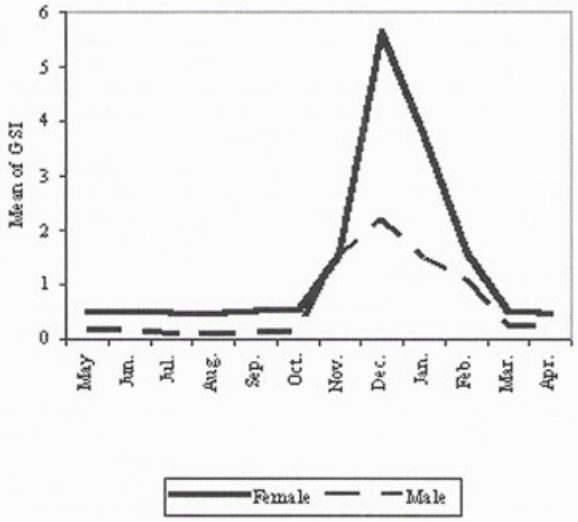


Fig. 1. Monthly variation in the gonadosomatic index (GSI) of male and female *Diplodus vulgaris*.

The absolute Fecundity (F_a) - total length (TL) relationship was:
Log F_a= -1.05838256 + 4.561628117 log TL (n=55, p< 0.05).

The number of eggs produced during spawning season (F_a) increased from 16552 to 79807 eggs with a change in TL from 14.5 to 20.4 cm.

The relative fecundity (F_r) in relation to TL, the following equation is derived:
Log F_r = - 1.05749653 + 3.560942817 logTL (n=55, p<0.05)
F_r ranged from 877 to 3873 eggs/cm.

The absolute fecundity (F_a)-gutted weight (wt) relationship was:
F_a = - 16136.996 + 791.5738694 wt (n=55, p<0.05)
43.2% and mature eggs constituting 56.8% of the total number of eggs.
eggs / fish with an increase in average gutted weight from 45.4 to 122.9 (g).
F_r in relation to wt was:
F_r = 352.2987 + 2.7004 wt (n=55, p<0.05)
The mean F_r rose from 449 to 649 eggs/gm wt.

References

1 - Nikolsky G.V. 1965. Theory of fish population, *Academy of Science. USSA*.

2 - Zaki M.I. and Hamza A.K. 1986. Reproductive biology and induced spawning of solea (L) in Egypt. *Bull. Nat. Inst. of ocean and fish ARE*, 12: 115-125.

3 - Tarnavsky N.P. 1965. Fecundity of *Vimbor vimbanation* carnala (pallas) from the Dniepervoper, *J. Ichth.* 1(34): 91-95.

4 - El-Maghraby A.M., Botros G.A., Hashem M.T. and Wassef E.A. 1982. Maturation, spawning and fecundity of two Sparid fish *Diplodus sargus*, (L.) and *Diplodus Vulgaris*, (Geoff.) In the Egyptian Mediterranean water. *Bull. Inst. Oceanog. & Fish. ARE*, 8(2): 51-67.

BIOMETRIC ANALYSIS OF GILT SARDINE, *SARDINELLA AURITA* VALENCIENNES, 1847, IN THE EASTERN ADRIATIC SEA

Barbara Zorica*, Gorenka Sinovčić, Marijana Franičević and Vanja Čikeš Keč
Institute of Oceanography and Fisheries, Split, Croatia - * zorica@izor.hr

Abstract
Biometrical characters of gilt sardine, *Sardinella aurita,* were analysed using random samples from the eastern part of the Adriatic Sea from October 2000 to February 2002. The total length of 769 specimens ranged between 8.0 and 28.4 cm. The length-weight relationship was $W=0.0034TL^{3.214}$, and positive allometry was established.

Keywords: Biometry, Sardinella aurita, Adriatic Sea

Introduction

This study presents the results of a two-year investigation (October 2000 – February 2002) of the gilt sardine, *Sardinella aurita* Valenciennes, 1847, which is distributed in the Atlantic Ocean, the Mediterranean Sea and the Black Sea. Some aspects of its biology in the Adriatic Sea have been described before (1, 2, 3).

The objective of this paper was to examine the morphometric and meristic characters of gilt sardine from the eastern part of the Adriatic Sea and compare those with the ones from the western part of the Adriatic.

Materials and methods

All samples were taken from the purse seine and beach seine catches from October 2000 to February 2002, which were realised in the Novigrad Sea (44° 15'N; 15° 30'E), Kaštela Bay (43° 35'N; 16° 25'E) and off Šolta island (43° 15'N; 16° 15'E).

Overall, 219 specimens were analysed. All sixteen lengths were measured (nearest mm total length, *TL*) and weights were recorded (nearest 0.01 g wet weight). Twelve morphometric characters were expressed as % of *TL* and three characters as % of head length (*HL*). Five meristic characters were also measured. Length-length relationships were established using linear regression analysis. The length-weight relationship was described using $W= aTL^b$ (4). The hypothesis of isometric growth was tested with *t*-test. Condition was determined using Fulton's condition factor (*K*).

F-test ($P<0.05$) was used to test for significant differences between the mean values of the different morphometric characters between eastern and western Adriatic Sea.

Results and discussion

TL ranged from 8.0 to 28.4 cm (mean = 13.8 ± 3.749 cm), exhibiting modal lengths between 12.0 and 13.5 cm. The values of all characters examined are presented in Table 1. We compared our results with those obtained from the western Adriatic Sea (5). The comparison of morphometric and meristic characters between these two parts showed no statistical difference (F-test, $P>0.05$) (Fig.1). Therefore we can assume that these two populations originated from the same stock although further investigations are necessary.

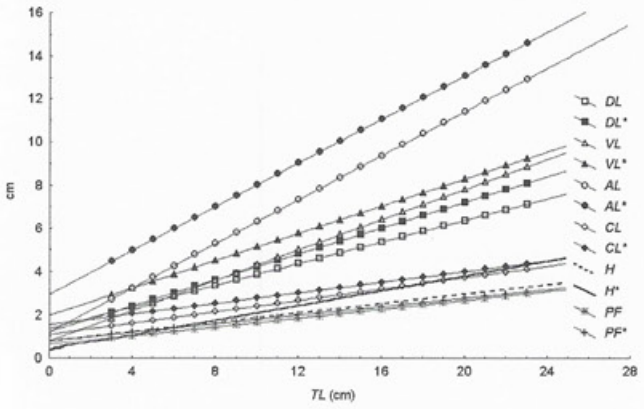


Fig. 1. Length-length relationships of *Sardinella aurita* from the catch samples realised in the eastern and the western (*) part of the Adriatic Sea.

The length-weight relationship in the Middle Adriatic was $W=0.0034TL^{3.214}$ (n=769, $r^2=0.9546$, $P<0.001$, SE(b)=0.0124). The value of $b=3.214$ was significantly ($P>0.05$) different from 3.0, indicating positive allometry.

Fulton's condition factors ranged between 0.304 and 0.759 (mean=0.693±0.0927).

Table 1. Morphological and meristic characters of *Sardinella aurita* (n=219) from the eastern Adriatic Sea, 2000 –2002.

Morphological characters		Range (cm)	Mean±*SD*
Total length (*TL*)		11.3-15.0	12.4±0.482
	% *TL*		
Standard length (*SL*)		78.91-86.07	82.88±0.704
Distance of dorsal fin (*LD*)		32.28-39.83	36.00±1.178
Distance of anal fin (*LA*)		53.68-65.55	60.74±1.174
Distance of pelvic fin (*LV*)		34.40-45.08	41.42±1.005
Distance of pectoral fin (*LP*)		15.52-22.03	19.77±0.887
Head length (*HL*)		17.36-23.93	21.95±0.835
Maximum body height (*H*)		15.52-23.28	18.26±1.058
Minimum body height (*h*)		6.03-8.62	6.99±0.516
Length of dorsal fin basis (*DF*)		10.34-14.66	12.25±0.677
Length of pectoral fin (*PF*)		14.66-18.97	16.22±0.740
Length of anal fin basis (*AF*)		10.34-14.66	12.36±0.659
Length of ventral fin (*VF*)		7.76-10.34	9.32±0.522
	% *HL*		
Pre-orbital length (*Se*)		30.77-38.46	36.20±2.164
Eye diameter (*Ee*)		23.08-30.77	27.33±1.58
Post-orbital length (*Po*)		38.46-50.00	42.00±2.467
Merisitic characters			
Number of rays in dorsal fin (*D*)		15-17	16.28±0.592
Number of rays in anal fin (*A*)		12-16	13.88±0.792
Number of rays in ventral fin (*V*)		7-9	8.87±0.378
Number of rays in pectoral fin (*P*)		13-17	15.02±0.667
Number of vertebrae (*Vert.*)		46-48	47.00±0.408

References

1 - 1. Kačić I., 1976. On the occurrence of young *Sardinella aurita* in the Adriatic Sea. *Rapp. Comm. int. Mer Médit.*, 23: 35-36.
2 - Gamulin T. and Hure J., 1983. Mriješćenje i mrijestilišta pelagičnih riba u Jadranskom moru (The spawning and spawning areas of pelagic fishes in the Adriatic Sea). *Acta Adriat.*, 24(1/2): 55-95 (In Croatian, English summary).
3 - 3. Sinovčić G., Franičević M. and Čikeš Keč V., 2003. Unusual occurrence and some aspects of biology of juvenile gilt sardine (*Sardinella aurita* Valenciennes, 1847) in the Zrmanja River estuary (eastern Adriatic). *J. Appl. Ichthyol.*, 19 (in press).
4 - Ricker W. E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. *Bull. Fish. Res. Board Can.*, 191: 382.
5 - Latini E. and Pettorossi L., 1977. Osservazioni sui caratteri biometrici e meristici di *Sardinella aurita* Valencienne nell'alto Adriatico (Pisces, Clupeidae). *Quad. Lab. Tecnol. Pesca.*, 2(3):143-151.

LES COPÉPODES DU GOLFE DE GABÈS (TUNISIE) : RÉSULTATS D' UNE CAMPAGNE ESTIVALE

Zouari Leila [1] *, Ayadi Habib [1], Hamza Asma [2], Bouaïn Abderrahmen [1]

[1] Laboratoire de Planctonologie, Unité de recherche 00/UR/0907 Ecobiologie et Ecophysiologie animales.
Département des sciences de la vie, Faculté des Sciences de Sfax, Tunisie - * Leila@tunet.tn, Habib.Ayadi@fss.rnu.tn
[2] Institut National des Sciences et Technologie de la Mer, Sfax, Tunisie

Résumé

Le Golfe de Gabès situé sur la façade Sud-Est de la Tunisie fait l'objet de nombreuses explorations scientifiques depuis le début du siècle vu sa richesse halieutique, pétrolière ainsi que pour ses grandes variabilités écologiques. Dans le présent travail, nous avons essayé de regrouper toutes nos observations taxonomiques et écologiques relatives aux zooplanctons marins du Golfe de Gabès à partir d'une compagne réalisée en été 2002 sur des zones côtières.

Mots clé : Golfe de Gabès; Zooplancton

Introduction

Le Golfe de Gabès est caractérisé par un climat pré-saharien ; les eaux sont le siège de fortes marées semi-diurnes qui peuvent atteindre 2m à Gabès. Il possède d'abondantes ressources halieutiques, surtout d'espèces à valeur commerciale importante (1)

De par sa géomorphologie particulière, le golfe de Gabès présente une étiquette zoo biologique spéciale présentant les caractéristiques d'un milieu fermé plutôt que celui d'une mer ouverte; cet écosystème est considéré en Méditerranée parmi les mers eutrophes de large production primaire (1). La connaissance du zooplancton dans la compréhension globale du fonctionnement des écosystèmes marins revêt une importance capitale. Cependant, les études relatives à la faune planctonique font presque défaut et sont très souvent sporadiques dans le golfe de Gabès, d'où l'intérêt de ce travail. Cette étude nous a permis de reconnaître la richesse spécifique au niveau des différents sites et de suivre les fluctuations spatiales des différents groupes zooplanctoniques fréquentant le golfe et particulièrement le groupe des copépodes.

Matériel et méthodes

Dix neuf stations côtières de prélèvement du golfe de Gabès ont été choisies (Fig. 1). Il s'agit d'une campagne estivale au cours de l'année 2002. L' échantillonnage a été réalisé à l'aide d'un filet à plancton par traits horizontaux, à une vitesse de 2 nœuds pendant 5 minutes avec un filet à plancton standard de 19cm de diamètre et 64cm de long et ayant un vide de maille de 75µm.

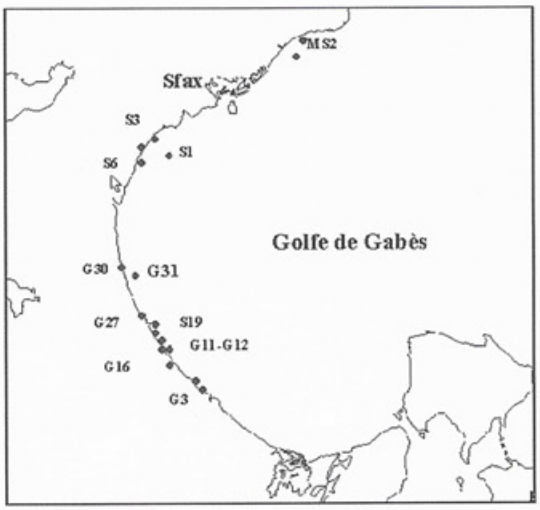


Fig. 1. Localisation des stations de prélèvement dans le golfe de Gabès.

Le volume d'eau filtré V est : **V=v*t*S** ; avec **v**=vitesse du trait **;t**=durée du trait **;S**=surface d'ouverture du filet.

Afin de concentrer le zooplancton collecté, ce dernier est filtré sur un filtre de 80µm de vide de maille. On a effectué des sous-échantillonages. Nos résultats sont exprimés en ind/m^3. Le comptage a été fait à l'aide d'une cuve de Dollfus sous une loupe binoculaire. La détermination des espèces de copépodes nécessite en plus d'un examen microscopique, une dissection des appendices. Leur identification s'est réalisée à l'aide d'ouvrages de détermination adéquate .

Résultat et discussions

Le zooplancton inventorié au niveau des différentes stations du golfe se compose des principaux groupes suivants : copépodes, appendiculaires, larves d'annélides, chétognathes, œufs divers .... avec une nette dominance des copépodes. Nous nous sommes intéressés particulièrement à ce groupe. La composition spécifique des différents échantillons nous a permis d'identifier 30 espèces, dont 19 calanoïdes, 6 cyclopoïdes, et 5 harpacticoïde (Tableau 1).

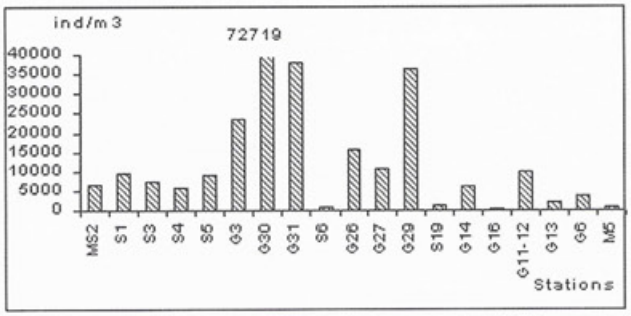


Fig. 2. Variation spatiale des copépodes totaux dans les différentes stations du golfe de Gabès.

Table 1. Composition spécifique des groupes des copépodes au niveau des différentes stations du golfe de Gabès.

Calanoïde	*Centropages typicus, C. hamatus, Labidocera Wallastoni, Spinocalanus sp, Paracalanus sp, P.parvus, Acartia sp, A.Grani, A.Bifilosa, A.discaudata, Calanus sp, C. minor, C.helgolandicus, Microcalanus sp, Augaptilus glacialis, Scolecithriella auropecten, Clausocalanus sp, Chirundina parvispina.*
Cyclopoïde	*Holicyclops neglectus, Oithona sp, O. nana, Pseucyclops sp, Cyclops strenuus, Eucyclops sp.*
Harpacticoïde	*Moraria mrăzeki, Microarthridion littorale, Euterpina acutifrons, Harpacticus littoralis, Aegisthus spinolosus.*

Une nette dominance d'*Acartia granie* et *centropages typicus* a été enregistrée pour les calanoïdes. Le genre *Oïthona* acquière aussi des densité considérable au niveau des différents échantillons. Pour les harpacticoïdes l'espèce *Euterpina acutifrons* domine. Cependant, on note la présence du cyclopoïde *Halicyclops neglectus* exclusivement au niveau de la station MS_2. Cette espèce paléarctique a été observée particulièrement en Europe. En Tunisie elle a été rencontré pour la première fois en 2002 (2). Elle pourrait être introduite par le biais des eaux de ballast. Les échantillons au niveau des stations G3, G30, G31 et G29 acquièrent des densité zooplanctoniques importantes avec un maximum de 5,3 10^4 ind/m^3 en G30 dû a la prédominance des copépodes qui représentent une moyenne de 83% du zooplancton total. Cette importance quantitative témoigne du rôle trophique important de ce groupe au sein des écosystèmes marins.

Références

1 - Barale V., 1994. Mediterranean colours. *La lettre de la CIESM*, 4 p.
2 - Turki S., 2002. Contribution à l'étude bio-écologique des rotifères, cladocères, copépodes des eaux continentales tunisiennes et dynamique saisonnière des zooplanctons de la retenue du barrage de Bir Mcherga.

DISTRIBUTION ET RECRUTEMENT DES PRINCIPALES RESSOURCES DEMERSALES DE LA MEDITERRANEE MAROCAINE

Zoubi A. [1] *, Berraho A. [1], Idelhaj A. [1], Shafee M. S. [2]

[1] Institut National de Recherche Halieutique (INRH), 2 Rue de Tiznit, Casablanca, Maroc – * abdelaziz_zoubi@hotmail.com
[2] Institut Agronomique et Vétérinaire Hassan II, Rabat, Maroc

Résumé

Ce travail est consacré à l'étude de l'abondance des principales espèces de la pêcherie démersale marocaine et à leurs lieux et périodes de recrutement. Les résultats obtenus montrent une abondance plus marquée au niveau des strates côtières (isobathes moins de 200 m) pour le cas de pageot acarné, di rouget de vase et au niveau des grands fonds (au-delà de 200 m) pour le merlu européen. Indépendamment de l'espèce, le recrutement le plus prononcé a lieu en automne et surtout au niveau de la région Est d'Al Hoceima.

Mots clés: Méditerranée, Maroc, espèces démersales indice d'abondance, recrutement

Introduction

En Méditerranée marocaine, la pêcherie démersale est axée principalement sur l'exploitation des sparidés (pageot acarné), des mullidés (rouget de vase) et des merlucciidés (merlu européen). Ce travail entend contribuer à une étude de la répartition de ces stocks, leur recrutement ainsi que leur variation spatio-temporelle dans cette région.

Matériel et méthodes

L'étude de la répartition bathymétrique et géographique des espèces est réalisée à partir du traitement des données (rendements et fréquences de tailles) collectées lors des 12 campagnes de chalutage effectuées par l'INRH en Méditerranée marocaine, durant la période 1985-1993 durant les saisons d'été, de printemps et d'automne. L'engin utilisé est un chalut de fond de 38 mm de maillage, La durée des traits de chalut est de 30 min et la vitesse moyenne de pêche est d'environ 3 nœuds (1). La couverture de la zone d'étude est réalisée par un réseau de 45 stations (traits de chalut) se répartissant de 50 m jusqu'à 500 m. Les données de taille et de rendement (kg/h) ont été groupées en 3 strates bathymétriques (0-100 m, 101-200m, 201-500 m) et deux zones géographiques (zone Ouest et Est d'Al Hoceima). Cette zonation a été adoptée en raison de la largeur du plateau continental (2). Les indices d'abondance, Rij (Kg/heure), ont été calculés par strate bathymétrique et par zone géographique à l'aide de la formule suivante: $Rij = (1/N).\ \Sigma(r.60/d)$ (1); avec r le rendement demi-horaire de l'espèce par trait de chalut ; N est le nombre de traits de chalut effectués dans la strate i et la zone j; d est la durée du trait en min. La détermination des principaux lieux et saisons de recrutement de ces espèces est faite par analyse des distributions de tailles établies par saison, par zone géographique et strate bathymétrique.

Résultats

1. Indice d'abondance

Pour le pageot acarné l'abondance décroît de l'Ouest à l'Est et de la côte (0-100 m) où les rendements les plus élevés sont réalisés (5,68 à 56,95 kg/h contre 1,3 à 14,4 kg/h respectivement) vers la strate de profondeur moyenne (101-200 m) (soit 1,38 à 22,9 kg/h à l'Ouest contre 0,1 à 34,85 kg/h à l'Est). Le rouget de vase pour sa part, présente une abondance plus marquée durant toute l'année dans les fonds de moins de 100 m où les rendements observés varient entre 0,29 et 4,11 kg/h à l'Ouest d'Alhoceima contre 0,68 et 7,88 kg/h à l'Est. Le merlu européen abonde par contre au niveau des strates de grandes profondeurs (au delà de 200 m) (0,80 à 6,19 kg/h à l'Ouest contre 1,01 à 4,18 kg/h à l'Est).

2. Structure de tailles et recrutement (Tab. 1)

Les distributions de tailles obtenues par saison et par strate bathymétrique et géographique permettent de relever chez le pageot acarné, le rouget de vase et le merlu blanc un recrutement plus marqué en automne surtout à l'Est d'Al Hoceima. Quelle que soit l'espèce, ce recrutement se fait au niveau des strates côtières (0-100 m) où abondent particulièrement les jeunes. Au-delà de cette strate de profondeur, s'observent surtout les individus plus âgés.

Tab. 1: Tailles les plus faibles observées et pourcentage des immatures dans les prises réalisées à l'Est d'Al-Hoceima.

Espèces	Taille totale la plus faible (recrutement) observée au niveau des prises	Pourcentage moyen des immaturesdans les prises/saison (isobathes < 50 mètres)		
		Automne	Printemps	Eté
Pageot acarné	6 cm	71	35	22
Rouget de vase	5 cm	58	29	27
Merlu blanc	7 cm	80	26	24

Discussion et conclusions

Il ressort de cette étude que les indices d'abondance varient en fonction de la zone géographique et au sein de la même zone, certaines strates sont plus riches que d'autres. La variation de l'indice d'abondance est régie par différents facteurs, parmi lesquels le type de fond dans lequel est répartie l'espèce (3) et les conditions physico-chimiques (température en particulier) et hydrologique (upwellings, etc.) du milieu qui jouent également un rôle prépondérant dans la répartition géographique des espèces (4). La saison d'automne constitue pour les espèces étudiées, la principale période de recrutement. Cette période concorde bien avec celle observée dans d'autres régions. En effet, les études similaires menées en Méditerranée espagnole situe la période de recrutement marqué au mois d'août pour le merlu blanc (5), tandis que pour le rouget de vase, cette période de recrutement plus prononcé s'étend de septembre à octobre (6).

Références

1 - Idelhaj A., Benbouchaib K. and Lazar N., 1986. Résultats de la campagne exploratoire du plateau continental de la Méditerranée marocaine. *FAO Rapp. Pêches*, 347: 85-98.

2 - I.S.P.M, 1991. Rapport sur l'état des ressources dans les eaux marocaines – Groupe de Travail des experts marocains – CEE.

3 - Domanevskaya M. V., 1982. Specifics of the distribution of *P. acarne* (Sparidae) in the southwestern Mediterranean sea. *Journal of Ichtyology*. Vol. XXII: 127-130.

4 - Barkova N., Domanevskaya M.V. and Sewdykh L.N., 1981. Répartition et cycles vitaux de quelques espèces de poissons dans les secteurs côtiers (34.1.3 et 34.3.1) de l'Atlantique Centre-Est. F.A.O., COPACE/TECH/81.

5 - Larraneta M.G., 1970. Sobre la alimentation, la maduration sexuel et la talla de premera captura de *M. merluccius*. *Inv. Pesq.*, 34 (2): 401-408.

6 - Orsi Relini L., and Peirano A., 1982. In Informes Technicos–Instituto Espagnol de Oceanografia: Las pesquerias demersales del mar de Al boran. Evolution en los ultimos decenos. Minesterio de Agricultura, Pesca y Alimentation, n° 142, Madrid 1993.

ETUDE DES POSSIBILITES D'AMENAGEMENT DES SPARIDES DANS LA REGION MEDITERRANEENNE MAROCAINE

A. Zoubi [1] *, A. Berraho [1], M. S. Shafee [2]
[1] Institut National de Recherche Halieutique (INRH), Casablanca, Maroc
[2] Institut Agronomique et Vétérinaire Hassan II, Rabat Instituts, Agdal, Maroc

Résumé

Le présent travail vise à analyser, sur la base des données collectées lors des campagne de chalutage effectuées par l'INRH à bord du N/*R Charif Al Idrissi*, la variation du rendement par recrue (Y/R) des stocks de sparidés exploitées dans la zone méditerranéenne marocaine. Selon les scénarios envisagés, une augmentation de maillage à 52 mm permettrait de sauvegarder particulièrement les stocks côtiers (bogue, pageot acarné et rouget de vase) et cela, par la limitation davantage des prises des jeunes chez ces stocks actuellement en état d'exploitation avancée.

Mots clés: Méditerranée, Maroc, pêcherie démersale, sparidés, Rendement par recrue

Introduction

La bogue (*Boops boops*, Linnaeus 1758) et le pageot acarné (*Pagellus acarne,* Risso 1826), constituent une grande part (19% et 32 % respectivement) dans les débarquements des ressources de fond par les chalutiers actifs en Méditerranée marocaine. L'objectif de cette étude est d'étudier par application du modèle de production par recrue (1) aux stocks de la bogue et de pageot acarné, l'augmentation ou la diminution de la production par recrue, suite à une simulation de changement de l'effort de pêche ou du maillage de cul-de-chalut de l'engin de pêche.

Matériel et méthode

Les données de taille et le matériel d'âgéage (écailles) utilisés ont été collectés durant les campagnes de chalutage réalisées par l'INRH durant la période 1990-2000.

Pour l'analyse du rendement par recrue (Y/R) (2) des espèces, les paramètres de croissance du modèle de croissance (3) ont été estimés par espèce (4). L'âge au recrutement, pris comme étant la taille du plus petit poisson observé au niveau des débarquements de la pêche commerciale, a été estimé à 0,30 an pour la bogue, et 0,50 ans pour le pageot acarné. L'âge de première capture (Tc) (1), a été estimé à 0,90 an pour la bogue et 1,20 ans pour le pageot acarné. Le coefficient de mortalité naturelle (M) calculé (5), est de 0,31 pour la bogue contre 0,75 pour le pageot acarné. Les coefficients de mortalité par pêche (F) actuels sont calculés (6) et se situent à 1,43 pour la bogue et 0,54 pour le pageot acarné.

Trois tailles de mailles ont été essayées dans cette étude (1) pour la comparaison des rendements par recrue; la maille 40 mm (maillage légal) utilisé comme maillage de référence et les maillages 52 mm et 67 mm.

Résultats

Les scénarios d'augmentation du maillage du cul de sac du chalut ou de réduction de l'effort de pêche ont permis de constater que pour le stock de pageot acarné (Fig. 1), la limitation de l'effort de pêche ou l'augmentation du maillage ne semble pas améliorer la situation.

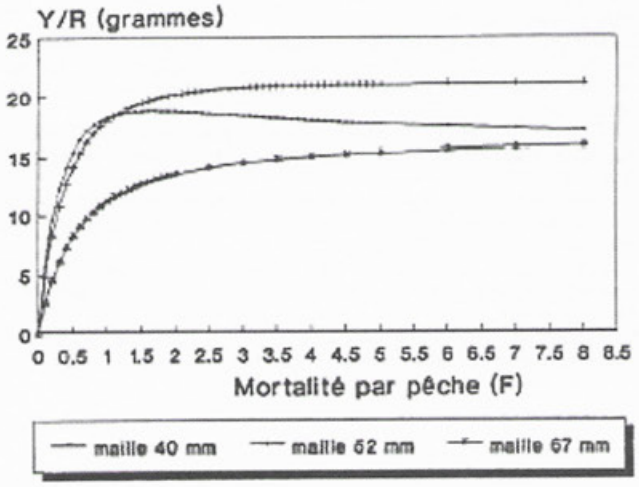


Fig. 1. Variations du rendement par recrue du pageot acarné en fonction du maillage et de la mortalité par pêche.

Pour le cas de la bogue (Fig. 2), le rendement par recrue pourrait être amélioré de 9 à 35% par l'augmentation de maillage à 52 mm ou par une diminution de l'effort de pêche de 70%.

Avec le maillage légal, le rendement par recrue maximum (40,45 g) est réalisé à un niveau d'effort plus faible (F = 0,40) que le niveau d'effort actuel (F = 1,43) permettant un rendement d'environ 31,9 g.

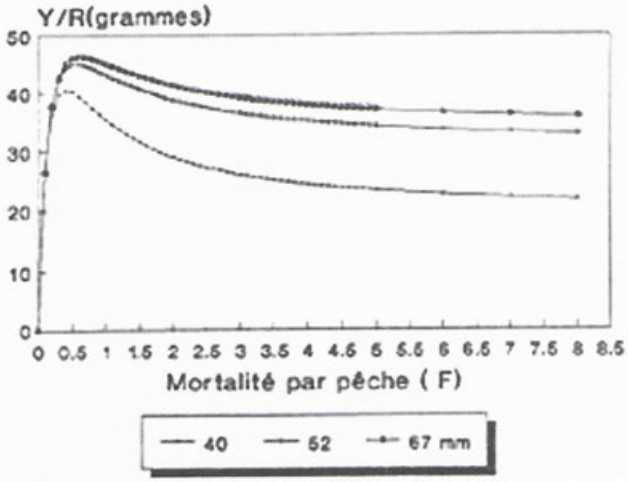


Fig. 2. Variations du rendement par recrue (Y/R) de la bogue en fonction du maillage et de la mortalité par pêche.

Conclusion

Globalement pour toute la pêcherie demersale, déjà en phase de surexploitation, l'augmentation de maillage du chalut à 52 mm, pourrait contribuer à améliorer, à long terme les rendements de le pêcherie demersale. Cette mesure, jointe à un renforcement de la surveillance au niveau de la bande interdite au chalutage, constituerait un compromis qui permettra de sauvegarder particulièrement les stocks côtiers (pageot acarné, bogue et rouget de vase) par la limitation des prises des jeunes chez ces stocks.

Références

1 - Beverton R.J. H and Holt S.J., 1957. On the dynamics of exploited fish populations. *Fishery Invest. Lond,* Ser. 2, 19, 533 p.

2 - Gulland J.A., 1969. Manuel des méthodes d'évaluations des stocks d'animaux aquatiques. 1ère partie: Analyse des populations. Manuel des sciences aquatiques. FAO, 4, 160 p.

3 - Von Bertalanffy L., 1938. A Quantitative Theory of organic growth. *Hum. Biol.,* (10): 191-213.

4 - Zoubi A., 2001. Etude de la biologie de croissance des principaux stocks demersaux de la Méditerranée marocaine. *Rapp. Comm. int. Mer Médit.,* 36: 341.

5 - Pauly D., 1980. On the interrelationship between natural mortality and mean environmental temperatures in 175 fish stocks. *J. Cons. Int. Explor. Mer.,* 39 (2): 175-192.

6 - Pauly D., 1982. Une sélection des méthodes simples pour l'estimation des stocks de poissons tropicaux. FAO. Circulaire sur les pêches n° 729, 61 p.

THE SPREAD OF THE INVASIVE VARIETY OF *CAULERPA RACEMOSA* IN THE ADRIATIC SEA

A. Žuljević [1] *, B. Antolić [1], M. Despalatović [1], V. Onofri [2]
[1] Institute of Oceanography and Fisheries, Split, Croatia - * zuljevic@izor.hr
[2] Institute of Oceanography and Fisheries, Dubrovnik, Croatia

Abstract
By the end of 2003, *Caulerpa racemosa* had been discovered at 11 locations along the Croatian coast of the Adriatic Sea. Here we discuss the possible mechanisms and vectors of its long distance dispersal.

Key-words: Caulerpa racemosa, Adriatic Sea, dissemination

Introduction

The first record of the invasive variety of *Caulerpa racemosa* (Forsskål) J. Agardh (Caulerpales, Chlorophyta) in the Mediterranean Sea was in 1990 in Tripoli (Libya). In the next 10 years it was found also in Tunis, Egypt, Cyprus, Turkey, Greece, Malta, Italy, France, Spain and Croatia (1). The vector of its introduction to the Mediterranean Sea as well as its phylogenetic relations are still unknown (2). Moreover there is still doubt about the vectors of its long distance dispersal.

The first report in the Adriatic Sea was in 2000 on the Pakleni archipelago (3). Here we present new data about its spread along the Croatian part of the Adriatic Sea, and discuss a possible mechanism of its long distance dispersal.

Observation and Discussion

By the end of 2003, 11 distant stations of *Caulerpa racemosa* had been discovered (Fig. 1). The algae proliferates on rocky, sandy and muddy bottoms, in photophilic and sciaphilic communities, as well as in meadows of *Posidonia oceanica* (L.) Delile and *Cymodocea nodosa* (Ucria) Ascherson seagrass, and on sessile animals such as sponges. It grows from 0.5 to 50 m deep, with the densest colonies forming between depths of 2 and 30 m. The most dense colony was recorded on Pakleni Island at 7 m deep where the canopy contained 2600 m m^{-2} of total stolon length and nearly 27 000 fronds m^{-2} (3).

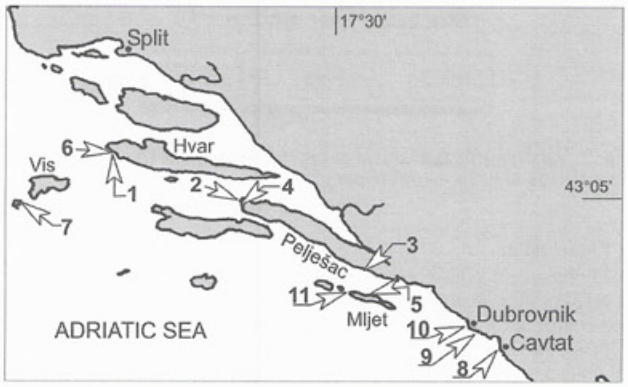


Fig. 1. Stations of *Caulerpa racemosa* numbered by historical record: 1) Pakleni Islands, 2) Cesminova Cove, 3) Marčuleti Bay, 4) Mirca, 5) Cape Pusti, 6) Vela Garška Cove, 7) Mezuporat Cove, 8) Cavtat, 9) Dubrovnik – Cape Osti, 10) Dubrovnik, 11) Goli Islet.

Several mechanisms could be involved in the long distance dispersal of the alga throughout Adriatic Sea.

Anchoring. As is the case with *C. taxifolia*, it is likely that *C. racemosa* could be transported in boat anchor lockers. However, most of the infested stations in the Adriatic Sea are not suitable or common mooring places.

Fishing nets. The infestation in Mirce village was probably introduced by fishing nets from the significantly larger colony in Ćesminova Cove. The alga was observed in a small fishing harbour where fishermen clean their nets.

Sexual reproduction. There is no strong evidence that sexual reproduction in the Mediterranean Sea is successful. The only observation of the formation of both types of gametes was in Greece (4), but with a low percentage of gamete conjugation and formation of planozygotes. Moreover, the authors suspect that the observed zygotes could have been an artefact of incomplete cleavage during gametogenesis, which at the time of observation looked like planozygotes.

Fragmentation. As with fragments of *C. taxifolia*, fragments of *C. racemosa* do not float. Due to its spherical ramuli, *C. racemosa* fragments sink relatively slowly, and may be more easily transported by currents. However, thalli of *C. racemosa* consist predominantly of the creeping stolon. In *C. taxifolia* the predominant part are fronds. Becouse of that, in the colonies of *C. taxifolia* there are usually numerous frond fragments, while in *C. racemosa* colonies fragments are rare.

Epiphytes. *Caulerpa racemosa* grows on other macro algae such as *Cystoseira* and *Sargassum* species. Detached *Cystoseira* or *Sargassum* thalli could float for several days and disperse attached *C. racemosa.*

Propagules. Spherical ramuli can separate from the fronds and act as propagules (5) that could be carried by currents and waves. It is not known how far the propagule could be carried.

Ballast water. In order for ballast water to be a vector of *C. racemosa* spread, there must be a floating phase of its lifecycle (fragments, propagule or zygotes). Although it is unknown if *C. racemosa* has this floating phase, ballast water is usually released offshore far away from the recorded colonies in the Adriatic Sea.

Currents. Most of the *C. racemosa* records in the Adriatic Sea correspond with the flow of the cyclonic Adriatic Current. The closest colony from where the algae could have originated and been driven by the cyclonic Adriatic Current was found in the Ionian Sea (Zakynthos Island) in 1993 (6). Unfortunately there is no information about *C. racemosa* along the Albanian coast which could support the theory of dispersal by currents.

Conclusion

The geographic distribution of most of the *C. racemosa* colonies in the Adriatic Sea suggests that the cyclonic Adriatic Current could be the basic vector of *C. racemosa* long distance dispersal. The portion of the thallus that floats (fragments, propagules, zygotes or epiphytic transportation) remains unknown.

References

1 - Verlaque, M., Boudouresque, C.F., Meinesz, A., Gravez, V. 2000. The *Caulerpa racemosa* complex (Caulerpales, Ulvophyceae) in the Mediterranean Sea. *Bot. Mar.*, 43: 49–68.

2 - Durand, C., Manuel, M., Boudouresque, C.F., Meinesz, A., Verlaque, M., Le Parco, Y. 2002. Molecular data suggest a hybrid origin for the invasive *Caulerpa racemosa* (Caulerpales, Chlorophyta) in the Mediterranean Sea. *J. Evolution. Biol.*, 15: 122-133.

3 - Žuljević A., Antolić B., Onofri V. 2003. First record of *Caulerpa racemosa* (Caulerpales, Chlorophyta) in the Adriatic Sea. *J. Mar. Biol. Assoc.*, 83: 711-712.

4 - Panayotidis P., Žuljević A. 2001. Sexual reproduction of the invasive green alga *Caulerpa racemosa* var. *occidentalis* in the Mediterranean Sea. *Oceanol. Acta*, 24 (2): 199-203.

5 - Renoncourt, L., Meinesz, A. 2002. Formation of propagules on an invasive strain of *Caulerpa racemosa* (Chlorophyta) in the Mediterranean Sea. *Phycologia*, 41: 533-535.

6 - Panayotidis P., Montesando B. 1994. *Caulerpa racemosa* (Chlorophyta) on the Greek Coasts. *Cryptogam. Algol.*, 15: 159-161.

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ESTIMATION DE LA BIOMASSE ALGALE GLUCIDIQUE ET PROTÉIQUE ET DU MÉTABOLISME DANS LA SALINE DE SFAX, TUNISIE

Olfa Abid *, Habib Ayadi et Abderrahmen Bouain

Laboratoire de Planctonologie, Unité de recherche 00/UR/0907, Ecobiologie et Ecophysiologie animales.
Département des Sciences de la Vie, Faculté des Sciences de Sfax, Tunisie - * Olfa.Abid@fss.rnu.tn, Habib.Ayadi@fss.rnu.tn

Résumé

L'intérêt que présente le dosage des glucides et des protéines pour estimer la biomasse algale et leur métabolisme est grand. Le rapport Protéines/glucides (P/G) renseigne sur l'augmentation ou la diminution des ressources azotées du milieu. Leur diminution dans l'eau entraîne un ralentissement de la synthèse protéique des algues et induit une orientation métabolique vers une synthèse glucidique intense. Les paramètres de l'environnement tel que la température peuvent jouer un rôle important pour l'augmentation ou la diminution de la synthèse protéique.

Mots clés : saline, phytoplancton, protéines, glucides, métabolisme

Dans le cadre des recherches biologiques dans la saline de Sfax (Sud Est de la Tunisie), nous étudions la composante phytoplanctonique vu le rôle important qu'elle revêt dans la production primaire des écosystèmes côtiers. Plusieurs travaux ont montré l'intérêt de l'étude du métabolisme cellulaire des algues (1). Les principaux constituants cellulaires phytoplanctoniques, à savoir les protéines, les glucides et les lipides, sont considérés comme des descripteurs de la biomasse de ces peuplements et des indicateurs de leur état et de leur activité physiologique (2).

Un échantillonnage mensuel a été effectué au niveau de cinq bassins de la saline (Fig. 1). Nous avons enregistré la température de l'eau, la salinité et la pH. L'évaluation de la biomasse est faite par le dosage des protéines et des glucides. Ce dosage a un grand intérêt aussi pour la détermination du métabolisme algal.

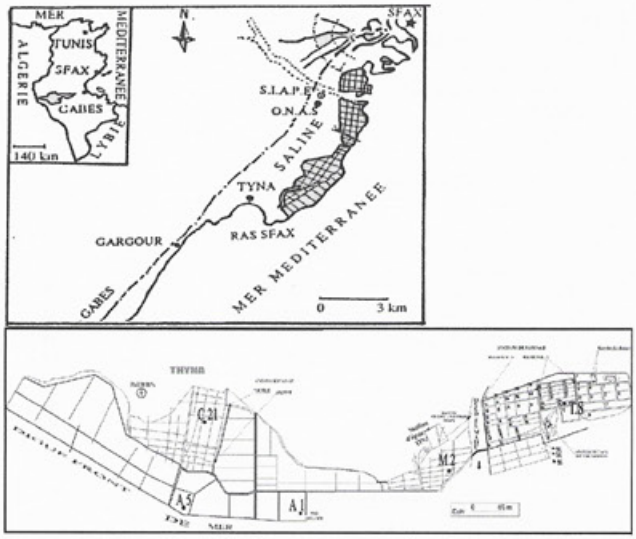


Fig. 1. Localisation des sites d'échantillonnage dans la saline de Sfax.

Le suivi des paramètres abiotiques montre que la salinité augmente de la prise d'eau vers les tables salantes suite au phénomène d'évaporation. Les valeurs de la température et du pH varient aussi. L'évolution spatiale de la moyenne des teneurs en protéines est exprimée par la figure 2.

Ces teneurs oscillent entre 1.99 mg/l au niveau de A1 et 17.17mg/l au niveau de TS. Les valeurs élevées sont dues au paroxysme du développement du phytoplancton à côté d'autres microorganismes tels que les protozoaires et les tintinnides (3). Cette variation est aussi liée à la température.

Les valeurs de la biomasse glucidique varient aussi. Elles diminuent avec l'augmentation de la salinité. Ceci corrobore avec les travaux de Benner (4). Le rapport protéines/glucides montre alors que si les teneurs en protéines sont faibles celles des glucides sont importantes. Le métabolisme des algues microscopiques tend vers une synthèse glucidique poussée en cas de carences en ressources azotées (5) comme il a été noté en milieux lacustres (6).

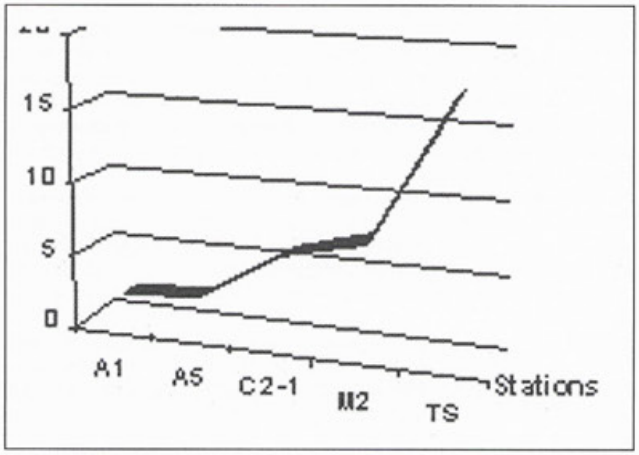


Fig. 2. Evolution spatiale de la moyenne des teneurs en protéines algales dans la saline de Sfax.

Références

1 - Maurin N., Amblard C. et Bourdier G., 1995. Vertical and seasonal variations of inorganic carbon allocation into macromolecules by phytoplankton population in a brown-colored and a clear-water lake. *Hydrobio.*, 300/301: 57-70.

2 - Damiri L., Alaoui M.M et Bahhou J., 2002. Dynamique des populations microphytobenthiques couplée à leur composition biochimique au sein du réservoir Allal El Fassi (Marroc). *Rev. Sci. Eau.* 15/1 : 101/109.

3 - Ayadi H., Toumi N, Abid O., Medhioub K., Hammami M., Sime-Ngando T., Amblard C. et Sargos D., 2002. Etude qualitative et quantitative des peuplements phyto- et zooplanctoniques dans les bassins de la saline de Sfax. *Rev. Sci. Eau*, 15(1): 123-135.

4 - Benner R., 2003. The relationship beteween dissolvedcarbohydrates and carbohydrate-degrading enzymes in the salinity gradient of the Pomeranian Bight (Southern Baltic). *Oceanologia*, 45(3): 437-452.

5 - Terry K.L., Hirta J. and Laws E. A., 1983. Light limited growth of tow strains of the marine diatoms *Phaecodactylum tricornitum* Bohlin : chemical composition, carbon partitioning and the diel periodicity of physiological processes. *J. Exp. Mar. Biol. Ecol.*, 68: 209-227.

6 - Alaoui M.M., 1985. Dynamique des population et évolution métabolique du phytoplancton d'un lac eutrophe (Lac Aydat, PUY de DOME, France). Thèse de doctorat de 3ème cycle, Univ. Blaise Pascal. 206 p.

EPIPHYTIC DIATOM COMMUNITY ON MACROPHITE LEAVES IN IZMIT BAY (MARMARA SEA)

Yelda Aktan

Istanbul University, Fisheries Faculty, Laleli, Istanbul, Turkey - yaktan@istanbul.edu.tr

Summary

In marine coastal ecosystems, benthic algae are important contributors to primary production and a limiting resource for sessile plants and animals. The aim of this study, from March 1999 to September 2000, was to characterize the diatom flora among the algal epiphytes in two macrophytes from Izmit Bay, Marmara Sea: *Cymodocea nodosa* (Ucria) Aresch and *Zostera noltii* Horneman. Diatoms were identified by Scanning Electron Microscopy and quantitative analyses were conducted to estimate the diatom abundance. In the study period, 4 centric, 25 pennate diatom taxa were recorded on two macrophytes.

Key words: epiphytic diatom, Izmit Bay, Marmara Sea

Introduction

Algal epiphytes on macro algae play an important role in marine communities, contributing to the primary productivity of ecosystems, supplying a main food source for animals such as molluscs and amphipod crustaceans and comprise a major portion of the biota present in a given area [1, 2]. As for the micro flora, diatoms are always dominant. Despite the importance of benthic algae (particularly diatoms) in marine communities, little information is available about the timing and patterns of epiphyte distribution on marine macrophytes [3].

This study is part of a larger investigation on the ecological distribution of benthic diatom communities along the coast of Izmit Bay. The aims of this study are to characterize the epiphytic diatom flora among the benthic algal composition and at the same time to contribute to the knowledge of benthic diatom diversity of the Marmara Seas.

Izmit Bay is located on the north-eastern part of Marmara Sea and it is one of the most polluted areas in Turkey. The Bay has been receiving more than 300 industries' effluents, together with the untreated domestic waste-waters from the small cities and also from Izmit, the most populated city of the region. The Bay was also affected by a powerful earthquake (on August 1999) and by the subsequent fire in the refinery situated on the north-eastern coast [4].

Materials and Methods

Temperature, dissolved oxygen, salinity and pH were measured in surface water. Nutrient (Nitrate, *o*-phosphate and silicate) analysis were determined bimonthly in TÜBITAK Research Center by a Technicon Autoanalizer II System.

Sampling was carried out monthly by SCUBA-diving and snorkelling. A part of host plants (*Cymodocea nodosa* and *Zostera noltii*) was fixed in 4% formaldehyde and the other parts were desiccated to constitute a herbarium. In the laboratory, epiphytic diatoms on host plants were separated by washing-tearing methods and temporary slides were prepared for counting. In every counting, minimum 100 diatoms frustules were counted and abundances were calculated. Diatoms were identified by light and scanning electron microscopy and photographed.

Results and Discussion

Temperature changed according to sites and seasons related also to turbulence of wind and wave. Salinity values were considerably varied in the littoral zone. Besides marine diatoms, freshwater species were recorded also on epiphytic flora.

Macrophytes were recorded as "rarely present" (6%, n=18) at Yalova and "constantly present" (83%, n=18) at Dereköy, a partly sheltered area. A total of 29 epiphytic diatom taxa were recorded. *Achnanthes* spp., *Cocconeis* spp. ("true" epiphytes, with adnate cells) and *Navicula ramosissima* var. *mucosa* (metaphyton, with motile cells living in mucilage tubes) were dominant in these assemblages.

Table 1. Values of physical and chemical parameters.

	min	max	average
Temperature (^{0}C)	7	28	17.5
pH	7.4	9.5	8.5
Salinity (‰S)	16	28	22
NO^-_3-N (µg l^{-1})	2	40.9	13
PO^-_4-P (µg l^{-1})	2	38	8.2
SiO_2 (µmol l^{-1})	0.12	7.17	5.5
Suspended solids (mg l^{-1})	17.8	32.4	22.6

Cymodocea nodosa and *Zostera noltii* were suitable host plants at selected sites because of wide distribution. Moreover, their leaves constituted a suitable settlement surface for a characteristic micro algal community.

Epiphytic diatoms did not show considerable seasonal variations at Izmit Bay. However, their abundances changed. In spring and autumn, an extensive epiphytic diatom growth was observed on the host plants that, furthermore, besides being affected by a remarkable diatom cover, are also colonised by small filamentous algae (*Ectocarpus, Callithamnion, Polysiphonia, Cladophora* and *Ceramium*).

Acknowledgments. This study was supported by the Research Fund of Istanbul University, Project Number: T-670/190299

Table 2. Epiphytic diatom taxa, h: habitats (B=Brackish; M=Marine; F=Freshwater) and rc: relative abundances (n=18).

Taxa	rc	h
Centrales		
Actinocyclus subtilis (Greg.) Ralfs in Pritch	17	M
Melosira moniliformis (O. F. Müll.) Ag.	28	B M
M. nummuloides Ag.	33	B
Skeletonema costatum Grev. in Cleve	6	M
Pennales		
Achnanthes spp.	78	
A. brevipes Ag.	56	B
Amphora alata (Ehrenb.) Kütz.	6	M
A. exigua Greg.	17	B M
Caloneis sp.	28	
Cocconeis disculus (Schum.) Cléve	6	M
C. pediculus Ehrenb.	28	F
C. scutellum Ehrenb.	50	M
Cylindrotecha closterium (Ehr.) Lew&Rein	50	M
Fragilaria oceanica Cléve	39	M
Grammatophora marina (Lyngb.) Kütz.	6	M
Lichmophora abbreviata Ag.	39	M
Lichmophora paradoxa (Lyngb.) Ag.	28	M
Navicula menisculus Schum.	6	B
N. ramosissima var. *mucosa*(Aleem)Hendey	72	M
N. rostellata Kütz.	17	M
N. tripunctata (O. F. Müller) Bory	39	F
Nitzschia apiculata (Greg.) Grun.	6	M
N. frustulum var. *perpusilla* (Rabh.) Grun.	11	B F
Stauroneis membranacea (Cléve)F.W.Mills	6	M
Striatella unipunctata (Lyngb.) Ag.	22	M
Synedra crystallina (Ag.) Kütz.	11	M
S. tabulata var. *fasciculata* (Kütz.) Grun.	56	B M
S. tabulata var. *parva* (Kütz.) Grun.	28	B M
Toxonidea insignis Donk.	6	M

References

1 - Scipione and Mazzella, 1992. Epiphytic diatoms in the diet of crustacean amphipods of *Posidonia oceanica* leaf stratum. *Oebalia*, XVII: 409-412.

2 - Snoeijs, P., 1994. Distribution of epiphytic diatom species composition, diversity and biomass on different macroalgal hosts along seasonal and salinity gradients in the Baltic Sea. *Diatom Research*, 9(1): 189-211.

3 - Dural, B, Aysel, V., Lök, A, Güner, H., 1997. Benthic algal flora of the natural artificial substrata of Hekim Island (Izmir, Turkey). *Algological Studies*, 85, 31-48.

4 - Okay, O. S., Tolun, L., Telli-Karakoç, F., Tüfekçi, H., Morkoç, E. 2001. Izmit Bay (Turkey) ecosystem after Marmara Earthquake and subsequent refinery fire: the long term data. *Marine pollution Bulletin*, 42(5): 361-369.

APPROCHE GÉNOMIQUE DE L'ÉTUDE DE LA PHYSIOLOGIE DE L'ANÉMONE TEMPÉRÉE *ANEMONIA VIRIDIS*

D. Allemand [1, 2], C. Ferrier-Pagès [1], E. Kulhanek [1, 2], D. Zoccola [1], C. Sabourault [2], E. Tambutté [1], S. Tambutté [1 *], D. Zoccola [1]

[1] Centre Scientifique de Monaco, Monaco - * stambutte@centrescientifique.mc
[2] UMR 1112 UNSA-INRA, Faculté des sciences, Parc Valrose, Nice, France

Résumé

La plupart des Cnidaires possèdent des symbiotes intracellulaires photosynthétiques les obligeant à vivre dans la zone côtière où ils sont soumis aux radiations solaires et aux influences anthropiques. Une approche génomique de la régulation de l'expression des gènes d'*Anemonia viridis,* nous a permis de déterminer les mécanismes d'adaptation de cet organisme aux conditions hypoxiques nocturnes. Une banque soustractive d'ARNm (nuit-jour) et une puce ont été réalisées. Les résultats de l'hybridation entre la puce et des populations d'ADNc exprimés le jour ou la nuit permettent d'envisager d'utiliser cet outil pour l'étude de la réaction de ces organismes aux différents stress environnementaux.

Mots clés : génomique – hypoxie – cnidaire - adaptation

Introduction

Les Cnidaires constituent un embranchement important d'animaux marins, appartenant aux Radiaires et considérés comme les premiers Métazoaires (Eumétazoaires, diploblastes) apparus il y a environ 600 millions d'années. Leur étude présente donc un grand intérêt du point de vue de l'évolution et de la biologie du développement. De plus, la plupart de ces organismes vivent en symbiose avec des algues intracellulaires, qui en réalisant la photosynthèse produisent de grandes quantités d'oxygène durant la journée (60 % de saturation en O_2 des tissus après seulement 20 minutes d'éclairement). Au contraire, durant la nuit, la respiration combinée des deux partenaires conduit à une situation d'hypoxie voire d'anoxie (1). La présence des symbiotes photosynthétiques oblige ces organismes à vivre dans la zone côtière, les soumettant ainsi à la fois aux radiations solaires et aux influences anthropiques.

La grande résistance des Cnidaires aux variations d'oxygène et leur simplicité d'organisation par rapport aux mammifères en font un bon modèle d'étude afin de mieux comprendre les phénomènes d'adaptation des tissus aux variations d'oxygène. Pour connaître les gènes impliqués dans la résistance des Cnidaires aux stress oxiques, nous avons réalisé, sur l'anémone de mer méditerranéenne *Anemonia viridis*, une banque soustractive entre les ARNm exprimés la nuit et ceux exprimés le jour. Nous présentons les résultats préliminaires obtenus à partir de l'exploitation de cette banque.

Matériel et méthodes

Modèle biologique

Notre modèle d'étude, *Anemonia viridis*, est élevé en aquarium, dans nos laboratoires, à une température de 17°C ± 0,5. Cette anémone de mer est la plus commune en Méditerranée. Cet Actiniaire, pouvant atteindre 15 cm de hauteur, vit sur les fonds rocheux des zones bien éclairées. La paroi de l'animal est composée de 2 feuillets épithéliaux, l'ectoderme et l'endoderme, séparés par une couche acellulaire, la mésoglée. C'est au niveau de l'endoderme que sont localisées les zooxanthelles, symbiotes photosynthétiques et intracellulaires, à l'origine des variations journalières de la concentration en O_2 au sein des tissus.

Construction d'une banque soustractive

Les anémones sont soumises à un cycle nuit/jour de 12 heures à l'aide de lampes HQI-TS 400 W (Philips) fournissant une intensité lumineuse de 250 mmol m^{-2} s^{-1}. Deux populations d'ARNs ont été extraites, soit à l'obscurité (ARNs Nuit) soit à la lumière (ARNs Jour). La banque soustractive a ensuite été réalisée en suivant les instructions du fournisseur (Clontech PCR-select™ cDNA substraction kit). L'efficacité de la soustraction est analysée par l'amplification d'un fragment du gène d'actine. La PCR est réalisée soit sur ADNc total, soit après soustraction et ceci après 18, 23, 28 ou 35 cycles d'amplification.

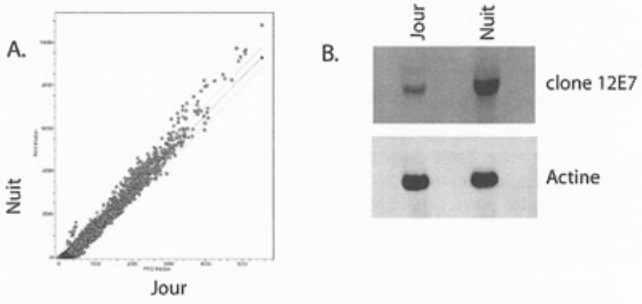
Résultats

Préparation et hybridation d'une puce ADN

Environ 1000 fragments d'ADNc issus de cette banque ont été isolés, amplifiés et déposés sur lames de verre. Un contrôle de la qualité du dépôt a été réalisé par coloration des lames au Vistragreen (Molecular Probes). Les puces ont ensuite été hybridées en utilisant comme sondes des populations d'ADNc de nuit et de jour marquées avec deux fluorochromes différents (CyScribe First-Strand cDNA labelling kit). Chaque clone de la banque a été déposé en duplicat sur trois blocs différents de la même lame. Un swap (inversion des marquages) permet de corréler l'expression de chaque clone en s'affranchissant de la qualité du marquage.

Sélection des clones d'intérêt

Une des lames hybridées avec des sondes d'ADNc de jour marquées au Cy3 et de nuit marquées au Cy5 a été analysée. Le graphique représente l'intensité d'hybridation de chaque clone, mesurée à 635 nm (Nuit) en fonction de celle mesurée à 532 nm (Jour) (Figure 1A). Ainsi, des clones situés au-dessus de la droite [Nuit=Jour] sont surexprimés la nuit. Certains de ces clones sont ensuite utilisés comme sonde sur northern blot pour valider la surexpression des gènes ainsi sélectionnés. Par exemple le clone 12E7 est 3,2 fois plus exprimé la nuit que le jour alors que le contrôle actine est exprimé de la même façon (logiciel NIH image) (Figure 1B).



Conclusion

La compréhension des mécanismes d'adaptation des organismes aux variations d'oxygène est un enjeu fondamental et appliqué important tant en ce qui concerne l'hypoxie que l'hyperoxie (traitement à l'oxygène, ischémie - reperfusion, cancérologie...). L'étude d'organismes simples a souvent été le point de départ vers la découverte de nouveaux mécanismes, de voies métaboliques ou régulatrices originales, de protéines ou de gènes non encore caractérisés chez les Vertébrés (œuf d'oursin, *C. elegans*...). L'étude des Cnidaires, qui constituent les premiers véritables Métazoaires (Eumétazoaires), est incontournable. Ici, nous avons utilisé la particularité que présentent ces organismes à résister de façon naturelle à l'hypoxie et aux variations hypoxie / hyperoxie. Les résultats obtenus démontrent la faisabilité d'utiliser ces organismes pour étudier le transcriptome au cours d'épisode hypoxique naturel. Cette approche expérimentale facilite considérablement l'étude d'un organisme dont le génome est encore quasiment inconnu. Ces résultats constituent une première application de la génomique sur un organisme marin, et permettent d'envisager d'utiliser cet outil pour l'étude de la réaction de ces organismes aux différents stress environnementaux.

Références

1 - Richier S., Merle P. L. , Furla P., Pigozzi D., Sola F. and Allemand D., 2003. Characterization of superoxide dismutases in anoxia- and hyperoxia-tolerant symbiotic cnidarians. *Biochimica et Biophysica Acta.*, 1621: 84–91.

OBSERVATIONS SUR *ARTEMIA* SP DANS LA SEBKHA EZ-ZEMOUL (AIN M'LILA, ALGERIE NORD-EST)

Amarouayache M. [1], Derbal F. [2] * et Kara M. H. [2]

[1] Centre de Recherche Scientifique et Technique sur les Régions Arides (CRSTRA), Biskra, Algérie
[2] Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie - * mfderbal@yahoo.fr, kara_hichem@yahoo.com

Résumé

L'artémia apparaît dans la sebkha Ez-zemoul à partir du mois de janvier. Sa densité est variable et les proportions relatives de ses différents stades de développement varient au cours de la saison humide. Le *sex-ratio* est généralement en faveur des mâles. Les femelles se reproduisent essentiellement par oviparité (plus de 93%), à partir d'une longueur totale de 8 mm. Elles produisent en moyenne 66,3 cystes par individu.

Mots-clés: Artemia sp., Sebkha, dynamique, reproduction, Algérie

Introduction

Artemia sp. est un petit crustacé branchiopode dont l'intérêt en pisciculture marine n'est plus à démontrer. Sa présence dans de nombreux sites en Algérie (1) a motivé quelques investigations sur son écobiologie (2, 3, 4) et sur les possibilités de son utilisation en pisciculture marine (2, 3, 5, 6).

Ce travail décrit la composition qualitative et quantitative de la population d'*Artemia* sp. dans la sebkha Ez-zemoul au cours de l'année 2003. Ses variations au cours de la saison humide (de janvier à juin) sont étudiées. Le *sex-ratio*, le mode de reproduction et la fécondité des femelles sont également examinés.

Matériel et méthodes

Mensuellement, de janvier à juin 2003, des échantillons d'eau sont prélevés dans la Sebkha Ez-zemoul, située dans le Nord Est de l'Algérie (34° 03' N, 06°20' E). Le volume filtré dépend de la concentration des animaux et varie de 1 à 10 l.

Le nombre total d'individus dans chaque échantillon est compté dans une cuve de Dolfuss et rapporté au litre. Les différents stades de développement sont identifiés et regroupés comme suit: nauplii (instars I à IV), juvéniles (instars V à XIV) et adultes (XV).

Le *sex-ratio* est exprimé par le rapport mâles/femelles. Le mode de reproduction est défini par la nature des œufs observés, après la dissection des femelles dont la fécondité est estimée par le comptage des embryons encystés.

Résultats et discussion

L'artémia apparaît dans la Sebkha Ez-zemoul à partir du mois de janvier. Elle atteint une densité proche de 60 individus/l en mars, date à partir de laquelle cette concentration diminue pour s'annuler en juillet. La quantité d'artémia dans les milieux hyperhalins a été peu abordée. D'après (7), une densité naturelle de 100 individus/l est considérée comme étant très élevée.

En janvier, les juvéniles dominent à plus de 78%, alors que les adultes sont inexistants. En mars, ces derniers approchent les 50%. En avril, puis en mai, de nouvelles générations de nauplii semblent apparaître, alors qu'en juin les adultes sont presque exclusifs (Fig. 1). Cette dynamique de la population d'artémia est identique à celle observée dans la saline de Meghrine en Tunisie (8), tandis que dans le Chott Marouane, où les températures estivales sont très élevées, l'artémia apparaît en janvier et disparaît en mai lorsque l'eau est saturée en sel (3).

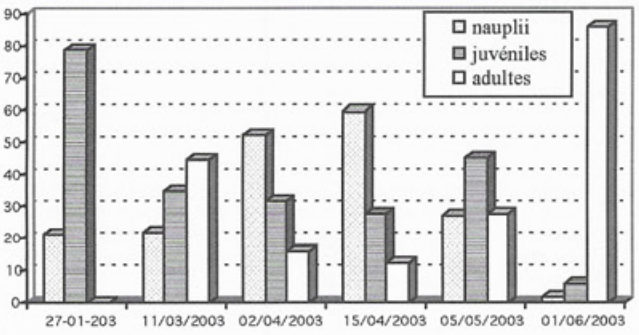


Fig. 1. Fréquence des différents stades de développement *d'Artemia* sp. dans la Sebkha Ez-Zemoul.

L'artémia de Sebkha Ez-zemoul est bisexuée. Les femelles ($7{,}05 \leq Lt \leq 11{,}6$ mm) atteignent des tailles plus grandes que celles des mâles ($6{,}15 \leq Lt \leq 9{,}32$ mm). Quelle que soit la période d'échantillonnage, le *sex-ratio* est en faveur de ces derniers et évolue entre 1,7 et 31,8. Les mâles seraient plus résistants aux températures élevées (9).

Les femelles se reproduisent essentiellement (93%) par oviparité, à partir d'une longueur de 8 mm. Le nombre moyen d'œufs produits par femelle atteint un maximum de 105 unités en mars et diminue à 20 unités en mai. En juin, toutes les femelles ont le sac ovigère vide.

La taille à la première reproduction est plus petite que dans le Chott Marouane (3) ou dans la saline de Sardaigne (10). Selon (11), cette taille est inversement proportionnelle à la salinité dans le milieu.

Références

1 - Gagneur J., Kara M.H., 2001. Limnology in Algeria. Pp. 1-34. *In*: Wetzel R.G., Gopal B. (eds). Limnology in developing countries. Vol. 3. International Association for Limnology.
2 - Haddag M., 1991. Contribution à l'étude d'une souche d'Artemia (*Artemia tunisiana*) endémique aux eaux de la saline d'Arzew (Algérie). Thèse de Magister en Sciences Biologiques. ISMAL., Alger, 61 p.
3 - Amarouayache M., 2002. l'Artemia du Chott-Merouane (El-Oued): biométrie, dynamique, caractéristiques de l'éclosion et biomasse exploitable. Mémoire de Magister. Univ. Annaba, Algérie, 67 p.
4 - Amarouayache M., Derbal F. Chaoui L., Kara M.H., 2002. L'artemia du Chott Marouane: systématique, biométrie, composition biochimique et reproduction. In: Ecologie animale en Afrique du Nord. Colloque international, Toulouse (France), 24-27 juin 2002.
5 - Kara M.H., 1998. Bases écologiques et biologiques de l'élevage du loup *Dicentrarchus labrax* dans la région d'Annaba. Thèse de Doctorat d'Etat Es-Sciences Naturelles. Univ. Sci. Tech. Houari Boumediene. Alger, 172 p + annexes.
6 - Kara M.H., Bengraine A.K., Derbal F., Chaoui L., Amarouayache M., sous presse. Quality evaluation of a new strain of Artemia from Chott Marouane (North-East Algeria). *Aquaculture*.
7 - Lavens P., Leger P., Sorgeloos P., 1986. Production, utilization and manipulation of *Artemia* as food source for shrimp and fish larvae. *Oceanis*, 4: 229-247.
8 - Turki S., 1988. Observations biologiques sur *Artemia* dans les salines de Megrine. *Bull. Inst. Nat. Scient. Tech. Oceanogr. Pêche Salammbô*, 15: 39-46.
9 - Van Stappen G., Gholamreza F., Sorgeloos P., 2001. International study on *Artemia* LXIII. Field study of the *Artemia urmiana* (Günther, 1890) population in lake urmiah, Iran. *Hydrobiologia*, 466: 133-143.
10 - Mura G., 1993. Seasonal distribution of *Artemia salina* and *Branchinella spinosa* in a saline astatic pond in south west Sardinia Italy (Anostraca). *Crustaceana*, 64 (2): 172-191.
11 - Amat F., 1982. Diferenciacion y distribucion de las poblaciones de *Artemia* de Espana. III. Oviparismo y ovoviviparismo. Estudio cualitativo y cuantativo. *Inv. Pesq.*, 46: 3-13.

BENTHIC FAUNA OF THE SYRIAN COAST – ASSESSMENT OF THE STATE OF MIGRANT AND INVASIVE SPECIES

Izdihar Ammar

High Institute of Marine Research, Lattakia, Syria - i-ammar@scs-net.org

Abstract

During the period 1992-2003 the specific composition and distribution of the zoobenthos along the Syrian coast was studied from the surface to 200 m. A total of 579 species were recorded, most belong to the Atlantic and Mediterranean fauna, whereas 45 are Lessepsian and Indopacific species: 20 Gastropoda, 10 Bivalvia, 14 Crustacea and 1 Ascidiacea. Some of these species became dominant. Some migrants tolerate pollution.

Keywords: Lessepsian, Benthos, Gastropoda, Crustacea, Red Sea

Introduction

Recent interest in the biogeography of the Mediterranean led to the development of a data bank of the marine fauna. Indo- Pacific species constitute 5% of the overall marine fauna of the Mediterranean [1], whereas they are the 12 % in the southeastern Mediterranean, 4.68% of the macrozoobenthos of the Lebanese coast [2] and only 1% of the soft bottom macrobenthic fauna of Cyprus [3]. In this study we report on the Red Sea and Indo-Pacific species recorded from the littoral and sublittoral zoobenthos of the coast of Syria [4, 5, 6].

Material and Methods

In the period 1992-2003, samples were collected down to 200 m depth by diving and by Van-Veen grab and dredge, to study both benthos and granulometry.

Results and Discussion

A total of 579 species belonging to 16 macrotaxa are recorded: 11 Porifera, 8 Cnidaria, 7 Bryozoa, 6 Sipunculida, 45 Polychaeta, 232 Gastropoda, 136 Bivalvia, 86 Crustacea, 19 Echinodermata, 4 Brachiopoda, 6 Ascidiacea and 19 species belonging to Oligochaeta, Nemertini, Placophora, Cephalopoda, Scaphopoda [7, 8].

The composition of the macrofauna was dominated by Gastropoda (40.10%), Bivalvia (23.49%), Crustacea (14.85%) and Polychaeta (7.77%).

Lessepsian migrants

They represented 7.77 % of the total zoobenthos. The majority belongs to 3 major taxa:

- **Crustacea** (14 species 16.80 %): *Penaeus japonicus, Trachypenaeus curvirostris, Metapenaeus stebbingi, Erugsquilla masseversis, Ixa monodi* (first record from Syria, observed at Lattakia sites), *Myra subgranulata, Portunus pelagicus, Charybdis helleri, Thalamita poissonii, Atergatis roseus, Heteropanope laives, Macrophthalmus graeffei* (first record from Syria, observed at Lattakia sites), *Leptochela aculeocaudata, L. pugnax, Alpheus migrans* (first record from Syria, observed at Banias sites).
- **Bivalvia** (10 species 7.53 %): *Anadara secticostata, Brachidonta pharaonis, Chama pacifica, Gafrarium pectenatum, Pinctada radiata, Mallius regula, Crassostrea cucullata, Saccostrea cucullata, Spondylus spinosus, Tapes bruguierei, Tellina rastellum.*
- **Gastropoda** (20 species 8.62 %): *Cerethium scabridum, C. kochi, Euchilus atratus, Diodora ruepelli, Conus flavidus, C. kermadecensis, Peristernia nussatula, Bullia rogersi, Nassarius deshayesiana, Strombus decorus persicus, S. oldi, S. gibberulus, Thais carnifera, Cypraea caurica, C. pulchra, C. helvola, C. chinensis, C. gangranosa, Rissonia bertholetii, Pirenella conica,*
- **Ascidiacea** : *Phallusia nigra* is dominant, especially inside the port of Banias.

Distribution and dominance

The Lessepsian migrant shrimp *Penaeus japonicus* is commercially important, and is more abundant at the depth 50-70 m on muddy and sandy bottoms. *Portunus pelagicus* is common at depths comprised between 50 and 70 m. The tow species *Erugsquilla mantis* (Atlantic) and *S. massawenses* (Lessepsian migrant) are found together at depths over 50 m. The crab *Subgranulata fugax* is dominant on muddy bottoms at depth over than 50 m, together with *Charybdis helleri. Leptochela aculeocaudata, Heteropanope laives* are common on rocky bottoms. *Brachidonta pharaonis* is dominant along the rocky shores at all sites, as also the tow species *Malleus regula* and *Gafrarium pectinatum. Pinctada radiata* can be locally abundant. *Cerithium scabridum* is dominant along the shores in the littoral and infralittoral of all sites. *C. kochi* appears as common species on muddy-sand bottoms between 13 and 20 m near BETS (Banias electro-thermal station), being still more abundant at 70 m.

Thais carnifera occurs near shore, together with the local species *T. haemostoma. Bolinus brandris* is common on soft bottoms between 50 and 70 m. *Strombus decorus* is dominant on muddy - sandy bottom down to 70 m. *Diodora ruipplli* is common on rocky shores

Another species still waiting to defined. These species are more abundant near the Banias electro thermal station [9] (Fig. 1).

Laboratory studies and the correlation index between specimen conditions and their content of petroleum hydrocarbons and heavy metals suggest that the migrant species in the littoral are either pollution-tolerant sessile species or opportunistic species [10].

56 Species of Mollusca and Crustacea live both along the Syrian coast and in the Black Sea, 12 species of Mollusca belonging to the Mediterranean Western Basin fauna have been recorded recently from the Syrian Coast.

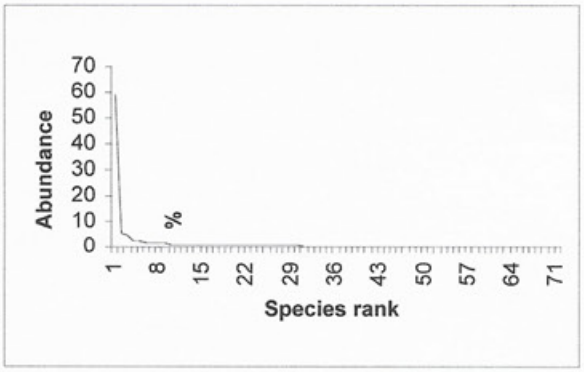


Fig. 1. Dominance curve of species at BETS.

References

1 - Fredj G., Bellan-Santini D., Menardi M., 1992. Etat des connaissances sur la faune marine méditerranéennes. *Bulletin de l'Institut Océanographique de Monaco* 7: 1-88.

2 - Bitar G., Kouli S., 2001 Nouvelles données sur la faune et la flore benthiques de la côte libanaise. Migration Lessepsienne. *Thalassia Salentina*, 25:71-74.

3 - Hadjichristophorou M., Argyrou, M., Demetropoulos A., Bianchi T.S. 1997. A species list of the sublittoral soft-bottom macrobenthos of Cyprus. *Acta adriara*, 38: 3-32.

4 - Por D.F. 1978. Lessepsian migration. the influx of red sea biota into the mediterranean by way of the suez canal. Springer–Verlag Berlin Heidelberg New York. 226 p.

5 - Galil B., Froglia C. and Noel P,. 2002. CIESM Atlas of exotic species in the Mediterranean. Vol. 2: Crustaceans. CIESM Publishers, Monaco.192 p.

5 - Zenetos A. Gofas S., Russo G., Templado J,. 2003. CIESM Atlas of exotic species in the Mediterranean. Vol. 3: Molluscs. CIESM Publishers, Monaco. 376 p.

7 - Ammar I., Saker F., 1994 Quantitave study of zoobenthos in Lattakia sublittoral zone (Syria). *Tishreen Univ. Sci. J.*, 2: 146-183.

8 - Ammar I., Saker F., 1996. Specific composition and abundance of zoobenthos in sublittoral zone of Lattakia Coast (Syria). 36th Science Week Publications, pp. 516-540.

9 - Ammar I., Mohammad I., Saker F., 2002. Multivariate & Univariate Analysis of Changes in the Composition of the Zoobenthic Communities at Banias Sublittoral Zone (Syria). *Tishreen Univ. Sci. J.*

10 - Ammar I., Mohammad I., and Saker F., 2000. Determination of Petroleum Hydrocarbons and its Temporal and Spatial changes in marine organisms of Banias Coast (Syria). 40th Science Week Publications. Pp. 349-366.

DYNAMICS AND BIOMASS OF ZOOPLANKTON IN THE NORTH LAGOON OF TUNIS (SOUTH WESTERN MEDITERRANEAN LAGOON)

Neila Annabi-Trabelsi [1] *, Mohamed Néjib Daly Yahia [2], Naceur Ben Maiz [3] et Mohamed Salah Romdhane [4]

[1] Département de Biologie, Faculté des Sciences de Sfax Tunisie, - * annabi.neila@voila.fr

[2] Groupe de recherche d'Hydrologie et de Planctonologie. Faculté des sciences de Bizerte, Tunisie - Nejib.Daly@fsb.rnu.tn

[3] Société de Promotion du Lac de Tunis. El Bouhaira, Tunis, Tunisie

[4] Institut National Agronomique de Tunisie, Agrocampus, Tunis, Tunisie - romdhane.medsalah@inat.agrinet.tn

Abstract

The aim of this study is to show the sensibility of zooplankton community to abiotic conditions and its inter-annual variations in coastal marine ecosystems such as the north lagoon of Tunis.

Key words: Zooplankton, copepods, dry weight

Introduction

The north lagoon of Tunis (2600 ha) is a shallow (average depth 1.5 m) restored lagoon located in the south western Mediterranean Sea. It communicates with the bay of Tunis by Kherreddine canal and its hydrodynamic conditions are influenced by atmospheric and tidal rhythms. This study is a part of a monitoring program concerning physico-chemical parameters and plankton communities, especially copepod diversity and dynamics, showing the importance of inter-annual variability. The abundance and biomass of zooplankton and environmental factors are compared between summer 2001 and 2002.

Materiel and methods

A weekly sampling strategy was undertaken during summer 2001 and 2002 in the monitoring routine station (Fig. 1). All zooplankton and physico-chemicals analyses were done by standard methods described in literature.

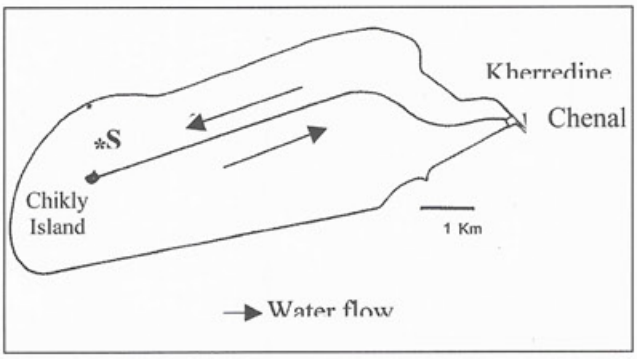


Fig. 1. The sampling station (s) in the north lagoon of Tunis.

Results and discussion

Surface water salinity, temperature, nitrites and phosphates values reveal a slight decrease between the two periods of study. However, an important increase in ammonia and nitrates concentrations was noticed (Table 1).

The zooplankton was dominated by copepods, appendicularians and medusae. The comparison between the two periods indicated a drastic decrease of total zooplankton from 10335 ind/m^3 to 2076 ind/m^3 partially explained by the phytoplankton biomass depletion (from 0.7µg/l to 0.4 µg/l chlorophyll a) and the abundance of macrozooplankton competitors (Schyphomedusae) in the second study period. However, in term of biomass, estimated as dry weight (1), a very little decrease was observed. In fact, the average values reached respectively 1512µg/m^3 and 1454 mg/m^3 in summer 2001 and 2002 (Fig. 2).

Table 1. Average summer values of physico-chemicals. Parameters in the north lagoon of Tunis.

Parameters	T (°C)	S (psu)	N-NH4 (µg/l)	N-NO3 (µg/l)	N-NO2 (µg/l)	P-PO4 (µg/l)
Summer 2001	27.1	40.4	280.6	43.4	5.2	15.5
Summer 2002	26.3	39	509	72	3.8	12.7

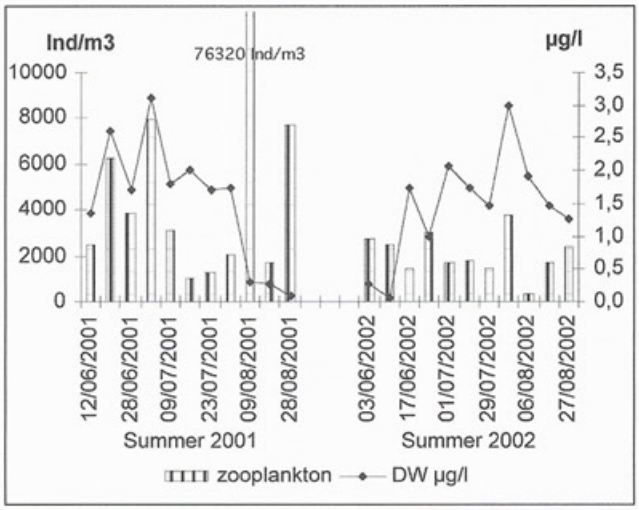


Fig. 2. Summer zooplankton and dry weight. Variations in the north lagoon of Tunis.

During these two seasons total zooplankton was dominated by copepod nauplii (91.52 % in summer 2001; 47, 90 in summer 2002) confirming the nursery role of the lagoon (2). Copepodites and adult copepods represented respectively 3% and 15.36% in summers 2001 and 2002.

The composition of dominant copepod species was also different in the two years. During summer 2001, the copepod community was dominated in order of rank by *Labidocera brunescens* (28.6%), *Centropages kroyeri* (12%), *Acartia clausi* (12%) and *Euterpina acutifrons* (10%). Whereas, in summer 2002, the dominant copepods were *Centropages kroyeri* (20%) *Oithona nana* (19%), *Acartia discaudata(16%)*, *Acartia clausi*(10%) and *Euterpina acutifrons* (10%).

This study reveals that the north lagoon of Tunis can be considered as a mesocosm where herbivorous planktonic populations are in competition for the limited phytoplankton stock. We hypothesize that the microbial loop must play an important role in this ecosystem.

Références

1 - Omori, M., Ikeda, T., 1984. Methods in marine zooplankton ecology. New-York, 325 p.

2 - Annabi-Trabelsi N., Ayadi H., Ben Maïz N. et Trabelsi E. B., 2001. Paramètres physico-chimiques, phytoplancton et copépodes d'un milieu lagunaire restauré : le Lac Nord de Tunis. *Rapp. Comm. int. Mer Médit.*, 36.

SITUATION IN SHALLOW-WATER *CYSTOSEIRA* SETTLEMENTS ON THE EASTERN ADRIATIC COAST

Boris Antolić *, Ante Žuljević, Ivana Grubelić, Marija Despalatović
Institute of Oceanography and Fisheries, Split, Croatia - * antolic@izor.hr

Abstract
In this paper is given the review of conditions of shallow-water *Cystoseira* settlements at 5 stations under different influence of pollutions along the eastern Adriatic coast.

Keywords: pollution, Cystoseira settlements, Adriatic coast

Introduction

The *Cystoseira* settlements are the climax vegetation on the hard bottom in the Mediterranean Sea. Together with *Posidonia oceanica* meadows, they are the main carrier of biodiversity in the infralittoral zone. Since these settlements are best developed between the surface and 10m depth, they are often exposed to marine pollution. In this paper, the analysis of influence of pollution on the epilithic part of shallow-water *Cystoseira* setllements on eastern Adriatic coast are given.

Material and methods

The investigations were performed between 1995 and 1999 on 5 areas of the eastern Adriatic coast (Zadra, Šibenik, Split, Pelješac peninsula, Dubrovnik) (Fig. 1). The samples were collected by SCUBA diving on 400 cm^2 squares from surface to 2m depth. The epilithic algal taxa with a presence higher than 1% were considered. The investigations covered the settlements of *Cystoseira adriatica* Sauvageau, *Cystoseira barbata* (Stackhouse) C. Agardh, *C. compressa* (Esper) Gerloff *et* Nizamudin, *C. crinitophylla* Ercegović, *C. humilis* Kützing *and C. spicata* Ercegović subsp. *crassa* Ercegović, which are the leading components of the benthic algal vegetation on the hard bottom of the eastern Adriatic coast (1). Special attention was paid to algal taxa from ecological supergroup ETNsl (including the eutrophic and tionitrophilic algae in a large sense) (2). The structure of *Cystoseira* setllements was studied by some phyto-sociological parameters: mean total cover of the whole sample (Rt%), mean total cover of the individual epilithic algal taxa (RMi%), qualitative (DN%) and quantitative (DR%) dominance of ecological supergroups (Phsl, Ssl, RMsl, ETNsl) and groups (ISR, D) (3).

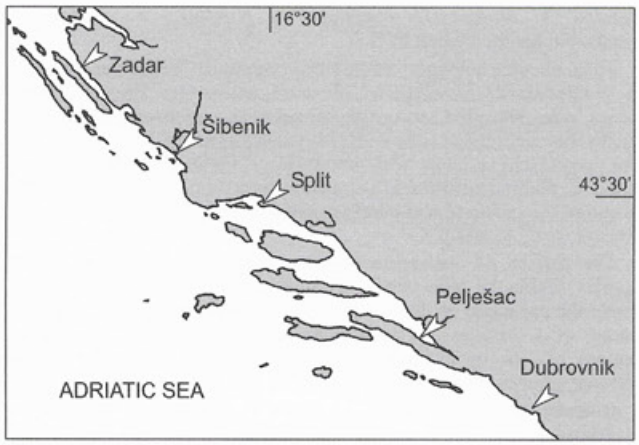


Fig. 1. Investigated area.

Results and discussion

The total number of epilithic algal taxa varied between 44 (*C. adriatica*; Šibenik) and 67 (*C. barbata*; Zadar), while the mean total cover of sample (Rt%) varied from 183.91% (*C. spicata* subsp. *crassa*; Dubrovnik) to 217.90% (*C. crinitophylla*; Split). Mean total covering of investigated *Cystoseira* (RMi%) varied between 66.60% (*C. crinitophylla*; Split) and 85.00% (*C. barbata*; Pelješac). The quantitative dominance (DR%) varied between 30.6% (*C. crinitophylla*; Split) and 45.0% (*C. spicata* subsp. *crassa*; Dubrovnik) (Figure 2). The algal taxa of Ssl ecological supergroup showed qualitative dominance (DN%) in the structure of the *Cystoseira* settlement. They were followed by the taxa of the Phsl ecological supergroup, with some lower values of DN%. In the Ssl

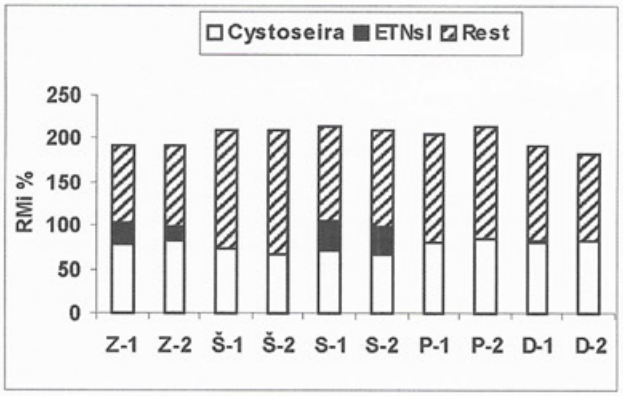


Fig. 2. Structure of epilithic part of Cystoseira settlements on the eastern Adriatic coast.
(Z-1, Zadar-*C.compressa*; Z-2, Zadar-*C.barbata*; Š-1, Šibenik-*C.crnitophylla*, Š-2, Šibenik-*C.adriatica;*
S-1, Split-*C.compressa*; S-2, Split-*C.crinitophylla*; P-1, Ploče-*C.crinitophylla*; P-2, Ploče-*C.barbata*; D-1, Dubrovnik-*C.humillis*; D-2, Dubrovnik-*C.spicata*.subsp.*crassa*)

ecological supergroup, the DN% values varied between 37.0% (*C. compressa*; Split) and 50.0% (*C. crinitophylla*; Pelješac), and in the Phsl ecological supergroup the values veried from 32.8% (*C. humillis*; Dubrovnik) to 45.5% (*C. adriatica*; Šibenik). The algal taxa of the Phsl ecological supergroup predominated by quantitative dominance (DR%). These values varied from 62.2% (*C. compressa*; Zadar) to 71.6% (*C. spicata* subsp. *crassa*).

The analysis of *Cystoseira* settlements regarding the N, DN%, Rt%, DR% and RMi% of individual algal taxa of ETNsl showed relatively large fluctuations. The highest values (8 and 9) were recorded in the Zadar and Split areas, much lower in the Pelje‰ac and Dubrovnik areas (1, 2 or 3). In the ·ibenik area these algal taxa were not observed. In areas with the best representation of this ecological supergroup (Zadar, Split), the DN% values varied between 11.3% (*C. compressa*; Zadar) and 13.0% (*C. compressa*; Split), than the DR% values varied from 8.8% (*C. barbata*; Zadar) to 15.1% (*C. compressa*; Split). The algal taxa that mostly contributed to the ETNsl quantitative dominance by their individual mean total covering (RMi%) in Zadar area in *C.compressa* settlement were: *Ulva rigida* (12.50%), *Chondracanthus acicularis* (6,47%), *Dictyopteris polypodioides* (3.38%) and *Dictyota dichotoma* var. *intricata* (2.21%); whereas, in *C. barbata* settlement were: *U. rigida* (7.08%), *Ch. acicularis* (4.00%), *D. polypodioides* (3.67%) and *D. dichotoma* var *intricata* (1.33%). Within the Split area, the *C. compressa* settlement consisted of *U. rigida* (14.33%), *Ch. acicularis* (8.67%), *D. polypodioides* (5.33%), *Hypnea musciformis* (1.67%) and *Gastroclonium reflexum* (1.33%), whereas in the *C. crinitophylla* settlement *Ch. acicularis* (13.60%), *U. rigida* (9.70%), *D. polypodioides* (2.60%), *H. musciformis* (2.20%), *G. reflexum* (1.60%) and *D. dichotoma* var. *intricata* (1.20%) were present.

References

1 - Ercegović, A. 1952. Jadranske cistozire. Njihova morfologija, ekologija i razvitak. - Sur les cystoseira adriatiques. Leur morphologie, écologie et évolution. *Fauna et Flora Adriatica*, IOR, Split, 2: 1-212.
2 - Boudouresque, F.C. 1984. Groupes ecologiques d'algues marines et phytocenoses benthiques en Méditerranée nord-occidentale: une revue. *Giorn. Bot. Ital.*, 118 (Suppl. 2): 7-42.
3 - Boudouresque, C.F. 1971. Méthodes d'étude qualitative et quantitative du benthos (en particulier du phytobenthos). *Téthys*, 3(1): 79-104.

ON THE ECOLOGY OF SEVERAL MEGABENTHIC SPECIES FROM THE SCIAPHILIC ALGAE COMMUNITY (NORTH AEGEAN SEA, GREECE)

Antoniadou C. *, Voultsiadou E., and Chintiroglou C.C.

Aristotle University, School of Biology, Department of Zoology, Thessaloniki, Greece - chintigl@bio.auth.gr

Abstract

This study examines the structure of the dominant megabenthic species from the sciaphilic algae community, spatially. The data were collected with a visual method and the randomly placed frames technique. The analysis of population densities indicated the separation of the sites in three main groups, in relation to substrates' inclination. Most of the examined species were randomly distributed as only *Agelas oroides* and *Leptopsammia pruvoti* showed a contagious pattern, while *Halocynthia papillosa* and *Microcosmus sabatieri* were evenly distributed.

Keywords: megabenthos, infralittoral, Aegean Sea, hard substrate

Introduction

The megabenthos from the sciaphilic algae community owns several species with important economic value; either as food source, e.g. *Microcosmus sabatieri*; or as a source of marine natural products, e.g. sponges of the genus *Agelas*, *Ircinia*, *Dysidea*, etc (1). Thus, there is a growing need to collect ecological data, in order to manage and conserve these populations (2). This study examines the spatial structure of the dominant megabenthic fauna from the sciaphilic algae community, in order to create a database appropriate for monitoring these ecosystems.

Materials and Methods

Data collection

Seven coastal stations were set in the North Aegean Sea. After preliminary sampling, the following species were found as dominant and thus quantitatively investigated: the sponges *Chondrosia reniformis*, *Diplastrella bistellata*, *Axinella cannabina*, *Axinella verrucosa*, *Agelas oroides*, *Petrosia dura*, *Dysidea fragilis*, *Ircinia variabilis*, the scleractinian *Leptopsammia pruvoti*, the bryozoan *Pentapora fascialis* and the tunicates *Halocynthia papillosa* and *Microcosmus sabatieri*. All these species are common inhabitants of the sciaphilic algae, the coralligenous and the semi-dark cave communities (2).

Sampling was carried out by SCUBA diving from 15 to 40 m depth, during summer 1998 and 1999. The investigated species are epibenthic, sessile and large enough, to enable visual (non-destructive) techniques to obtain the data (2). The method of randomly placed frames was applied (3) to estimate population density (1 x 1 m) and spatial dispersion (30 x 30 cm).

Data analysis

Numerical abundances data were analyzed by one-way ANOVA. Ordination techniques were then applied, based on Bray-Curtis similarity (4). The significance of the multivariate results was assessed with ANOSIM, while SIMPER analysis identified the contribution of each species to the overall similarity within a site (4). Morisita's index was calculated to estimate the spatial dispersion, whilst a chi-square test was used to determine the significance of deviation from random (3).

Results and Discussion

One-way ANOVA showed that the numerical abundance is not equally distributed in space, for the majority of the species (Table 1). Non-metric MDS indicates the separation of the sites in three groups (Fig. 1), while one-way ANOSIM confirmed the above discrimination

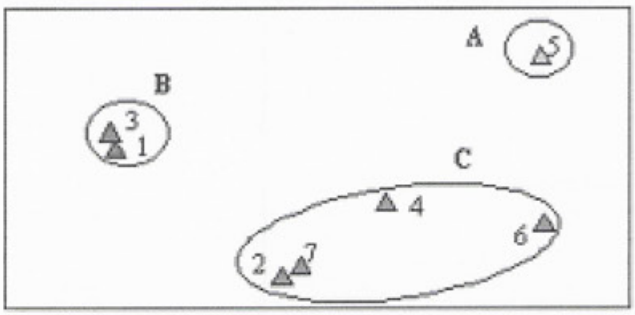


Fig. 1. Non-metric multidimensional scaling, based on Bray-Curtis similarity index, calculated from log transformed numerical abundance data. Stress value: 0.01.

Table 1. Pattern of dispersion (averaged over the sampling sites) of the dominant megabenthic species and one-way ANOVA values (F, p) testing for differences among sites.

Species	Pattern of dispersion	ANOVA	
		F	p
Agelas oroides (Schmidt, 1864)	contagious	28.79	0.000
Axinella verrucosa (Esper, 1794)	random	10.41	0.000
Axinella cannabina (Esper, 1794)	even	10.26	0.000
Chondrosia reniformis Nardo, 1833	random	45.22	0.000
Diplastrella bistellata (Schmidt,	random	12.14	0.000
Dysidea fragilis (Montagu, 1818)	random	7.6	0.000
Ircinia variabilis (Schmidt, 1862)	even	23.39	0.000
Petrosia dura (Nardo, 1833)	random	23.39	0.000
Leptopsammia pruvoti Lacaze-	contagious	1.74	0.20
Pentapora fascialis (Pallas, 1766)	random	45.01	0.000
Halocynthia papillosa (Linnaeus,	even	5.69	0.000
Microcosmus sabatieri Roule, 1885	even	2.32	0.07

(R: 0.81 p<0.1%). SIMPER analysis showed that the average similarity in-group B reaches 90.4%, while 5 species (L. *pruvoti, A. oroides, D. bistellata, C. reniformis, P. fascialis*) contribute for the overall 65%. The similarity in-group C reaches 80.6%, while 4 species (*A. oroides, D. bistellata, H. papillosa, A. cannabina*) contribute for the overall 62%.

Thus, all sites belong to a common community, where the sponges: *A. oroides* and *D. bistellata* are the dominant species. However, three facies were recorded, according to substrates inclination. The first facies was recorded at sites with steep inclination (>80–), i.e. group B; the second one at sites with intermediate inclination (60-80–), i.e. group C; and the third one at a site with slight sloping (55–), where the origin of the substrate was purely organic (dead colonies of *Cladocora caespitosa*), i.e. group A.

The pattern of dispersion was random for the majority of the species (Table 1), with certain exceptions which were the result of either the particular ecological needs of the species, e.g. the sciaphilic nature of *A. oroides* and *L. pruvoti*, which leads to an aggregative pattern (2), or of territoriality e.g. the solitary ascidians, which showed an even dispersion (5).

References

1 - Faulkner, D.J., 1995. Marine natural products. Nat. Prod. Rep., 12: 223-270.

2 - Antoniadou, C., 2003. Structure of hard substrate benthic assemblages at the lower infralittoral zone in the North Aegean Sea. Thesis, Aristotle University, Thessaloniki, Greece. pp. 1-446.

3 - Bakus, J., 1990. Quantitative ecology and marine biology. Balkema, G.A. Rotterdam. pp. 1-151.

4 - Clarke, K.R., Warwick, R.M., 1994. Change in marine communities: an approach to statistical analysis and interpretation. Natural Environmet Research Council, UK. pp. 1-144.

5 - Monniot, C., Monniot, F., Laboute, P., 1991. Coral reef Ascidians of New Caledonia. Institut Français. (ORSTOM eds). Collection faune tropicale no XXX- Paris. pp. 1-247.

FIRST ASSESSMENT OF THE NATURAL STOCK OF *MICROCOSMUS SABATIERI* IN SOUTH AEGEAN (GREECE)

Antoniadou C. [1], Chintiroglou C.C. [1] *, Voultsiadou E. [1] and Vafidis D. [2]

[1] Aristotle University, School of Biology, Department of Zoology, Thessaloniki, Greece - * chintigl@bio.auth.gr
[2] Fisheries Research Institute of Kavala, Nea Peramos, Kavala, Greece

Abstract

The spatial variation in population density and frequency distribution of the edible tunicate *Microcosmus sabatieri* was studied in South Aegean. Data was obtained with randomly placed frames. Overall, 316 specimens were collected and measured. Mean population density was 7 ± 1.87 indiv./m^2, while the pattern of dispersion was even. The size-frequency analysis indicated a mode at 10 cm.

Introduction

The continuous decrease of fish stocks has a severe economic impact on fisher's livelihood throughout the Mediterranean. Therefore a necessity emerges to turn from traditional fisheries resources to other alternatives (1). *Microcosmus sabatieri* Roule, 1885 is a Mediterranean endemic species, previously reported from the Aegean Sea (2). It is edible and of commercial interest in many Mediterranean areas (3). However, there is no data on its population structure.

This study present preliminary data on the status of *M. sabatieri* stocks in South Aegean, an area where it is strongly harvested.

Materials and Methods

Samples were collected with SCUBA diving at 3 sites (A: 36º30'459"N 26º19'859"E; B: 36º34'498"N 26º15'287"E; C: 36º31'733"N 26º28'317"E) along the coastline of Astypalaia, at a depth ranging from 30 to 55 m, in August 2003. The method of randomly placed frames (0.5 x 0.5 m) was applied to estimate population density and spatial dispersion, since *Microcosmus sabatieri* is an epibenthic and sessile species, thus permitting *in–situ* counting (4). In addition, all individuals found in a 30-min dive were collected and preserved in a 10% formalin solution.

Length-frequency distributions were constructed per site. Morisita's index was calculated at site B to estimate spatial dispersion. A chi-square test was used to determine the significance of deviation from random distribution (4).

Results and Discussion

Overall, 316 individuals of *Microcosmus sabatieri* were collected and measured. The mean population density from the three sampling sites was 7 ± 1.87 indiv./m^2. The lowest value (4 ± 1.17 indiv./m^2) was recorded at site A, the largest one (10 ± 2.1 indiv./m^2) at site B, whereas it was intermediate (6 ± 1.48 indiv./m^2) at site C. The pattern of dispersion was even (I = 1.15, x^2 = 7.2), which agrees with the territoriality behaviour of this solitary species (4).

The size-frequency histograms revealed a similar pattern among the three sites with a mode at 10 cm (Fig. 1). Size ranged from 2 to 16 cm, with the largest individuals caught at site B and the smallest ones at site C. The maximum length reported for the Mediterranean Sea is 22 cm (3), which is larger than the ones reported here (Fig. 1), a fact that might be the result of a strong fishing pressure.

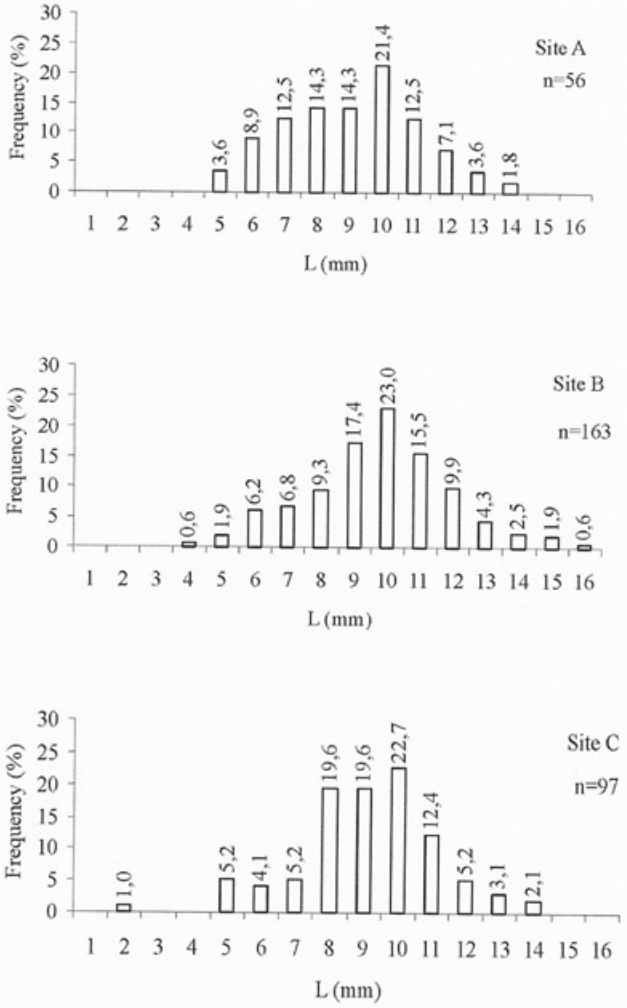


Fig. 1. Size-frequency distribution for *Microcosmus sabatieri* at different sites. n = number of individuals.

References

1 - Pauly D., Christensen V., Guenette S., Pitcher T.J., Sumaila U.R., Walters C.J., Watson R., and Zeller D., 2002. Towards sustainability in world fisheries. *Nature*, 418: 689-695.

2 - Koukouras A., Voultsiadou-Koukoura E., Kevrekidis T., and Vafidis D., 1995. Ascidian fauna of the Aegean sea with a checklist of the Eastern Mediterranean and Black Sea species. *Ann. Inst. Ocean. Paris*, 71(1): 19-34.

3 - Monniot C., and Monniot F., 1987. Ascidies (Ciones at Violet). Pp. 1-743-760. In: Fiches FAO d' identification des espèces pour les besoins de la pêche (révision I) – Méditerranée et mer Noire. Zone de pêche 37. Volume I. Eds Fischer W, Bouchon M.L. & Scneider M. Rome.

4 - Antoniadou C., 2003. Structure of hard substrate benthic assemblages at the lower infralittoral zone in the North Aegean Sea. Thesis, Aristotle University, Thessaloniki, Greece. Pp. 1-446.

PRÉSENCE DE L'ALGUE *CAULERPA RACEMOSA* (FORSSKÅL) J. AGARDH (CAULERPALES, ULVOPHYCEAE) DANS LES CÔTES CONTINENTALES DE L'ESPAGNE

Aurelio Aranda

Institut d' Ecologia Litoral. El Campello. Alicante, Espagne - aranda@ecologialitoral.com

Resumé

L'espèce envahissante en Méditerranée *Caulerpa racemosa* a été trouvée dans plusieurs localités du Pays Valencien pendant la surveillance des sites considérés de risque majeur pour l'introduction d'une autre espèce envahissante, *C. taxifolia.* En 1999 trois Km^2 étaient atteints à Castellón; en 2000 elle a été trouvée à Alicante et la cartographie réalisée en 2002 revèle que 10 Km^2 de fonds environ, le long de 18 Km de côte étaient atteints. Plus récemment en 2002 elle a été trouvée à Sagunto (Valencia) et en 2003 à la Réserve Marine de Tabarca (Alicante) avec plus de 3 000 m^2 colonisés.

Mots clés: Benthos, Caulerpa racemosa, Méditerranée occidentale, espèces envahissantes

Introduction

Caulerpa racemosa est une algue verte de distribution pantropicale, naturelle des eaux temperés-chaudes (1) et dont la présence en Méditerranée a été attribuée à une migration lessepsienne. Après la première signalisation en Méditerranée en Tunisie (2), toutes les localités connues pour cette espèce étaient localisées dans le secteur sud-oriental. Depuis 1990, l'expansion de *Caulerpa racemosa* se poursuit rapidement en Méditerránée occidentale (1) et on la considère comme une espèce qui dépasse largement le potentiel envahissant d'une autre espèce récemment introduite en Méditerranée, *Caulerpa taxifolia* (Vahl) C. Agardh (3).

Résultats

Depuis 1993 la "Conselleria de Medi Ambient de la Generalitat Valenciana" a mis en marche un programme de surveillance des côtes de l'autonomie pour detecter la présence ou la possible implantation de *C. taxifolia.* La surveillance est faite par des chercheurs de l'Institut d'Ecologia Litoral le long des côtes de la région sur un nombre variable de sites selon les années. En ce moment 41 sites considérés comme de risque majeur d' implantation sont surveillés chaque année en plongée ou avec un système de vidéo sous-marine. La plupart des sites correspond à des ports de plaisance et des aires proches ainsi qu'à des aires de mouillage forain. *Caulerpa taxifolia* n'a pas été encore trouvée sur les côtes de la région (5). Après les campagnes de sensibilisation dirigées vers les pêcheurs et plongeurs depuis 1993, on a reçu de nombreuses alarmes sur la présence de l'espèce, mais aucune se correspondait avec *C. taxifolia.* Cependant, après vérification, certaines alarmes correspondaient à *Caulerpa racemosa.*

Après une alarme reçue en 1999 sur la présence de *C. taxifolia* face à la centrale thermique de Castellón on a verifié la présence d'une tache de *C. racemosa;* une recherche intensive avec vidéo des alentours de cette tache le long de 25 Km de transects a permis de délimiter l'aire touchée par cette espèce, à savoir 3 km^2 (6) en ce moment. Dans ce site, l'algue pousse sur matte morte de *Posidonia* avec *Caulerpa prolifera* jusqu'à 15 m de profondeur, aux environs de la plateforme de déchargement de combustible de la centrale.

Des alarmes ultérieures ont été reçues, mais aucune correspondait avec *C. taxifolia;* par contre, *C. racemosa* a été trouvée aux environs des grand ports d'Alicante et de Sagunto où elle occupe des aires importantes. Au début de 2000, *C. racemosa* a été trouvé dans la baie d'Alicante; une cartographie réalisée à la fin 2002 revèle que la surface touchée était de presque 10 Km^2 le long de 18 Km de côte, et l'algue colonise soit la matte morte de *Posidonia,* l'herbier étant clairsemé par le mouillage des grands bateaux marchands, soit les fonds détritiques envasées entre 15 et 34 m de profondeur. L'aire affectée á Sagunto reste encore à cartographier. En septembre 2003, on a trouvé l'espèce à la Réserve Marine de Tabarca (Alicante) avec plus de 3.000 m^2 colonisés sur un fond d'herbier, à 20 m de profondeur, degradé par les chaînes d'une bouée de signalisation d'un haut-fond .

Si bien *a priori C. racemosa* semble moins agressive que *C. taxifolia* puisqu'elle se trouve de forme mixte avec *C. prolifera,* sur des herbiers dégradés ou dans les fonds détritiques, on a vérifié que cette espèce provoque des effects négatifs sur le benthos méditerranéen (4) et elle montre une large répartition écologique. Les conséquences de l'entrée de cette espèce sur les communautés indigènes, notamment sur les herbiers de phanérogames et peuplements sur substrat dur, sont encore peu connues en Méditerranée.

Références

1 - Verlaque, M., Boudouresque, C.F., Meinesz, A., Gravez, V. 2000. The *Caulerpa racemosa* Complex (Caulerpales, Ulvophyceae) in the Mediterranean Sea. *Bot. Marina,* 43: 49-68.

2 - Hamel, G. 1930. Chlorophycées des côtes françaises. *Rev. Algol.* I-XV. 223 pp.

3 - Piazzi, L., Balata, D., Ceccerelli, G., Cinelli, F. 2001. Comparative study of the growth of two co-occurring introduced green algae *Caulerpa taxifolia* and *Caulerpa racemosa* along the Tuscan coast (Italy, Western Mediterranean). *Cryptogamie-Algologie,* 22 (4): 459-466.

4 - Piazzi, L., Balestri, E., Magri, M., Cinelli, F. 1997. Expansion of the tropical algae *Caulerpa racemosa* (Forsskål) J. Agardh (Briopsidophyceae, Chlorophyta) along the Tuscany coast (Italy). *Cryptogamie-Algologie,* 18 (4): 343-350.

5 - Aranda, A., Guillén, J. E., Gras, D., Bueno, M., Cuesta, F. 2001. Le réseau de surveillance pour détecter *Caulerpa taxifolia* sur le littoral du Pays Valencien. années 1993 à 1998. *Fourth Int. Workshop on Caulerpa taxifolia,* Gravez, V., Ruitton, S., Boudouresque, C.F., Le Direac'h, L., Meinesz, A., Scabbia, G., Verlaque, M. (eds.), Gis Posidonie publ., France, pp. 85-91.

6 - Aranda, A., Mallol, J., Solano, I. 1999. Presencia del alga *Caulerpa racemosa* Forsskål J. Agardh (Chlorophyta, caulerpales) en el Mediterráneo ibérico. Actas XIII Congreso Nac. Bot. Criptogámica, 53.

MYSIDACEA (CRUSTACEA) AS ECOLOGICAL AND BIOGEOGRAPHICAL MARKERS IN MEDITERRANEAN BRACKISH ENVIRONMENTS

Antonio P. Ariani [1] * and Karl J. Wittmann [2]

[1] Dipartimento di Zoologia, Università di Napoli Federico II, Naples, Italy - * ariani@unina.it
[2] Lab. Ökophysiologie und Ökotoxikologie, Institut für Medizinische Biologie der Universität Wien, Währinger Strasse 10, A-1090 Vienna, Austria - karl.wittmann@univie.ac.at

Abstract

The brackish water mysid faunas (especially *Diamysis*) are well differentiated between the eastern and the western basins of the Mediterranean. Unlike the more species-rich meta- to polyhaline waters, the meso- and oligohaline waters frequently show only a single mysid species, that is *D. mesohalobia* in the eastern and the vicariant *Mesopodopsis slabberi* in the western Mediterranean. Paleogeographical and paleoecological considerations suggest that certain mysids with low-salinity affinities may have colonized the Mediterranean from the East (brackish Paratethys) while other "brackish" species may have immigrated from the West, i.e. from the Atlantic, at the end of the Messinian salinity crisis.

Keywords: Mysidae, faunas, lagoons, salinity, paleoecology

Until recently, only relatively few species of the family Mysidae were cited from the Mediterranean brackish ponds, lagoons, and estuaries. However, recent extensive faunistic investigations led to a revision of the genus *Diamysis* Czerniavsky, and to new ideas about the colonization of the Mediterranean brackish environments by mysids (1).

Main information could be obtained from *Diamysis* species, previously lumped together under the name *D. bahirensis* (G. O. Sars). As a consequence of its emendation, this species now appears to be restricted almost entirely to the SW Mediterranean basin. *D. bahirensis* lives in poly- to metahaline waters, with salinity (S) ranging from 25 (drain near Mazara del Vallo, Sicily, previously unknown locality) to 40 (Stagnone di Marsala, Sicily).

A similar ecology, but a different geographical distribution, is reported for *D. lagunaris* Ariani & Wittmann. It inhabits the NW Mediterranean (where a new population has been discovered in 2003 on Menorca Island, Baleares) and also shows one Atlantic population in Portugal, possibly due to passive transport (Cunha, cited in 1) from the Mediterranean.

Two *Diamysis* species, this is *D. hebraica* Almeida Prado-Por and *D. sirbonica* Almeida Prado-Por, and the species complex *D. mesohalobia* Ariani & Wittmann inhabit the eastern Mediterranean. The first two taxa, both from the Levantine basin, are known only from one oligohaline stream or one metahaline lagoon, respectively. The nominal form of *D. mesohalobia* is present with very dense populations in mesohaline karstic springs of the Adriatic basin, whereas the subspecies *gracilipes* and *heterandra* mostly prefer more saline waters in the Adriatic and Ionian basins. Lastly, a stygophilic species closely allied to *D. m. mesohalobia*, i.e. *D. camassai* Ariani & Wittmann (2), is endemic of mesohaline dolinas near the Ionian coast of southern Italy.

Owing to the mineral composition ($CaCO_3$ instead of fluorite) and certain morphological features, the statoliths of all Mediterranean species of *Diamysis* remind the statoliths of Mysidae from Miocene deposits of the brackish Paratethys. This gives further evidence (1, 3) to Bacescu's hypothesis (4) of a brackish water, Paratethyan origin of these forms. Therefore, the *Diamysis* ecology and distribution pattern in the Mediterranean may be understood in relation to a colonization of this basin starting from the East (Paratethyan drainage during the salinity crisis), with adaptation to near-marine salinity upon expansion towards the West. In line with this context, laboratory experiments showed (1) that survival of brood pouch larvae in *D. lagunaris* and *D. m. gracilipes* is higher at mesohaline compared with euhaline conditions, though the test populations originated from marine or mixoeuhaline natural waters. It is also most remarkable that inspections of many meso- or hypohaline waters in the western Mediterranean yielded no *Diamysis* population, but occasionally *Mesopodopsis slabberi* (van Beneden) as the only mysid species (Étang de Berre, S = 15, and Étang de Mauguio, S = 12; Golfe du Lion). The Mediterranean forms (5) of the genus *Mesopodopsis* Czerniavsky may be considered, therefore, as vicariants of *Diamysis* in low salinity waters of the W Mediterranean, although co-occurring with *Diamysis* in the E Mediterranean.

The oligo- to mesohaline waters of the Mediterranean are usually inhabited by only one mysid species (belonging to *Diamysis* or *Mesopodopsis*), as *D. hebraica* at Nahal Taninim in Israel (S = 0.7-1.8), *D. m. gracilipes* with its "anomalous" population in the Fiume Chidro (southern Italy, S = 4), *D. m. mesohalobia* with all populations in southern Italy (S = 10-16), *Mesopodopsis slabberi* with the above cited populations.

On the contrary, the poly- to metahaline waters are usually inhabited by more than one mysid species; if only one, this is again a *Diamysis* (*D. lagunaris* in the Étang de La Palme, Golfe du Lion; S = 23) or a *Mesopodopsis* (mouth of Lao river, Tyrrhenian coast of Calabria, S = 38). With the exception of *Paramysis helleri* (G. O. Sars), showing calcareous statoliths and belonging to a typical Ponto-Caspian genus (5), all remaining mysids (including *Mesopodopsis*) associated with *Diamysis* and/or *Mesopodopsis* have fluorite statoliths and may be considered of Atlantic origin. They belong to the genera *Siriella* Dana, and *Leptomysis* G. O. Sars.

The *Siriella* species most frequently encountered are *S. armata* (M.-Edwards) and *S. jaltensis* Czerniavsky, which share brackish affinities with *S. clausii* G. O. Sars. *Leptomysis* is a typically Mediterranean marine genus (6), but one species, *Leptomysis truncata* (Heller) is also found in brackish environments: in the Golfe du Lion together with *Diamysis*, *Paramysis* and *Siriella* (Étang de Thau, Étang de Leucate) or with *Diamysis* and *Siriella*, exclusively (mouth of the Rhône in Port St. Louis). The atlantic genus *Neomysis* has been reported as *N. integer* (Leach) from only one Mediterranean brackish locality: the Arles canal near Fos (7) in the Golfe du Lion. However, recent investigations (7) in this locality as well as in the near Étang de l'Estomac did not confirm previous data.

In conclusion, mysids may be considered suitable study objects in order to reconstruct the colonization of the Mediterranean brackish environments (mainly the less saline ones) in relation to paleogeographical and paleoecological situations.

References

1 - Ariani A. P., and Wittmann K. J., 2000. Interbreeding *versus* morphological and ecological differentiation in Mediterranean *Diamysis*, with description of four new taxa. *Hydrobiologia*, 441: 185-236.

2 - Ariani A. P. and Wittmann K. J., 2002. The transition from an epigean to a hypogean mode of life: morphological and bionomical characteristics of *Diamysis camassai* sp. nov. (Mysidacea, Mysidae) from brackish-water dolinas in Apulia, SE-Italy. *Crustaceana*, 74: 1241-1265.

3 - Ariani A. P., Wittmann K. J. and Franco E., 1993. A comparative study of static bodies in mysid crustaceans: evolutionary implications of crystallographic characteristics. *Biol. Bull.* 185: 393-404.

4 - Bacescu M., 1954. Crustacea: Mysidacea. *Fauna Republicii Populare Romîne*, 4 (3), 126 p.

Wittmann K. J., 1992. Morphogeographic variations in the genus *Mesopodopsis* Czerniavsky with descriptions of three new species (Crustacea, Mysidacea). *Hydrobiologia*, 241: 71-89.

5 - Wittmann K. J., 1986. Untersuchungen zur Lebensweise und Systematik von *Leptomysis truncata* und zwei verwandten Formen (Crustacea, Mysidacea). *Ann. Naturhist. Mus. Wien*, 87 B: 295-323.

6 - Bacescu M., 1940. Les Mysidacés des eaux méditerranéennes de la France (spécialement de Banyuls) et des eaux de Monaco. *Bull. Inst. Océanogr.*, Monaco, 795: 1-46.

7 - Wittmann K. J. and Ariani A. P., 2000. *Limnomysis benedeni*: Mysidacé ponto-caspien nouveau pour les eaux douces de France (Crustacea, Mysidacea). *Vie et Milieu*, 50: 117-122.

ESTABLISHMENT OF THE PROTECTED PARTS OF THE KOSTRENA MUNICIPALITY AQUATORIUM

M. Arko-Pijevac [1] *, Č. Benac [2], M. Kovačić [1], M. Kirinčić [1], Ž. Gržančić [3]

[1] Natural History Museum Rijeka, Rijeka, Croatia - * primuzri@ri.tel.hr
[2] University of Rijeka, Faculty of Civil Engineering, Rijeka, Croatia
[3] Učka Nature Park Public Institution, Lovran, Croatia

Abstract

The sublittoral of the Kostrena Municipality Aquatorium was studied by geomorphological, sedimentological and biological researches. 35 species of macroalgae and 196 species of macrofauna were recorded, alongwith 9 benthic biocoenoses with several developed associations of green algae and facies of corals and sponges. It has been proposed that the submarine area of Kostrena should be proclaimed a national monument, with a special law.

Keywords: Marine protection area, Benthic biocoenology, Geology, Northern Adriatic Sea

Introduction

This programme covered geomorphological, sedimentological and biological researches into the sublittoral to evaluate the littoral and sublittoral zones of a part of the Kostrena Municipality Aquatorium. The investigated area is situated on the northern part of the Rijeka Bay (the northern Adriatic Sea), strongly affected by domestic and industrial waste. Five locations have been chosen to propose a protection program for this interesting coastline.

Methodology

Five transects were investigated from the surface to 40 m depth, in July-August 1999, by direct observations using SCUBA diving techniques. Temperature and of light intensity were measured. *In situ* observations and notes were supplemented with photodocumentation. The most common species were determined in the field. The species that required more detailed analysis were collected and identified in the laboratory. Benthic communities were classified according to Pérès and Picard (1), and Bellan-Santini *et al.* (2). The composition of the fish assemblage was investigated by visual census (3).

Results and Discussion

The Kostrena coast is predominantly formed in Carbonaceous Upper Cretaceous and Paleogenic rocks. The submarine relief is diversified. The basic characteristic is a submarine precipice, up to 70 m from the coastline. Its peak is at 15 m, and its foot at 30 to 35 m depth. On the exposed parts of the shore, where the erosive impact of the waves is significant, the sea bottom is predominantly rocky, even as deep as 10 to 15 m. At the bottom, the spurs of a carbonate rocky base can often be seen, which is elsewhere covered by sliding shelly sand layer, less than 1 m thick and of loose consistency. Closer to the shore, in the wave belt, above the basic rocky mass, pebbles can be seen, and sporadically even beaches, which consist of sliding gravel. Real cliffs are formed through erosive wave impact, and at their foot, at the steep submarine slopes formed from rolled-off material, submarine screes are created. Small-grain sandy sediments are situated under submarine slopes. In the deeper submarine areas, at depths greater than 35 m, the bottom is mildly sloping, almost levelled. At the surface there is a fluid glutinous mud.

The biological researches showed the presence of 35 species of macroalgae and 196 species of macrofauna (Cyanophyceae 1, Rhodophyta 13, Phaeophyta 9, Chlorophyta 9, Porifera 24, Cnidaria 15, Nemertina 1, Echiurida 1, Sipunculida 1, Mollusca 44, Annelida 10, Crustacea 32, Tentaculata 5, Echinodermata 10, Tunicata 4, Pisces 49). Nine benthic biocoenoses were recorded with several developed associations of green algae and facies of corals and sponges: biocoenosis of supralittoral rock, biocoenosis of upper mediolittoral rock, biocoenosis of the lower mediolittoral rock, biocoenosis of infralittoral algae (association with *Acetabularia acetabulum*), association with *Halimeda tuna* and association with *Dasycladus vermicularis*), praecoralligenous aspect of coralligenous biocoenosis (facies with *Eunicella cavolinii;* facies with *Parazoanthus axinellae*), coralligenous biocoenosis, the biocoenosis of semi dark caves (facies with *Verongia cavernicola*), the biocoenosis of coastal detritic bottom and the biocenosis of scree. According to the Mediteranean Action Plan (MAP) list, facies *Eunicella cavolinii* and 8 floral and faunal species are classified as especially valuable. Individual and poorly developed specimens of brown algae point to the degraded condition of the surface layer up to 3 m in depth (*Fucus virsoides* and *Cystoseira* sp.)

A total of 49 fish species were recorded during SCUBA diving. The fish species assemblage and their abundance depended on habitat and greatly varied with depth, even within the depth range of the infralittoral zone. Most of the bottom was made of steep rocky slope. Usually bare or with poorly developed algal cover. Therefore, small, epibenthic species (families Gobiidae, Blenniidae, Tripterygidae) were well represented. On the contrary, small labrids of genus *Symphodus* were rare. Devastation of fish community by anthropic factors (fishing and disturbance) was evident by disappearance of larger species of rocky habitat (*Labrus* spp., *Sciena umbra*, *Scorpaena scrofa*) and by presence of only small and medium sized specimens of several *Diplodus* species (*D. puntazzo, D. sargus, D. vulgaris*). Trophic structure of the fish assemblage showed richness of mesocarnivores and microcarnivores, a low number of herbivores and omnivores, and absence of macrocarnivores.

Most identified crustaceans are Decapoda (27 taxa), 6 of which are recorded as rare species (*Periclymenes ametisteus, Alpheus macrocheles, Pagurus sculptimanus, Xanto pilipes, Herbstia condiliata, Pinotheres pinotheres*). Crustaceans were found from the supralittoral biocoenosis of hard beds and rocks (*Chthamalus stellatus, Chthamalus depressus, Balanus perforatus, Pachigrapsus marmoratus, Ligia italica*) to the coralligenous biocenosis in lower infralittoral zone (*Galathea strigosa, Munida rugosa*) at 40 m depth.

Faunistic and floristic data point to the well preserved biodiversity in the Kostrena Municipality Aquatorium, suggesting the necessity of protection measures. The purpose of establishing the protected area is to preserve highly valued communities as centers for the entire restoration of species in biocoenoses. The protected sea and submarine areas are statutory defined (the Constitution of the Republic of Croatia, declaration on environmental protection in the Republic of Croatia, Enviromental Protection Act, Preservation of Natura Act) and documents on spatial planning (Spatial Plan of the Primorsko-Goranska County). The form and degree of protection of maritime environments depend on the existing state (state before the protection programme is introduced). Is important that the internationally recognised and internationally set categories are used, enabling easier implementation of protection and better integration into national and international system of protected areas of the same category. According to the proposals submitted in environmental plans prepared by the Primorsko-Goranska County and the Municipality of Kostrena, it has been propounded that the submarine park of Kostrena should be proclaimed a national monument pursuant to the effective law.

References

1 - Pérès, J.M. and Picard, J., 1964. Nouveau manuel de bionomie benthique de la mer Méditerranée. *Rel. Trav. Stn. Mar. Endoume,* 47: 5-137.

2 - Bellan-Santini, D., Lacaze, J.-C. and Poizat, C., 1994. Les biocénoses marines et littorales de Méditerranée: synthèse, menaces et perspectives. Muséum National d'Histoire Naturelle, Paris, 246 p.

3 - Bortone, S. A., Kimmel, J. J. and Bundrick, C. M. 1989. A comparison of three methods for visually assessing reef fish communities: time and area compensated. *Northeast Gulf Sci.,* 10 (2): 85-96.

BIOLOGICAL AND GEOLOGICAL VALORISATION OF THE COASTAL LINE AND SUBMARINE AREA OF THE ISLANDS CUTIN MALI I CUTIN VELI AIMING TO ESTABLISH A PROTECTED AREA

M. Arko-Pijevac [1] *, Č. Benac [2], M. Kovačić [1], M. Kirinčić [1], Ž. Gržančić [3]

[1] Natural History Museum Rijeka, Rijeka, Croatia - * primuzri@ri.tel.hr
[2] University of Rijeka, Faculty of Civil Engineering, Rijeka, Croatia
[3] Učka Nature Park Public Institution, Lovran, Croatia

Abstract

Geological, sedimentological and biological investigations of the submarine zone of Ćutin Veli and Ćutin Mali islets (Kvarnerić, Adriatic Sea), aimed at biological and geological assessment, led to the proposal of a protected area. In the coastal area of Ćutin Veli and Ćutin Mali islets 8 biocoenoses were determined, 5 of which, according to the Mediterranean Action Plan, are classified as especially valuable communities with 19 floral and faunal species.

Keywords: Marine protected areas, Benthic biocoenology, Geology, Adriatic Sea

Introduction

Although the Kvarner area is relatively well investigated, the eastern, northern and western coasts of the island of Cres are practically unstudied. No published data on the biology and geology of the islets of Ćutin Veli and Ćutin Mali, situated in the Kvarnerić (Adriatic Sea), off the south-eastern coast of the island of Cres are available. Geological and biological researches of the Ćutin islets were carried out in the periods October 16-19, 2001 and June 17-20, 2002.

Methodology

The research of benthic biocoenoses was carried out by using the method of direct observation and photodocumentation by means of SCUBA-diving equipment. On the basis of field notes and material determination we determined the benthic communities according to the classification of Pérès and Picard (1) and Bellan-Santini *et al.* (2). The methodology of crab gathering was carried out by using the technique of autonomous diving at transects up to 40 m in depth, or 100 m from the shore, and by special crab traps (3). The composition of the fish assemblage was investigated by using the visual census method. A modified method of point counts was employed (4).

Results and Discussion

The islets of Ćutin Veli and Ćutin Mali are part of the submerged karstic plateau extending along the eastern coast of the island of Cres. That is why the sea bottom surrounding the islands is very shallow. The eastern edge of the karstic plateau is a submerged scrap extending from the Meli cape toward south-east. Submerged scrape sinks vertically to the depth of 35 to 50m. After that, the sea bottom is slightly inclined to horizontal. In the submarine zone of the researched area there are three basic types of sea bottom: bare rocks with no sediment layer to the depth of 8.5 m, the basic rocky mass is covered with coarse sands to gravel in greater depths, and finely grained muddy sediment on the bottom exceeding 40 m in depth.

In the area of investigation 52 species of macroflora (Cyanophyta 1, Rhodophyta 26, Phaeophyta 13, Chlorophyta 12, Angiospermae 1) and 195 species of macrofauna (Sarcodina 1, Porifera 25, Cnidaria 22, Placophora 2, Gastropoda 21, Bivalvia 17, Cephalopoda 1, Echiura 1, Sipuncula 1, Polychaeta 8, Crustacea 23, Bryozoa 9, Echinodermata 12, Tunicata 5, Pisces 46) were determined. The total of 6 hardbed biocoenoses was determined: the biocoenosis of upper mediolittoral rock, biocoenosis of lower mediolittoral rock, biocoenosis of infralittoral algae, precoralligenous aspect of a coralligenous biocoenosis, coralligenous biocoenosis and biocoenosis of semi-dark caves. Furthermore, two biocoenoses of soft bottoms were determined: the biocoenosis of *Posidonia oceanica* meadows and the biocenosis of littoral detritic bottom. Within the determined biocenoses, relative to the domination and cover of greater areas of the bottom surface, different facies and associations are developed. The Mediterranean Action Plan (MAP), which is part of the UN program, established a list of communities, associations and facies, as well as a list of areas to be included in the national list of areas of interest for protection. In the coastal area of Ćutin Veli and Ćutin Mali islets 8 biocoenoses were determined, 5 of which, according to the MAP, are classified as especially valuable communities with 19 floral and faunal species. In the circalittoral step, at the depth of 40-50 m, fifty to sixty percent of the detritic bottom is covered by invasive alga *Womersleyella setacea*. Greater settlements of the alga in the northern Adriatic were first described on the eastern coast of the island of Cres (5).

Qualitative research focused on decapods revealed 24 species in the Ćutin seabed. The greatest part of the decapod fauna was found in the infralittoral zone, up to 10 m in depth. This is because the meadows of *Posidonia oceanica* extend at that depth, and are the ideal habitat and shelter for this group of invertebrates. *Brachycarpus biunguiculatus* was recorded, this is the first recorded from the Adriatic. Three species considered as rare in the Adriatic were also recorded: *Processa macrophthalma, Ilia nucleus* and *Inachus phalangium* (6). The species *Homarus gammarus* and *Maja squinado* included in the Coding list of endangered or threatened species, Annex II of the Barcelona Protocol, were also found.

A total of 46 fish species was recorded during the dives. The greatest contribution to biodiversity was given by the family Gobiidae (13 species), followed by the Labridae (8 species) and Sparidae (8 species). The frequency of occurrence per each point reveals that the hyperbenthic species *Coris julis* and *Chromis chromis*, and epibenthic gobies *Gobius xanthocephalus, Gobius vittatus* and *Thorogobius ephippiatus* were most frequent. The most abundant species in general is *Chromis chromis,* whereas, within the benthopelagic and hyperbenthic species, *Oblada melanura* and *Spicara smaris*, *Coris julis* and *Boops boops* were among the most numerous. Among the epibenthic species, the most numerous were the gobies *Gobius vittatus* and *Gobius xanthocephalus*.

In order to preserve the important benthic communities extending from the mediolittoral to the circalittoral zone, protection of the area of Veli and Mali Ćutin islands is required due to intensive human activity in the form of fishing and diving tourism. Since the area of investigation was small, the area of the Ćutin islets should be integrated with the protection of other parts of the eastern coast of Cres and of other islets in the Aquatorium.

References

1 - Pérès, J.M. and Picard, J., 1964. Nouveau manuel de bionomie bentique de la mer Méditerranée. *Rel. Trav. Stn. Mar. Endoume,* 47: 5-137.
2 - Bellan-Santini, D., Lacaze, J.-C. and Poizat, C., 1994. Les biocénoses marines et littorales de Méditerranée: synthèse, menaces et perspectives. Muséum National d' Histoire Naturelle, Paris, 246 p.
3 - Turkay, M., 1979. Results of collecting decapods with small traps in the Aegean sea. Quad. Lab. *Tecnol. Pesca.*, 3 (2-5): 339-345.
4 - Bortone, S. A., Kimmel, J. J. and Bundrick, C. M. 1989. A comparison of three methods for visually assessing reef fish communities: time and area compensated. *Northeast Gulf Sci.*, 10 (2): 85-96.
5 - Sartoni, G. and Rossi, S., 1998. New records for the benthic algal flora of the Northern Adriatic Sea. *Flora Mediterranea,* 8: 9-15.
6 - Števčić, Z., 1990. Check list of the Ariatic decapod Crustacea. *Acta Adriat.*, 31: 183-274.

COMPOSITION SYSTEMATIQUE DE LA FAUNE MYSIDOLOGIQUE DE LA BAIE ET LA LAGUNE NORD DE TUNIS

Asses. R [1], Daly Yahia. M. [1 *] et Daly Yahia-Kefi. O [2]

[1] Groupe de Recherche en Hydrologie et Planctonologie, Laboratoire de bio surveillance de l'environnement, Faculté des sciences de Bizerte, Zarzouna, Bizerte, Tunisie

[2] G.R.H.P. Institut National Agronomique de Tunis, Tunisie - dalyyahia.ons@inat.agrinet.tn

Résumé

Dans le cadre de l'étude des péracarides bentho-planctoniques des côtes nord tunisiennes, nous nous sommes intéressés à la distribution taxonomique et quantitative des populations de mysidacés au niveau du complexe Baie - Lagune Nord de Tunis. 11 espèces ont été identifiées: 6 espèces récoltées au niveau de la baie de Tunis sont dominées par *Paramysis arenosa* et *Paramysis helleri,* représentant 49,38% des mysidacés, 6 autres dans la lagune nord de Tunis, dominées par *Diamysis bahirensis* et *Siriella sarsi* dont l'abondance relative atteint 78,46%.

Mots clés : Mysidacés, Méditerranée Sud Occidentale

Introduction

Les mysidacés jouent un rôle important dans la chaîne trophique marine, c'est un maillon clé qui relie le domaine benthique au domaine pélagique (1). A l'échelle méditerranéenne les études sur les mysidacés se font de plus en plus rares, les seuls travaux d'ordre taxonomique sont ceux de (2) (3) et (4).

Matériels et Méthodes

Dans la lagune nord de Tunis, 8 stations sont prospectées de janvier à juin 2002 avec une fréquence mensuelle. Dans la baie de Tunis, au niveau de la "swach zone", 3 stations de prélèvement (BT1, BT2, BT3) sont visitées de décembre 2001 à juin 2002 avec la même fréquence (Fig. 1).

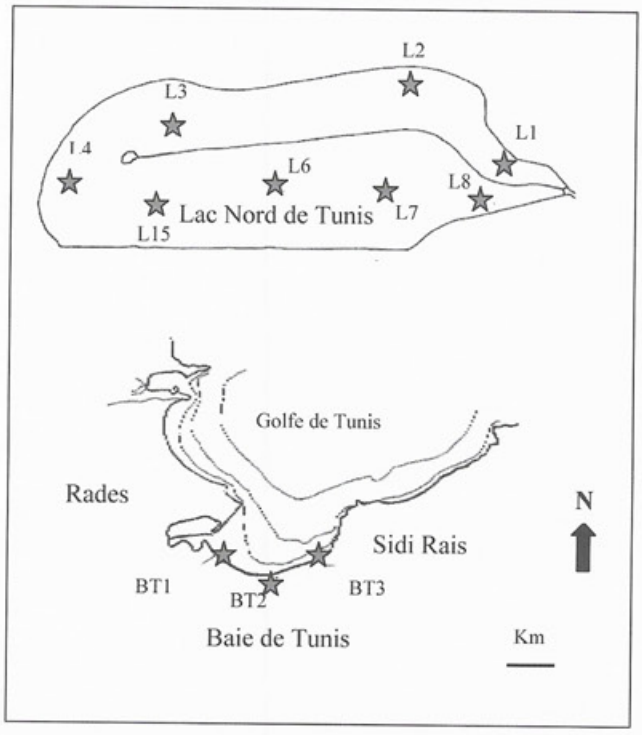


Fig.1. Stations d'échantillonnages des Mysidacés

La récolte de la faune mysidologique est réalisée au moyen d'un traîneau supra-benthique d'ouverture rectangulaire, équipé d'un filet de 300µm de vide de maille et traîné à la surface du substrat.

Résultats

L'identification spécifique révèle une richesse spécifique de 11 espèces, 6 espèces sont présentes au niveau de la lagune (*Siriella armata, S. clausi, S. sarsi, S. crassipes, Diamysis bahirensis, Mesopodopsis slabberi*) et 6 au niveau de la baie de Tunis (*Gastrosaccus sanctus, G. mediterraneus, Leptomysis mediterranea, Paramysis helleri, P. arenosa, Mesopodopsis slabberi*). Seule *Mesopodopsis slabberi* est commune.

Au niveau de la baie de Tunis, le peuplement est dominé par *Paramysis arenosa* avec une abondance relative de 35.29% et *Paramysis helleri* (24,09%). *Mesopodopsis slabberi* et *Gastrosaccus mediterraneus* sont peu représentées (respectivement 3,60% et 0,07%).

Dans la lagune nord, c'est l'espèce *Diamysis bahirensis* qui domine (66,02% du peuplement), ensuite et par ordre d'abondance décroissante s'observe *Siriella sarsi* (12,44%), *Siriella armata* (11,46%), *Siriella clausi* (8,26%), *Mesopodopsis slabberi* (1,57%) et *Siriella crassipes* (0,25%).

Conclusion

L'étude de la distribution et de la dynamique des mysidacés au niveau des deux milieux d'études montre que la composition spécifique du peuplement présent au niveau de la baie de Tunis est différente de celle de la lagune nord. Une seule espèce *Mesopodopsis slabberi* est présente simultanément dans les deux milieux. Sa présence s'explique par sa capacité à s'adapter aux différents biotopes et à des salinités différentes (5). L'absence de femelles ovigères au niveau de la baie et leur présence au niveau de la lagune montre bien que cette espèce se reproduit dans la lagune et non pas dans la baie.

Pour les espéces présente uniquement dans la baie de Tunis: *Paramysis arenosa, Paramysis helleri* et *Gastrosaccus sactus* leur densité est relativement faible en raison probablement de l'important hydrodynamisme de ce milieu, et du fait que la majorité des espèces préfèrent les biotopes calmes. De plus les densité mysidologiques élevés enregistrées dans la Lagune de Tunis semblent résulter du niveau trophique plus élevé de cet écosystème (6).

Remerciement. Nous tenons à remercier Mr. Karl Wittmann, Professeur à l'Académie des Sciences de Vienne pour son aide dans la vérification de l'identification de nos espèces.

Références

1 - Elizalde, M., Dauvin, J.C., Sorbe, J.C., 1991. Les mysidacés suprabenthiques de la marge sud du canyon du Cap-Ferret (Golfe de Gascogne): répartition bathymétrique et activité natatoire. *Annales de l'Institut océanographique,* 67 (2): 129-144.

2 - Sars, G.O., 1877. Nye Bridsag til Kunddkaben om Middelhavets Invertebra fauna I. *Middelhavet Mysider.* Arch. F. Math. og Naturvid. Bd II : 10-119.

3 - Bacescu, M., 1941. Les Mysidacés des eaux méditerranéennes de la France (spécialement de Banyuls) et des eaux de Monaco. *Bulletin de l'Institut Océanographique,* 795: 1-46.

4 - Wittmann, K. J. et Ariani,A., 1998. *Diamysis bacescui* n.sp. A new benthopelagic mysid (Crustacea: Peracarida) from mediterranean seagrass meadow: description and comments on statolith composition. *Trav. Mus. Natul.Hist. "Grigore Antipa"* Vol XL : 35-49.

5 - Moffart, A.M., Jones, M.B., 1992. Bionomics of Mesopodopsis slabberi and Neomysis integer (Crustacea: Mysidacea) in the Tamar estuary. Taxonomy, biology, and ecology of Baltic Mysids. *Arch. Rostok University,* 109-118.

6 - Annabi-Trabelsi N.,El Bahri. T., Daly Yahia M.N., Ben Maiz N., Rhomdane M.O., 2001 Preliminary evaluation of trophic state of the North Lake of Tunis. maters Applic of trophic index (TRIX), *Revue Water, Waste and Environnemnt Research,* 1-9.

HYDROBIOLOGIC OBSERVATIONS IN SYZYGY IN A LATITUDINAL SECTION IN THE MESSINA STRAITS

F. Azzaro *, F. Decembrini, F. Raffa
IAMC-CNR, Messina, Italy - * azzaro@ist.me.cnr.it

Abstract
The effects of tidal streams have been investigated in the Messina Straits during April 1994 in syzygy through significant hydrologic stations, at the same time of the stationary phase (slack waters) between low and high tide phases. Two distinct water masses with different physico-chemical characteristics come from Tyrrhenian and Ionian Seas at different stages of the tide. When the current flows southward, the Ionian water upwelling (highest salinity and nutrients) was most evident along the Calabrian coast, whereas along the Sicilian coast in northward flow. Salinity and nitrate were positively correlated.

Keywords: Hydrology, nitrates, chlorophyl- a, coastal upwelling system, Straits of Messina

Introduction

In the Strait of Messina, upwelling events have been documented since the beginning of this century (1), because their dynamics are determined by the presence of tidal currents (with semi-diurnal phase) and the consequent alternating presence of two water masses. These coditions lead to semidiurnal periodic oscillations of the currents flows, of Tyrrhenian waters into the Ionic basin (southward current) and vice versa (northward current), with a brief slack waters interval. Moreover, coastal geomorphology is responsible for turbulence phenomena as shown by the presence of internal waves. This leads to the upwelling of Ionic waters (Levantine Intermediate Water origin), which are colder, more salty and richer in nutrients in respect to the Tyrrhenian surface waters (Atlantic Water origin).

The distribution of tracing parameters (such as temperature, salinity and nitrates [2]) and the photoautotrophic biomass (standard methods [3]) in a selected west-east section (3 stations: W, C, E) is discussed (Fig. 1). Measurements were carried out (N/O *Urania*, April 1994) in syzygy lunar phases, when the currents reach maximum intensity (>5 knots). The vertical profiles (0-80m) of the cross-sectional flows of current across the transect for the time series at station C were computed with the Hopkins method [4]. Measurements (CTD/rosette) were performed during a 24 hour cycle in correspondence to the 4 stationary phase (with slack waters), this to individuate the upwelling of deep waters. In fact, the maximum chemical-physical differences are manifested when the flowing water has undergone less mixing and better preserves the characteristics of its zone of origin [5].

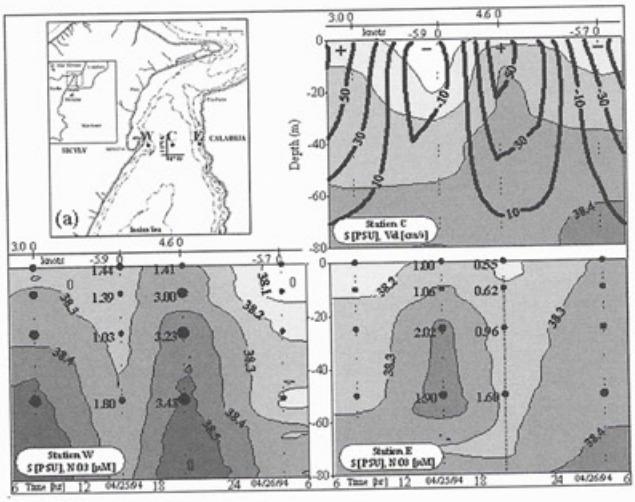


Fig. 1. Location of the stations in the Straits of Messina (a); isohalines distribution in all the stations, for nitrates in stations W-E (•), and for the normal component of the velocity, across the transect at station C [—]. Estimated current speed (Knots) and direction (+=S→N; −=N→S) from «Tavole di Marea I.I.M.M.».

Results and Discussion

The temperature measured in the whole water column showed variation in the order of half degree (14.16±0.29°C), in both slack phases. The salinity better evidenced the change from the southward to the northward current. In the station-W, the distribution of isohalines during a diurnal cycle ranged between 38.3 PSU in upper waters and 38.6 PSU in bottom layer during the stationary phases after northward current (Fig. 1). Since the tide changes, lower halines values were found mainly in the last sampling (38.03 at the surface and 38.32 PSU at the bottom). The distribution of isohalines in the station-E was opposite to station-W, with surface values of 38.3 PSU but in southward current, while in the opposite phase at surface the salinity value was of 38.11 PSU. As shown in figure 1, in station-E there were intruding water bodies able to modify the normal stratification. In the station-C, the distribution of isohalines is similar to station-W, with the saltier water during the two phases of northward flow. The speed of the current at station-C, calculated in slack phases (Fig. 1), introduces a periodic oscillations typical of the alternating of the two tides. The values range between -50 and 70 cm/sec and the isoalines show the prevalence of the northward current in this section.

During the stationary phase after northward current, (Figure 1) an evident dissymmetry between West (2.77±0.80µM) and East coasts (0.93±0.4µM) was observed for nitrate values, with concentration maximum in the western side (3.43µM 50m), perfectly in agreement with salinity values. In the opposite phase, these nutrients were more similar from coast to coast (1.42±0.27µM station-W; 1.50±0.47µM station-E). The nitrates at station-C were not very different for both slack phases (1.84±1.07µM).

The enrichment of nutrients of the euphotic layer at the West coast does not correspond to the same trophic activity. In fact, the values of chlorophyll-*a* were always low for both the tides (0.14±0.05µg-Chla l^{-1} station-W; 0.14±0.05µg-Chla l^{-1} station-C; 0.12±0.02µg-Chla l^{-1} station-E).

Conclusions

The characteristics of the water column, in the Straits of Messina, change quickly between the southward and northward currents. However, the maximum excursions were found for all the parameters examined in northward currents, mainly in the western side in agreement with hydrodynamic factors that result from the coastal relief.

Upwelled waters along the western coast of the Straits were nutrients-rich but plankton-poor (HNLC). Water column instability, due to the turbulence caused by the alternating of the Ionian and Tyrrhenian waters provokes unfavourable conditions for phytoplankton growth as in calmer water.

References

1 - Vercelli F., 1925. Il regime delle correnti e delle maree nello Stretto di Messina. Comm. Inter. del Mediterraneo, Venezia, 1, 209 p.
2 - Strickland J.F.H., Parson T.R. 1972. A pratical handbook of seawater analisys. *Bull. Fish. Res. Ed. Can.*, 167: 311 p.
3 - Lazzara L., Bianchi F., Falcucci M., Hull V., Modigh M., Ribera D'Alcalà' M., 1990. Pigmenti clorofilliani. *Nova Thalassia*, 11: 207-223.
4 - Hopkins T.S., 1999. The thermohaline forcing of the Gibraltar exchange. *J. Mar. Syst.*, 20: 1-31.
5 - Azzaro F., Decembrini F. and Crisafi E., 1995. Continuous survey of upwelling in the Straits of Messina. *Rapp. Comm. Int. Mer Médit.*, 34: 67.

SEX STEROIDS IN MALE *DIPLODUS SARGUS* IN EGYPTIAN MEDITERRANEAN WATERS

Baghdadi, H.H.* [1], El-Gharabawy M.M. [2], Zaki M.I. [2] and El-Greisy Z.A. [2]

[1] * Institute of Graduate Studies and Research, University of Alexandria, Egypt - * Hodabaghdadi@yahoo.com

[2] National Institute of Oceanography and Fisheries, Alexandria, Egypt

Abstract

The annual reproductive cycle and variations in plasma sex steroids levels were studied in male white seabream, *Diplodus sargus*. The gonadosomatic index (GSI) and plasma testosterone (T), estradiol (E2) and progesterone (P) levels were measured T and E2 were correlated positively with the GSI, with their maximum reached at spawning season. In contrast, P levels attained the highest value at the pre-spawning period followed by a sharp decrease during spawning.

Keywords: Sparidae, Diplodus sargus, Reproductive cycle, Sex steroids

Introduction

White seabream, *Diplodus sargus* is considered to be one of the common and commercially important Sparidae along the Egyptian Mediterranean waters. However, there is lack of knowledge on its reproductive endocrinology. The present study examined the plasma steroid profile, in relation to testis size, in male white sea bream, during the natural annual reproductive cycle.

Materials and Methods

Fish used in the present study were captured alive three times a month from the Mediterranean Coast near Kayet Bey Castle at Anfoushy region, Alexandria, Egypt. Sampling was conducted from September 1996 to August 1997.

Blood samples were collected from the caudal vessels for steroid determination. After centrifugation, plasma was drawn off and stored at – 20°C until analysed. Following blood sampling, the gonads were excised and weighed for the determination of gonadosomatic index (GSI = gonad weight/body weight x 100). Steroids were determined using radioactive iodine I^{125} kits assembled in U.S.A. by diagnostic system laboratories, and counted by gamma counter.

Results and Discussion

Gonadal maturation in fish is regulated by the endocrine system, accompanied by dynamic changes in the serum steroid levels. Levels of androgens and estrogens exhibit clear variations from one month to another throughout the annual reproductive cycle.

The present study showed that there was a positive correlation between the GSI and the plasma testosterone (T) levels in male white seabream ($P < 0.001$). Both GSI and T increased gradually in the pre-spawning period, reaching the maximum values during the spawning season, followed by an obvious decrease in the spent and recovery periods (Fig. 1). This is in general agreement with that observed for several other species, such as *Carassius auratus* (1), *Salmo trutta* (2), *Oblada melanura* (3), and *Diplodus vulgaris* (4). The present study showed that plasma progesterone (P) levels in males decreased with spawning. This is also true of rainbow trout (5). P is also known to stimulate spermiation in male goldfish (6).

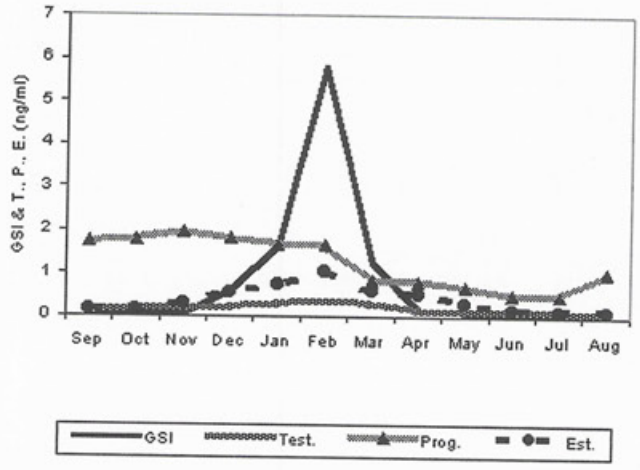


Fig. 1. Sex steroids in male *Diplodus sargus* in Egyptian Mediterranean waters.

Plasma estradiol (E2) levels increased gradually from the beginning of the breeding season reaching their maximum at the prespawning period. The E2 levels were correlated with the GSI ($P<0.001$). The results for E2 are in accordance with those for *Diplodus vulgaris* (4) and *Rhabdosargus haffara* (7) where the level of E2 reached its maximum in the prespawning period, then decreased throughout the spawning season to reach a minimum value for spent male.

References

1 - Schreck C. B. and Hopwood M. L. 1974. Seasonal androgen and estrogen patterns in gold fish *Carassius auratus*. *Trans. Amer. Fish. Soc.*, 103: 375 – 392.

2 - Billard R., Breton B., Fostier A., Jalabert B. and Weil C. 1978. Endocrine control of the teleost reproductive cycle and its relation to external factor. Salmonid and cyprinid models. Pp. 37-48. In : P.J. Gaillard and H.H. Boer, (eds.). Comparative Endocrinology. Elsevier/North-Holland Biomedical press, Amsterdam.

3 - Zaki M.I, Assem s.s, and Abu- Shabana M.B. 2001. Gonadotropin and steroid hormones in the plasma and pituitary gland of *Oblada melanusa* at various stages of maturation. *Rapp. com. int. Mer Médit.*, 36: 337.

4 - Abdallah M. 1996. Reproductive biology and physiology of *Diplodus vulgaris* in the Mediterranean Sea. Ph. D. Thesis, Faculty of Science, Tanta University.

5 - Campbell C. M., Fostier A., Jalabert B. and Truscott B. 1980. Identification and quantification of steroids in the serum of rainbow trout during spermiation and oocyte maturation. *J. Endocrinol.*, 85: 371-378.

6 - Billard R. 1976. Induction of sperm release in the gold fish by some steroids, *IRCS kibr. Compend.*, 4: 42.

7 - EL-Boray K. F. 1997. Reproductive biological studies on *Rhabdosargus haffara* in different water fish farms. Ph. D. Thesis, Faculty of Science, Zagazig University.

ÉTUDE PRÉLIMINAIRE CONCERNANT LA SÉPARATION D'UN MÉLANGE D'ALGINATES DE L'ALGUE BRUNE *CYSTOSEIRA BARBATA*

Doina Paula Balaban [1] *, Natalia Rosoiu [1], Florica Busuricu [2], Daciana Sava [3]

[1] Université "Ovidius", Faculté de Médecine, Constanta, Roumanie - * dpbalaban@yahoo.com
[2] Université "Ovidius", Faculté de Stomatologie et Pharmacie, Constanta, Roumanie
[3] Université "Ovidius", Faculté de Biologie, Constanta, Roumanie

Résumé

Dans le présent travail on propose un procédé de séparation des alginates. Ce procédé comporte les étapes suivantes: traitement à chaud des algues séchées avec une solution diluée d'aldéhyde formique, déminéralisation des algues à chaud avec solution aqueuse d'acide chlorhydrique, extraction des alginates avec solution alcaline aqueuse et précipitation des alginates avec éthanol en présence de la chlorure de magnésium. Le rendement de séparation du mélange d'alginates a été de 40% par rapport à la quantité d'algues sèches. L'élément de nouveauté est l'agent de précipitation: éthanol 98% en présence de la chlorure de magnésium.

Mots clés: Cystoseira barbata, alginates

Les algues marines constituent la principale végétation des mers et des océans. Elles se remarquent par leur grand taux de polysaccharides, dont les propriétés déterminent une large gamme d'application dans l'industrie alimentaire, en médecine, pharmacie et cosmétique. Parmi les polysaccharides qui existent en quantités valorisables, mentionnons l'acide alginique et ses sels, l'agar et le carragéeen.

L'acide alginique est l'un des composants structuraux des algues brunes. De point de vue structural, c'est un polysaccharide, pour unités structurelles répétitives, avec des restes d'acide D-manuronique et L-guluronique [1].

En Roumanie, le début des préoccupations liées à l'extraction des alginates a eu lieu en 1971, à l'Institut Roumain de Recherches Marines de Constanta. Ici on a alors conçu un procédé de séparation de l'alginate de sodium de l'algue brune *Cystoseira barbata* avec un rendement de 18,7% par rapport à la quantité d'algues sèches. Les études entreprises dans le cadre de cet Institut ont prouvé que le taux maximal d'acide alginique – à savoir 21% par rapport à la quantité d'algues sèches – est trouvé au cours du mois d'octobre [2, 3].

La raison pour laquelle nous avons entrepris cette étude est que nos expérimentations ont prouvé au printemps un taux maximal d'acide alginique – à savoir 41% par rapport à la quantité d'algues sèches. D'ailleurs, G. K. Yatsenko a déterminé une valeur de l'acide alginique extrait de l'algue brune *Cystoseira barbata* de 41,9% par rapport à la quantité d'algues sèches [4].

C'est pourquoi dans ce travail on présente un procédé de séparation d'un mélange d'alginates extraits de l'algue brune *Cystoseira barbata* du littoral roumain de la mer Noire.

Les étapes dans la mise au point du procédé de séparation ont été les suivantes (Fig. 1):

1. Le prélévement a été réalisé au cours du mois de mars, quand on a trouvé la quantité maximale d'acide alginique dans l'algue *Cystoseira barbata*.

2 - Dessication et broyage. Les algues ont été séchées à la température de 50°C, étant ensuite broyées en particules uniformes d'environ 75 mm, et lavées avec de l'eau distillée.

3 - Traitement à chaud des algues avec solution dilluée d'aldéhyde formique, suivi de leur lavage. Le but de cette étape est de rendre insolubles les protéines et de fixer les pigments. Par ce procédé on substitue, partiellement ou intégralement, l'opération de décoloration des alginates.

4 - Déminéralisation des algues. Cette opération a été effectuée par des lavages successifs, à chaud, du matériel végétal, en quatre bains successifs de solutions aqueuses d'acide chlorhydrique en concentrations de 0,25N, 0,15N, 0,10N, 0,05N.

5 - Filtrage et lavage du matériel végétal avec de l'eau distillée.

6 - Extraction du mélange d'alginates. L'extraction a été réalisée à chaud, avec solution aqueuse de carbonate de sodium en concentrations au-dessus de 0,1N (pH 9-11).

7 - Précipitation du mélange d'alginates. En vue de précipiter à chaud les alginates, on a utilisé, en tant qu'agent de précipitation, l'alcool éthylique 98% en présence de la chlorure de magnésium.

Le rendement d'extraction des alginates a été de 40% de la quantité d'algues sèches. La méthode d'extraction utilisée pour cette étude préliminaire est fondée, en lignes générales, sur le principe énoncé et réalisé par Stanford en 1880. L'élément de nouveauté est constitué par l'agent de précipitation: alcool éthylique en présence de chlorure de magnésium.

Si l'on a en vue le rendement de séparation du mélange d'alginates, on pourrait continuer l'étude tenant compte des multiples possibilités d'amélioration du procédé présenté.

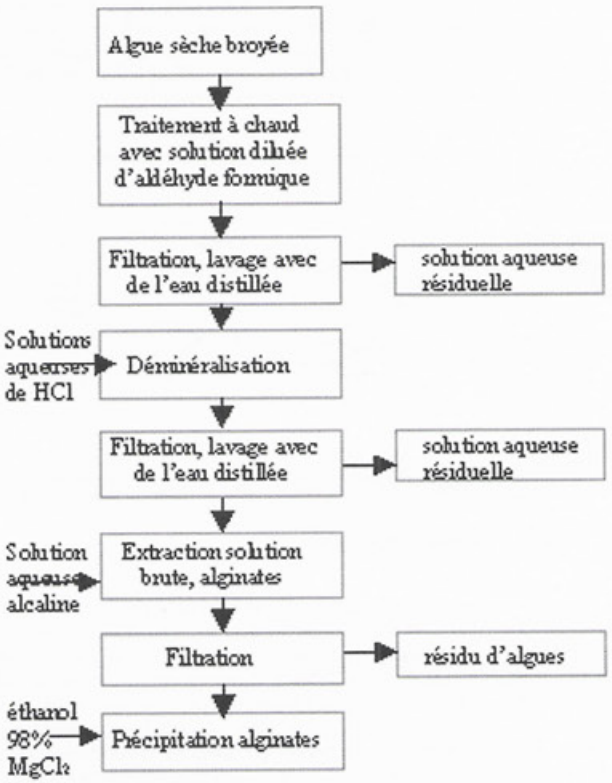


Fig. 1. Procédé de séparation des alginates de l'algue brune Cystoseira barbata.

Références

1 - Simionescu C., Rusan V., and Popa V., 1974. Chimia algelor marine. Editura Academiei RSR, Bucuresti. Pp. 83-91.
2 - Mîrza M., 1972. Some data concerning the dynamics of alginic acid and manitol in the brown alga *Cystoseira barbata*. *Recherches Marines*, 3: 149-156.
3 - Boghici V., and State G., 1973. Procédé d'obtention de l'alginate de sodium de l'algue *Cystoseira barbata* de la mer Noire. *Recherches Marines*, 3: 157-161.
4 - Yatsenko G. K., 1963. The content of alginic acid and manitol in *Cystoseira barbata*. *Nauchn. Dokl.Uspekhi Shkoly Biol. Nauki*, 1:149.

TOXIC PHYTOPLANKTONIC SPECIES IN THE SEA OF MARMARA

Neslihan Balkıs [1*] and Yelda Aktan [2]

[1] Istanbul University, Faculty of Science, Department of Biology, Vezneciler-Istanbul, Turkey - * neslbalk@istanbul.edu.tr
[2] Istanbul University, Fisheries Faculty, Laleli, Istanbul, Turkey

Abstract

Plankton studies in the Sea of Marmara have been continuing since the 1990s, leading to the identification of 11 toxic species. These studies did not show a significant increase in the individual numbers of toxic species. The recent change in water quality in the Marmara Sea suggest a possible increase of density of these species.

Keywords: Toxic micro-algae, Sea of Marmara

The Sea of Marmara is a relatively small inter-continental basin with a surface area 11500 km^2 and a volume of 3378 km^3 (Fig. 1). It is connected to the Black Sea and the Aegean Sea through the straits of Bosphorus and the Dardanelles, respectively. The basin is occupied by two distinctly different water masses throughout the year: one is the brackish waters (22-26 p.s.u) of Black Sea origin, forming a relatively thin surface layer (10-15 m thick) with a mean residence time of ~4-5 months, and the other is the subhalocline waters of Mediterranean origin (38.5-38.6 p.s.u.) separated from the former by a sharp interface (pycnocline) ~10-20 m thick [1;2]. The chemical oceanography of the Sea of Marmara is significantly influenced by the biochemistry of the Black Sea and the Aegean Sea. In the upper euphotic zone, concentrations of nutrients are relatively low and show seasonal fluctuations that reflect the photosynthetic activity [3]. Since primary production is always limited to the less saline upper layer (15-20 m) of the Sea of Marmara, the subhalocline waters of Mediterranean origin are always rich in nutrients [4].

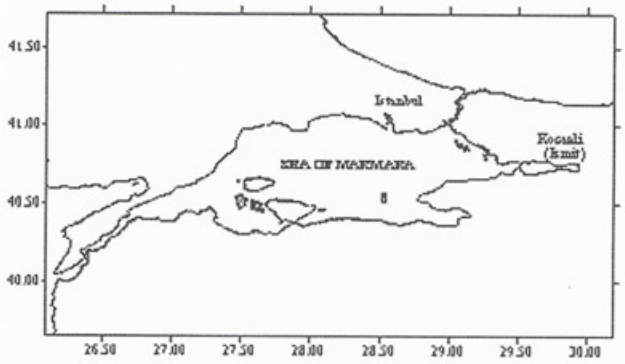


Fig. 1. Map of the Sea of Marmara.

Plankton studies in this sea have been continuing since the 1990s and there are only few data on phytoplankton and their ecological features [5-10]. A summary of the information on the toxic species in the Sea of Marmara is given in Table 1. Previous studies in the Sea of Marmara did not record a significant increase in the individual numbers of toxic species. The possibility of red-tides is discussed only in the project studies (unpublished data) of Izmit Bay. These toxic species reported from the seas of Turkey, caused fish mortalities, anoxia and hyperoxia in Izmir Bay [11].

The Black Sea has become polluted by river (mainly the Danube) and wastewater discharges. Because of the large volume of water inflow from the adjacent Black Sea (about 600 km^3) into relatively small upper layer volume (about 225 km^3) of the Sea of Marmara, the upper layer ecosystem of the latter has been influenced to a large extent [1;2]. In the next years, an increase in the abundance of these species may be observed. For this reason, these species should be monitored carefully by the studies programmed in this region, due to the dangerous effects of toxic algal blooms on human and ecosystem health, causing great economic damage to aquaculture and tourism.

The aims of this study are to constitute a toxic species list and to update the regional records on this basis.

Table 1. Toxic phtoplanktonic species in the Sea of Marmara. (Abbreviations: mc, maximum cell number in one liter; T, type of toxic effect; PSP, Paralytic Shellfish Poison; DSP, Diarrhetic Shellfish Poison; ASP, Amnesic Shellfish Poison; R, References).

Species	mc	T	R
DINOPHYCEAE			
Alexandrium minutum	net sample	PSP	10
Dinophysis acuminata	$2x10^2$	DSP	10
D. acuta	$6x10^2$	DSP	10
D. caudata	$2x10^3$	DSP	5,10
D. fortii	$3x10^2$	DSP	10
D. sacculus	$3x10^2$	DSP	10
Gonyaulax grindleyi	$1.3x10^3$	DSP	10
Phalacroma rotundatum	$6x10^2$	DSP	10
BACILLARIOPHYCEAE			
Pseudo-nitzschia delicatissima	$2.7x10^3$	ASP	6,7
P. pseudodelicatissima	net sample	ASP	10
P. pungens	$2x10^2$	ASP	6,10

References

1 - Unlüata U., Oğuz T., Latif M.A. and Özsoy E., 1990. On the physical oceanography of the Turkish Straits. pp. 25-60. In Pratt L.J. (ed.), The physical oceanography of sea straits. Kluwer, Dortrecht,

2 - Tuğrul S. and Polat S.C., 1995. Quantitative comparison of the influxes of nutrients and organic carbon into the Sea of Marmara both from anthropogenic sources and from the Black Sea. Pergamon, *Wat. Sci. Tech.*, 32 (2), 115-121.

3 - Baştürk Ö., Saydam A.C., Salihoğlu I. and Yılmaz A., 1986. Oceanography of the Turkish Straits. III, health of Turkish Straits, II:chemical and environmental aspects of the Sea of Marmara. METU, Erdemli-Içel, 86 p.

4 - Polat, S.C., Tuğrul, S., Çoban, Y., Baştürk, O. and Salihoğlu, I. (1998) Elemental composition of seston and nutrient dynamics in the Sea of Marmara. *Hydrobiologia*, 363, 157-167.

5 - Aubert M., Revillon P., Aubert J., Leger G., Drai C., Arnoux A. and Diana C., 1990. Transfert de polluants entre la mer Noire, la mer de Marmara et la mer Egée. Mers d'Europe. Etudes Hydrobiologiques, Chimiques et Biologiques, Tome 3, C.E.R.B.O.M. (Nice), 47 p.

6 - Uysal Z., 1996. A net-plankton study in the Bosphorus junction of the Sea of Marmara. *Tr. J. of. Botany*, 20, 321-327.

7 - Uysal Z. and Ünsal, M., 1996. Spatial distribution of net diatoms along adjacent water masses of different origin. *Tr. J. of. Botany*, 20, 519-525.

8 - Tüfekçi V. And Okuş E., 1998. Karadeniz-İstanbul Boğazı kıstağı, boğaz ve boğazın Marmara Denizi çıkışındaki fitoplankton dağılımı. Büyükşehirlerde atıksu yönetimi ve deniz kirlenmesi kontrolu sempozyumu. 18-20 Kasım 1998, İSKİ, 157-172.

9 - Balkıs N. 2000., Five dinoflagellate species new to Turkish seas. *Oebalia*, XXVI, 97-108.

10 - Balkıs N., 2003. Seasonal variations in the phytoplankton and nutrient dynamics in the neritic water of Büyükçekmece Bay, Sea of Marmara. *J. Plankton Res.*, 25 (7), 703-717.

11 - Koray T., 2002. Toxic and harmful phytoplanktonic species in the Aegean (including Dardanalles) and Northeastern Mediterranean Coastline. Workshop on Lessepsian Migration, 20-21 July 2002, Gökçeada, 40-45.

ENVIRONMENTAL FACTOR TRIGGERING THE LATE-WINTER DIATOM BLOOM IN THE NORTH ADRIATIC SEA

Bastianini M. [1] *, Acri F. [1], Bernardi Aubry F. [1], Casotti R. [2], D'Ortenzio F. [2], Miralto A. [2], Socal G. [1]

[1] Istituto di Scienze Marine, CNR, Venezia, Italy - mauro.bastianini@ismar.cnr.it

[2] Stazione Zoologica "A. Dohrn", Napoli, Italy

Abstract

A late-winter diatom bloom (*Skeletonema costatum*) typically occurs in the NW Adriatic Sea, triggered by nutrient inputs from the Po River and by increasing irradiance and temperature. In 2002, the onset of the bloom was delayed with respect to previous years, due to light limitation caused by cloud coverage in the form of fog. Therefore, phytoplankton could not efficiently use the available (and abundant) nutrients originating from the river outflow until the weather conditions and the total amount of irradiance improved to the point of triggering cell growth. In fact, when at the end of February an increased rainfall boosted Po river discharge, dissolved nutrients became available in significant amount, but irradiance was still low due to the fog. Only in March, mutated climatic conditions allowed sufficient light availability, which, coupled with available nutrients, triggered the *S. costatum* bloom. The temporal dynamics of bloom initiation may be fundamental in determining species composition, which, in turn, has been shown to have a strong impact on consumers recruitment.

Keywords: diatoms, bloom, Skeletonema costatum, fronts, Adriatic Sea

The annual cycle of phytoplankton populations in the Northern Adriatic Sea is mainly driven by thermal and irradiance fluxes. A key role is also played by the dilution processes that affect the distribution of water masses and the selection of phytoplankton populations (1).

The NW Adriatic shows a strong variability in duration and extension of phytoplankton patchiness, driven by river outflows and seasonal dynamics. Phytoplankton blooms can be observed all over the year in the area influenced by river discharge, but diatoms are the first group to burst in late winter, when the light availability increases, and dominate the phytoplankton community, both relatively and absolutely. Usually *Skeletonema costatum* is the dominant species in these late-winter blooms, followed by other species (e.g. *Chaetoceros*) later on (2).

The new production processes related to these blooms influence the entire basin and have a great impact on the evolution of plankton community for the whole year (3).

In February-March 2002 six stations, along a coast-to-offshore transect in correspondence to the Po river delta (Fig. 1), were sampled on a weekly basis. The phytoplankton and picoplankton community, was studied using flow cytometry, microscopy, and remote sensing (SeaWifs). Data on hydrology (temperature, salinity, dissolved oxygen, turbidity, fluorescence, dissolved nutrients) and meteorology (air temperature, pressure, wind direction and speed, irradiance) were also obtained using standard oceanographic methods.

During the first 45 days of 2002 precipitations in the whole northern Italy were very scant and the Po river discharge, which usually accounts for 1500 m^3s^{-1} in the same period, was as low as 700 m^3s^{-1} (Fig. 2). Dissolved nutrients and phytoplankton abundance were very low (Fig. 2).

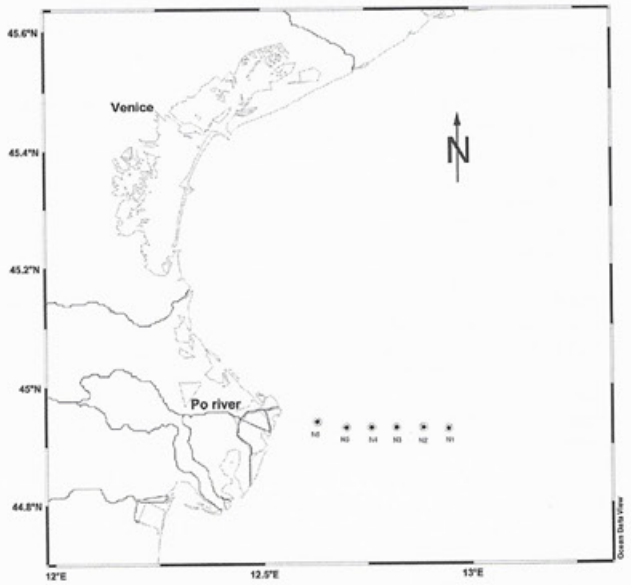


Fig. 1. Location of sampling stations.

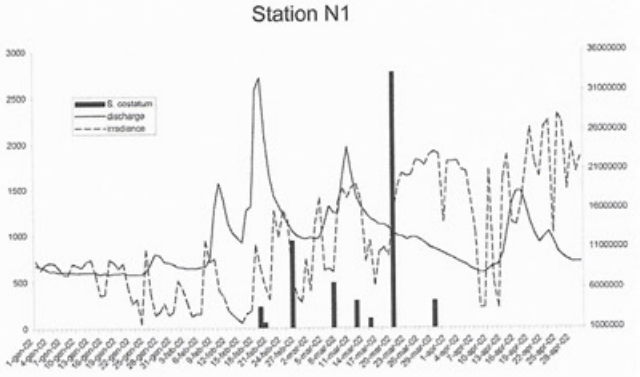


Fig. 2. Po river discharge, irradiance and *S. costatum* abundance.

During the second half of February, the rainfall increased significantly, and correspondingly river discharge increased. Even if higher concentrations of dissolved nutrients were measured, phytoplankton abundances were low along the whole transect. Finally, during the first weeks of March, meteorological conditions were favorable and the increased solar irradiation, conjugated with the constant relevant river discharge, triggered the beginning of the bloom. Therefore, light represented the ultimate triggering factor for the diatom bloom, and strongly favored *S. costatum*, a typical r-selected species (4). This species reached the maximum abundance (5.3 x 10^6 cells dm^{-3}) on 20th of March, in the station (N3), situated 10 miles offshore the Po river (Fig. 1). Here, the growth of *S. costatum* was enhanced by the most suited hydrologic conditions (low turbidity-sufficient nutrient concentration). The bloom was evident in all the three most offshore stations (N1 to N3 in Fig. 2). The spatial variability of phytoplankton abundance along the transect could be explained by the interdependence of microalgal growth from the main forcing factors: nutrient concentration and light availability. On the other side N6 is constantly supplied with nutrients that, therefore, never became a limiting factor, microalgal abundance is always quite high with a freshwater species composition, although high turbidity usually limits its growth.

References

1 - Harding L.W., Degobbis D., Precali R., 1999. Production and fate of phytoplankton: annual cycles and interannual variability. Ecosystem at the land-sea margin: drainage basin to coastal sea. *Coastal and Estuarine Studies*, 55: 131-172.

2 - Bernardi Aubry F., Berton A., Bastianini M., Socal G., Acri F., 2003. Phytoplankton succession in a coastal area of the NW Adriatic, over a 10-year sampling period. *Continental Shelf Research* in press.

3 - Fonda Umani S., Franco P., Ghirardelli E., Malej A., 1992. Outline of oceanography and the plankton of the Adriatic Sea. Proceedings of the 25th EMBS: 347-365.

4 - Gallagher J.C. (1980). Population Genetics of *Skeletonema costatum* (Bacillariophyceae) in Narragansett Bay. *J. Phycol.*, 16, 3: 464-474.

DONNÉES PRÉLIMINAIRES SUR LA DISTRIBUTION DU MACROZOOBENTHOS AU LARGE DE L'EMBOUCHURE DE OUED LAOU (MÉDITERRANÉE, MAROC)

Bayed A. [1] *, Chaouti A. [1] et Bazairi H. [2]

[1] Institut Scientifique de Rabat, Maroc - * bayed@israbat.ac.ma ; achaouti@hotmail.com
[2] Faculté des Sciences Aïn Chock, Casablanca, Maroc - hoceinbazairi@yahoo.fr

Résumé

Les peuplements macrozoobenthiques de la région côtière de Oued Laou sont réferables à la biocénose méditerranéenne de Sables Fins Bien Calibrés, avec dominance des Crustacés Amphipodes. Les niveaux de 10 m de profondeur sont plus riches et mieux structurés.

Mots clés: Western Mediterranean, macrozoobenthos, soft bottom, river input

Introduction

L'importance des biocénoses sableuses en Méditerranée est due au fait qu'elles occupent des aires côtières très étendues, où elles peuvent présenter une amplitude de variations structurelles et fonctionnelles même au sein d'une aire géographique restreinte (1).

Au Maroc, les études relatives au macrozoobenthos des substrats meubles du plateau continental méditerranéen sont quasi-absentes. Ce travail, premier de son genre en Méditerranée marocaine, tente de contribuer à la connaissance de la distribution du macrozoobenthos au niveau de la zone côtière située en face de l'embouchure de Oued Laou.

Matériel et méthodes

La zone d'étude se situe sur la côte méditerranéenne du Maroc à une centaine de kilomètres du détroit du Gibraltar au large de l'embouchure de Oued Laou (Fig. 1). Les 20 stations de prélèvements analysées ici se répartissent entre 5 et 10 m de profondeur, selon une maille de 1000 m maximum entre deux stations voisines de même niveau bathymétrique. Les prélèvements y ont été effectués, en avril 2003, à l'aide d'une drague conique. Une quantité de sédiment est prélevée pour l'analyse granulométrique. Le reste est tamisé sur place au moyen d'un tamis de 1 mm^2 de vide de maille. Le refus du tamis est fixé au formol à 8%. Au laboratoire, les refus sont lavés et triés et la macrofaune isolée, identifiée et comptée. Pour chaque peuplement stationnel, richesse spécifique (S), abondance (A), indice de diversité de Shannon (H') et équitabilité de Pielou (J') ont été calculés.

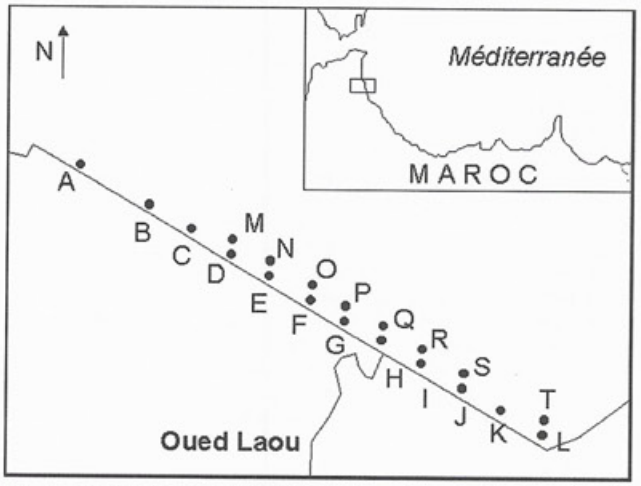


Fig. 1. Localisation des stations d'étude au large de l'embouchure de Oued Laou, sur la Méditerranée marocaine.

Résultats et discussion

Les sédiments des stations prospectées correspondent à des sables fins (Tabl. 1) dont les teneurs en éléments fins ne dépassent pas 5%. Les prélèvements biologiques ont permis de recenser un total de 94 taxons répartis en huit groupes zoologiques qui sont dominés par les Crustacés, Polychètes et Mollusques.

Une classification automatique hiérarchique utilisant l'indice de Bray-Curtis (dendrogramme non représenté ici) a mis en évidence des groupements de stations en fonction de la bathymétrie. Une comparaison de moyennes des valeurs de S, A, H' et J' (test de Student) entre les stations de 5 m de profondeur, d'un côté, et celles de 10 m, de l'autre côté, indique des différences significatives ($p<0,05$) en termes de S et H'. En revanche, les différences observées pour A et J' ne sont pas significatives pour les deux niveaux bathymétriques. Les stations situées à 10 m de profondeur sont plus riches ($S = 29,4 \pm 4,7$) et mieux structurées ($H' = 3,9 \pm 0,5$) que celles situées à 5 m de profondeur ($S = 18,7 \pm 7,0$; $H' = 2,8 \pm 0,7$). Par ailleurs, pour un même niveau bathymétrique, aucune différence significative n'a été mise en évidence entre les stations situées de part et d'autre de l'embouchure de Oued Laou.

Tab. 1 : Profondeur, nature sédimentaire, paramètres de structure et espèces dominantes des stations d'étude.
SF, Sable fin; Abr, *Ampelisca brevicornis;* Asp, *Apseudes* sp.; Aru, *Ampelisca* cf. *ruffoi;* Bgu, *Bathyporeia guilliamsoniana;* Bla, *Branchiostoma lanceolatum;* Esp, *Eurydice spinigera;* Gsa, *Gastrosaccus sanctus;* Lpe, *Leptocheirus pectinatus;* Nem, Nemertiens; Ssu, *Spisula subtruncata;* Uin, *Urothoe intermedia;* Ugr, *Urothoe grimaldii.*

Stations	Profondeur (m)	Sédiment	S	A	H'	J'	Espèces dominantes
A	5,0	SF	20	97	3,07	0,71	Esp (29%); Bgu (29%)
B	5,0	SF	18	97	2,87	0,69	Abr (46%)
C	5,0	SF	11	124	2,25	0,65	Abr (48%)
D	5,0	SF	27	243	2,50	0,53	Abr (62%)
E	5,5	SF	16	44	3,29	0,82	Bla (29%)
F	5,1	SF	16	58	3,46	0,87	Abr (24%)
G	5,7	SF	21	352	2,37	0,54	Aru (54%)
H	5,1	SF	28	621	1,56	0,33	Abr (78%)
I	5,7	SF	12	180	2,04	0,57	Abr (62%)
J	5,0	SF	19	45	3,81	0,90	Abr (20%)
K	4,8	SF	24	100	3,08	0,67	Abr (47%)
L	4,7	SF	12	49	3,07	0,86	Abr (25%); Gsa (20%)
M	10,2	SF	27	125	4,22	0,89	Lpe (14%); Abr (13%)
N	10,0	SF	25	204	3,13	0,68	Aru (32%)
O	10,0	SF	23	123	3,02	0,67	Ssu (50%)
P	10,0	SF	31	195	3,98	0,80	Ssu (21%)
Q	10,0	SF	35	175	4,08	0,80	Aru (18%); Asp (15%)
R	9,5	SF	36	154	4,29	0,83	Ssu (23%)
S	10,0	SF	31	117	4,42	0,89	Uin (13%); Ugr (12%)
T	10,1	SF	27	132	3,73	0,78	Nem (29%)

Les peuplements benthiques de la région côtière de Oued Laou se réfèrent à ceux de la biocénose méditerranéenne des sables fins bien calibrés (SFBC) (2) remarquable par l'absence totale des algues et des phanérogames marines dans ses peuplements et par la dominance des Mollusques Pélécypodes. Dans notre cas, si l'on se réfère aux espèces dominantes (Tab. 1), ce sont essentiellement des Crustacés Amphipodes qui sont les mieux représentés. Les niveaux de 5 m de profondeur sont dominés essentiellement par le Crustacé Amphipode *Ampelisca brevicornis*. Une seule espèce de Bivalve (*Spisula subtruncata*) domine dans certaines stations du niveau des 10 m de profondeur. Cette variation observée par rapport à la biocénose des SFBC serait probablement en relation avec les apports de Oued Laou dans cette zone côtière.

References

1 - Massé H., 1972. Quantitative investigations of sand bottom macrofauna along the Mediterranean north-west coast. *Mar. Biol.*, 15: 209-220.
2 - Pérès J.M., et Picard J., 1964. Nouveau manuel de bionomie benthique de la mer Méditerranée. *Rec. Trav. Stat. mar. Endoume*, 31 (47): 3-137.

PRESENCE DE *PATELLA FERRUGINEA* GMELIN, 1791 (GASTROPODA, PATELLIDAE) EN MEDITERRANEE MAROCAINE : SITUATION ACTUELLE ET PERSPECTIVES

Bazairi H. [1] * and Benhissoune S. [2]

[1] Faculté des Sciences Aïn Chock, Casablanca, Maroc - * hoceinbazairi@yahoo.fr
[2] Faculté des Sciences, Agadir, Maroc - benhissoune@hotmail.com

Résumé

De nombreuses populations de *Patella ferruginea* survivent encore en Méditerranée marocaine. Le nombre de localités où l'espèce est présente s'élève actuellement à 13. S'il est difficile d'estimer à l'heure actuelle la taille exacte et la structure des populations à l'échelle de toute la Méditerranée marocaine, les populations de Sebta, d'Al Hoceima et des Iles Chaffarines semblent être bien établies.

Mots clés: Patella ferruginea, Gastropoda, Western Mediterranean

Introduction

Autrefois répandue dans toute la Méditerranée occidentale, dont elle est endémique (1), *Patella ferruginea* est devenue aujourd'hui très rare et ne subsiste qu'en Corse, en Sardaigne, dans le sud de l'Espagne et en Afrique du Nord (2). Considérée comme l'espèce la plus menacée des invertébrés marins des côtes rocheuses de la Méditerranée occidentale (3; 4), *Patella ferruginea* figure parmi les espèces protégées en Méditerranée (convention de Berne, convention de Barcelone et "Directive des Habitats" de l'Union Européenne).

La présente note est une contribution à la connaissance du statut actuel de *Patella ferruginea* en Méditerranée marocaine. Cette étude se base sur une recherche bibliographique exhaustive et sur des données récentes provenant de notre exploration, en 2002 et 2003, de certaines côtes rocheuses de l'Atlantique et de la Méditerranée du Maroc.

Résultats et discussion

Dans la littérature, la présence de *Patella ferruginea* en Méditerranée marocaine a été signalée à Sebta (Se) (5; 6), dans la baie de Mdiq (Bm) (3), à Restinga, Cabo Negro (Cn) et Oued Laou (7), dans le Parc National d'Al Hoceima (Ah) (8), à Melilla (Me) (9) et aux Iles Chaffarines (Ic) (10; 11). Sur la côte atlantique marocaine, la présence de *Patella ferruginea* a été rapportée par de nombreux auteurs (12; 13) mais aucune localité exacte n'a été donnée. Pallary (14) la signale à Tanger mais cette citation n'a pas été reprise dans son travail de 1912-1920 (10) sur l'ensemble du Maroc. Fisher-Piette (5) n'a pas retrouvé l'espèce sur la côte atlantique du Maroc.

D'après nos prospections récentes, aucun individu de *Patella ferruginea* n'a été recensé en Atlantique. En Méditerranée, la présence de cette espèce a été repérée dans la baie de M'diq (Bm), à Cabo Negro (Cn), au niveau de la pointe de Targha (Pt) et de la pointe de Mekkad (Pm), à El Jabha (Ej), dans la région d'Al Hoceima (Ah), au niveau du Cap des Trois Fourches (Ct), à Karyat Arekmane (Ka), au niveau du Cap de l'Eau (Ce) et à Essaidia (Es). Toutes ces observations concernent la forme *Patella rouxii* bombée et à côtes peu marquées.

La Figure 1 illustre les localités où la présence de *Patella ferruginea* est confirmée. La distribution actuelle de l'espèce au Maroc se limite à la Méditerranée. Le nombre de localités hébergeant des représentants de cette espèce s'élève actuellement à 13 localités dont 7 sont nouvellement repérés (Fig. 1, localités encadrées).

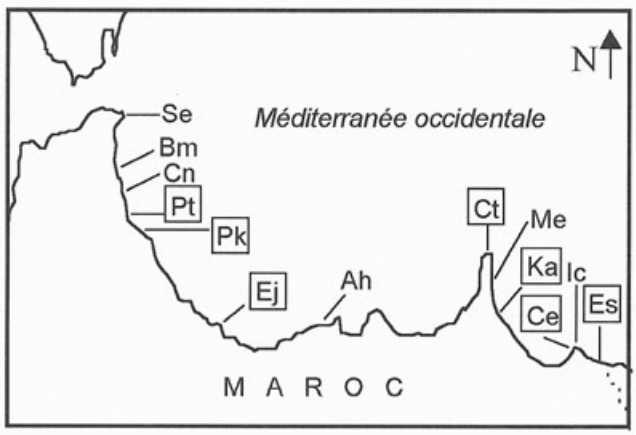


Fig. 1. Distribution de *Patella ferruginea* en Méditerranée marocaine (voir texte pour les abréviations des noms des localités).

Ces résultats montrent que des populations survivent encore et se maintiennent en Méditerranée marocaine, probablement en raison de l'état peu perturbé de ces côtes par rapport au Nord de la Méditerranée où les activités industrielles et touristiques sont bien développées.

S'il est difficile d'estimer à l'heure actuelle la taille exacte de ces populations, celles de Sebta (6), d'Al Hoceima (nos observations) et des Iles Chaffarines (11) semblent être bien établies.

Des études en cours permettront une évaluation précise des effectifs et de la structure des populations non encore étudiées. Ceci aboutira à développer les connaissances sur cette espèce et à mieux comprendre les raisons de sa disparition actuelle en de nombreux endroits de la Méditerranée occidentale et la diminution de ses populations dans les endroits où l'espèce se trouve encore. Mieux connue, *Patella ferruginea* pourrait être mieux protégée.

Références

1 - Boudouresque C. F., 1996. Impact de l'homme et conservation du milieu marin en Méditerranée. 2° édition. GIS Posidonie publ., Marseille, pp. 1-243.
2 - Maurin H. (dir.) *et al.*, 1994. Le livre rouge: inventaire de la faune menacée en France. Ed. Nathan, Muséum National d'Histoire Naturelle et Fonds mondial pour la nature (WWF-France), Paris, 176 p.
3 - Laborel-Deguen F., and Laborel J., 1991. Statut de *Patella ferruginea* Gmelin en Méditerranée. Pp 97-103. *In*: Boudouresque C. F., Avon M., and Gravez V. (ed.), les espèces marines à protéger en Méditerranée, GIS Posidonie Publ., Marseille.
4 - Ramos M. A., 1998. Implementing the Habitats Directive for mollusc species in Spain. *Journal of Conchology Special publications*, 2: 125-132.
5 - Fischer-Piette E., 1959. Contribution à l'écologie intercotidale du Détroit du Gibraltar. *Bull. Inst. Oceanog.*, 1145: 1-32.
6 - Guerra-Garcia J.M., Corzo J., Espinosa F., Garcia-Gomez J.C., 2003. Assessing habitat use of the endangered marine mollusc *Patella ferruginea* (Gastropoda, Patellidae) in northern Africa: preliminary results and implications for conservation. *Biol. Conserv.* (sous presse).
7 - Muniz-Solis R., 1972. El genero Patella y su dispersion en las costas marroquies. *Cuad. Bibl. Esp. Tetuan*, 6: 47-77.
8 - METAP/Plan Bleu – SECA, 1993. Parc National d'Al Hoceima: Plan directeur d'Aménagement et de Gestion, 190 p.
9 - Templado J., 1997. La lapa ferruginea. *Biologica*, 6: 80-81.
10 - Pallary P., 1912-1920. Exploration scientifique du Maroc, Malacologie. *Arch. Scientif. de l'Empire Chérifien*, fasc. II: 108 p.
11 - Grandfils R., 1982. Contribucion al conocimiento de *Patella ferruginea* (Gmelin, 1791). *Iberus*, 2: 57-69.
12 - Biagi V., and Poli D., 1986. Considerazione su una populazione di *Patella ferruginea* Gmelin, 1791 per le acque del Promontorio di Piombino. *Boll. Malacol.*, 22: 171-174.
13 - Cretella M., Scillitani G., Toscano F., Turella P., and Picariello O., 1994. Relatioships between *Patella ferruginea* Gmelin, 1791 and the other Tyrrhenian species of *Patella* (Gastropoda: Patellidae). *J. Molluscan Stud.*, 60: 9-17.
14 - Pallary P., 1902. Liste des Mollusques testacés de la Baie de Tanger. *Journ. De Conchyliologie*: 1-39.

TAXONOMIE ET ÉCOLOGIE NUMÉRIQUE DES DINOFLAGELLÉS AU NIVEAU DU PARC CONCHYLICOLE DE MENZEL JEMIL (LAGUNE DE BIZERTE, TUNISIE SEPTENTRIONALE)

Mouna Bellakhal-Fartouna et Ons Daly Yahia-Kéfi *

[1] Institut National Agronomique, Département des Ressources Animales et Halieutiques et des Ressources Agro-Alimentaires, Unité Ecosystèmes et Ressources Aquatiques, Groupe de Recherche en Hydrologie et en Planctonologie, Tunis, Tunisie
* dalyyahya.ons@inat.agrinet.tn

Résumé

Durant la période de juin à décembre 2002, quatre stations du parc conchylicole de Menzel Jemil ont été prospectées bimensuellement. Parmi les 55 taxa recensés, 20 sont susceptibles d'être nuisibles. Le maximum de densité cellulaire a été relevé en juillet avec 64 894 cellulesl^{-1}.

Mots clés : Dinoflagellés; taxonomie; parc conchylicole; Méditerranée occidentale

Introduction

La lagune de Bizerte a depuis longtemps une vocation halieutique et aquacole. Elle est localisée sur le littoral Nord de la Tunisie septentrionale (Fig. 1) entre 37° 8' et 37° 14' de latitude Nord et 9° 46' et 9° 56' de longitude Est et correspond à une dépression de forme elliptique. La superficie de cette lagune est d'environ 150 km^2 et sa profondeur maximale peut atteindre 12 m. L'activité aquacole dans la lagune a débuté vers les années 50 par l'ostréiculture. Le parc conchylicole de Menzel Jemil (NE de la lagune) constitue un plan d'eau propice à la conchyliculture (moules, huîtres et palourdes). Ce secteur aquacole de 1 ha de concession abrite 15 tables d'élevages.

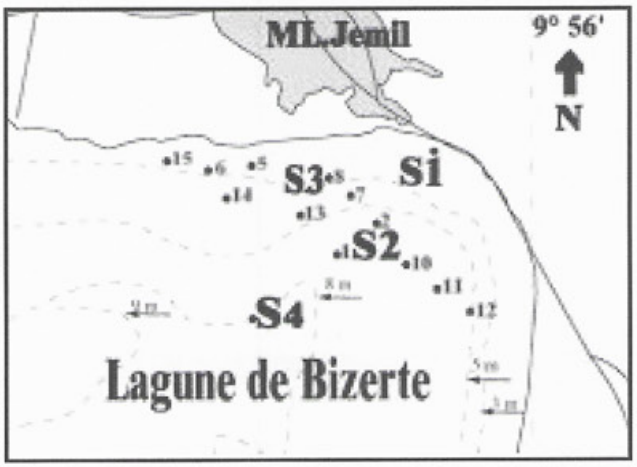


Fig. 1. Emplacements des stations d'étude du parc conchylicole de Menzel Jemil (STL).

Matériels et méthodes

Quatre stations (Fig.1) réparties selon une radiale de la côte vers l'extérieur des tables d'élevage ont été prospectées bimensuellement. L'échantillon destiné à l'étude du phytoplancton a été fixé au formol neutralisé et au lugol. L'examen microscopique a été réalisé à l'aide d'un microscope inversé (HUND) suivant la méthode d'Utermöhl [1].

Résultats et discussion

Cette étude nous a permis de recenser 55 taxa de dinoflagellés, dont 20 taxa sont susceptibles de provoquer des phénomènes d'eaux colorées et des intoxications humaines [2; 3; 4] à savoir: *Alexandrium* Halim *spp*, *Ceratium furca* (Ehernberg) Claprède et Lachman, *Dinophysis sacculus* Stein, *Gonyaulax polyedra* Stein, *Gonyaulax polygramma* Stein, *Gonyaulax spinifera* (claparède et Lachmann) Diesing, *Gymnodinium cf catenatum* Graham, *Gymnodinum sanguineum* Hirasaka, *Karenia mikimotoi* (Miyake et Kominami ex Oda) Hansen et Moestrup, *Gyrodinium spirale* Kofoid et Swezy, *Peridinum quinquecorne* Abé, *Prorocentrum lima* (eherenberg) Dodge, *Prorocentrum mexicanum* Tafall, *Prorocentrum micans* Ehernberg, *Prorocentrum minimum* Schiller, *Prorocentrum triestinum* Schiller, *Protoperidinium depressum* (Bailey) Balech, *Protoperidinium ovatum* (Schütt) Balech, *Scrippsiella faeroense* (Paulsen) Balech et Soarez, *Scrippsiella trochoidae* Fine et Loeblich III.

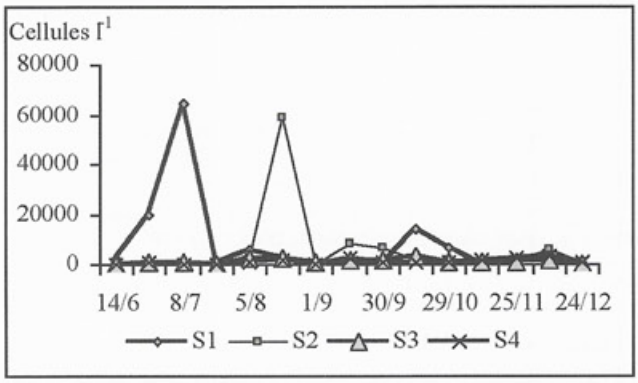


Fig. 2. Evolution bimensuelle de la densité cellulaire des dinoflagellés au niveau des 4 stations d'étude (juin 2002 - décembre 2002).

Les deux principales poussées ont été enregistrées au niveau de la station côtière S1 et de la deuxième table d'élevage du parc S2 avec des densités cellulaires respectives de 64 894 cellulesl^{-1} (8/07/2002) et 59 039 cellulesl^{-1} (19/08/2002) (Fig. 2). Les 2 taxa responsables de ces proliférations sont respectivement *Alexandrium* spp. (63 764 cellules l^{-1}) et *Gymnodinium sanguineum* (46 562 cellules l^{-1}).

Un gradient de densité cellulaire décroissant s'est installé de la côte vers l'extérieur des tables, avec S1 (311 500 cellulesl^{-1}), S2 (31 901 cellulesl^{-1}), S3 (4884 cellulesl^{-1}) et S4 (1906 cellulesl^{-1}), probablement en raison du caractère eutrophe de la station côtière et de l'efficience de filtration des bivalves au niveau des tables.

Les taxa qui ont joué un rôle déterminant dans la dynamique quantitative des dinoflagellés sont: *Ceratium furca* (11,12%), *Peridinum quinquecorne* (11,81%), *Gymnodinum sanguineum* (10,80%), *Scrippsiella trochoidae* (9,67%) et *Alexandrium* spp. (9,09%).

Cette étude a permis d'une part, de recenser les espèces susceptibles d'être nuisibles et de mettre en évidence une hétérogénéité spatiale de la densité cellulaire qui augmente de la côte vers les tables d'élevage et, d'autre part, de constituer un maillon dans le contrôle de la salubrité des bivalves mis en élevage.

Références

1 - Throndsen J., 1995. Estimating cell numbers. Pp. 63-80. In : Hallegraeff, G.M., Anderson, D.M., Cembella, A.D. (eds.), Manual on harmful marine microalguae. IOC. Manuals and guides N°33, UNESCO, Paris.

2 - Hansen G., Turquet J., Quod J-P., Ten-Hage L., Lugomela C., Kyewalyanga M., Hurbungs M., Wawiye P., Ogongo B., Tunje S., and Rakotoarinjanahary H., 2001. Potencially Harmful Microalgae of the Western Indian Ocean-a guide based on a preliminary survey. IOC Manuals and Guides No. 41,. 108 p.

3 - Moestrup Ø., Codd G.A., Elbrächter M., Faust M.A., Fraga S., Fukuyo Y., Cronberg G., Halim Y., Taylor F.J.R., and Zingone A., 2002. IOC Taxonomic Reference List of Toxic Plankton Algae. 40 p.

4 - Darnas A.H., Norte M., and Fernandez J.J., 2001. Toxic marine microalgae. *Toxicon*, 39 (2001): 1101-1132.

ALIENS AND VISITORS IN THE SOUTHERN ADRIATIC SEA: EFFECTS OF TROPICALIZATION

Giambattista Bello *, Nicola Casavola and Ermenegilda Rizzi
Servizio Ittico Ambientale, Provincia di Bari, Italia - gflca@tin.it

Abstract
The tropicalization of the Adriatic Sea is confirmed by the population expansion northward along its south-western coast of some resident species (the bony fishes *Thalassoma pavo* and *Sparisoma cretense*, the gastropod *Stramonita haemastoma*, the cephalopod *Octopus macropus*, and the short-term resident *Caulerpa racemosa*, a chlorophyte) and the settlement in the province of Bari of three tropical dinoflagellates (*Ostreopsis lenticularis, Coolia monotis*, and *Prorocentrum mexicanum*).

Key words: tropicalization, Adriatic Sea, Osteichthyes, Mollusca, algae

Much has been written about the phenomena collectively named "tropicalization of the Mediterranean" that have introduced changes in the biodiversity and biogeography of this sea (1). Such phenomena have also involved the Adriatic Sea, a well-delimited basin the biodiversity of which is generally deemed lower than the Mediterranean average (2). In the past years significant changes in the Adriatic physical conditions have been recorded (3) that may have in turn favoured the ingression of thermophilic species.

In this paper we report and discuss data that are further evidence of the tropicalization of the Adriatic Sea. They are based on information collected and observations carried out in the province of Bari (south-western Adriatic Sea) and concern examples of both "visitors", *i.e.* Mediterranean species whose populations expanded northward along the Apulian coast, and "aliens", *i.e.* extra-Mediterranean species.

In the summer of 1999 the occurrence in the province of Bari of "exotic" bony fishes was repeatedly reported by both professional and sport-fishermen. Indeed those fishes, *viz.* the ornate wrasse, *Thalassoma pavo* Linnaeus, 1758 (Osteichthyes: Labridae) and the parrotfish *Sparisoma cretense* (Linnaeus, 1758) (Osteichthyes: Scaridae), were not at all exotic *sensu strictu*, since they are common members of the Atlanto-Mediterranean ichthyofauna.

As far as the western side of the Adriatic Sea is concerned, until 1999 the population of *T. pavo* was well established in its southernmost part, that is little north of the Otranto Cape, which indicates the southern limit of the Adriatic Sea; few specimens were sporadically found north of Otranto up to Brindisi (the distribution given in the "FAO Fiches d'identification" for this fish embraces the whole South Adriatic Sea (4), probably because it includes the records of stray specimens). In 1999 the ornate wrasse population spread out northward along the coast from Otranto to Bari and many specimens were also caught or spotted in the following three years; in particular schools of juveniles were observed off Palese (north of Bari) in 1999 and 2000. The ornate wrasse seemingly disappeared from the waters of our province in 2003.

Very few specimens of the parrotfish *S. cretense* have been either caught by fishermen or observed by divers since 1999 and up to the summer 2003; its occurrence was also recorded in August 2000 in the southern part of Apulia, just outside the Adriatic Sea (5). The parrotfish is not considered an Adriatic species (4), although it has been occasionally collected here (6). Both *T. pavo* and *S. cretense* are members of the Mediterranean ichthyofauna of Mauretanic affinity and live in the southernmost and warmest part of the basin.

In about the same years we recorded a significant density increase of the red-mouth purpura *Stramonita haemastoma* (Linnaeus, 1767) (Gastropoda: Muricidae) in the posidonia grass beds off the harbour of Bari, in addition to *Hexaplex trunculus* (Linnaeus, 1758) that used to be the only muricid gastropod in those grass beds. *Stramonita haemastoma* too is a thermophilic species of Mauretanic affinity.

To complete the list of "visitors", we report the sudden occurrence in the south-western Adriatic Sea of a sub-population of the cephalopod *Octopus macropus* Risso, 1826 (Cephalopoda: Octopodidae). In the summer and autumn of 2003 many subadult and adult specimens of this species have been caught by fishermen trawling off Mola di Bari. Despite the fact that this octopus is reported as an Adriatic species in all cephalopod lists (7), it is indeed a fairly rare species there as well as in the whole Mediterranean (8). *Octopus macropus* is a cosmopolitan cephalopod that lives in warm temperate waters (8) and reproduces by planktonic paralarvae that can passively travel in the sea.

In 1999 we also received information on and afterwards checked for the presence of the exotic green alga *Caulerpa racemosa* var. *occidentalis* (J. Agardh) Børgesen, 1907 (Chlorophytes: Caulerpaceae) along the coast of Bari province, especially in sheltered areas off Monopoli. The history of the Mediterranean invasion by this pantropical chlorophyte is well known: first recorded in Tunisia in the '20s, it began to spread out quite rapidly in the early '90s and reached the south-western Adriatic in 1999 (present results) and the Croatian coast in 2000 (9).

Lastly we report the occurrence of three exotic dinoflagellates the presence of which became evident because of their harmful effects on people. HAB (Harmful Algal Bloom) phenomena were recorded for the first time in our province in August 2001 (10); unfortunately they showed again in the following two years, in late summer. The three microalgae identified in our waters are exotic and pantropical: *Ostreopsis lenticularis* Fukuyo, 1981 and *Coolia monotis* Meunier, 1919 (Ostreopsidaceae), and *Prorocentrum mexicanum* Tafall, 1942 (Prorocentraceae). The fact that HABs occurred for three years in a row indicates that these toxic dinoflagellates have become stable resident of the province of Bari coast.

The tropicalization of the Adriatic Sea is confirmed by two orders of events, namely the population expansion of some resident species – *i.e. T. pavo, S. cretense, S. haemastoma, O. macropus*, and *C. racemosa* – and the occurrence and establishment of three tropical species – *i.e. O. lenticularis, C. monotis*, and *P. mexicanum*.

References

1 - Bianchi C.N. and Morri C., 2003. Global sea warming and "tropicalization" of the Mediterranean Sea: biogeographic and ecological aspects. *Biogeographia*, 23.
2 - Bello G., 2003. The biogeography of Mediterranean cephalopods. *Biogeographia*, 23.
3 - Grbec B., Morović M., and Zore-Armanda M., 1998. Some new observations on the long-term salinity changes in the Adriatic Sea. *Acta Adriat.*, 39: 3-12.
4 - Bauchot M.-L., 1987. Poissons osseux. Pp. 891-1422. *In:* W. Fischer, M. Schneider & M.-L. Bauchot (eds.), Fiches FAO d'identification des espèces pour les besoins de la pêche. Méditerranée et mer Noire. FAO, Rome.
5 - Guidetti P. and Boero F., 2001. Occurrence of the Mediterranean parrotfish *Sparisoma cretense* (Perciformes: Scaridae) in the south-eastern Apulia (south-east Italy). *J. Mar. Biol. Ass. U.K.*, 81: 717-718.
6 - Šoljan T., 1975. I pesci dell'Adriatico. Mondadori, Milano.
7 - Bello G., 1990. The Cephalopod Fauna of the Adriatic. *Acta Adriat.*, 31: 275-291.
8 - Mangold K. and Boletzky S.v., 1987. Céphalopodes. Pp. 633-714. *In:* W. Fischer, M. Schneider & M.-L. Bauchot (eds.), Fiches FAO d'identification des espèces pour les besoins de la pêche. Méditerranée et mer Noire. FAO, Rome.
9 - Žuljević A, Antolić B., and Onofri V., 2003. First record of *Caulerpa racemosa* (Caulerpales: Chlorophyta) in the Adriatic Sea. *J. Mar. Biol. Ass. U.K.*, 83: 711-712.
10 - Rizzi E., Casavola N., Perillo A., Troncone A, and Cabrini M., 2003. From the Tropics to the Adriatic: *Coolia monotis* Meunier, *Ostreopsis lenticularis* Fukuyo and *Prorocentrum mexicanum* Tafall, toxic algae in sea water and marine organisms along the coast of the province of Bari. *Biogeographia*, 23.

CARACTÉRISATION ÉCOLOGIQUE DE L'HERBIER À *POSIDONIA OCEANICA* DE LA ZONE DE CAP GAMMARTH (TUNISIE)

Asma Ben Rehouma [1], Nejla Aloui-Bejaoui [1] *, Chedly Rais [2], et Habib Langar [3]

[1] Institut National Agronomique, Tunis,Tunisie - * bejaoui.nejla@inat.agrinet.tn
[2] Centre des Activités Régionales pour les Aires Spécialement Protégées (CAR/ASP), Tunis, Tunisie
[3] Institut National Des Sciences et Technologies de la Mer, Salammbô, Tunisie

Résumé

La présente étude porte sur la caractérisation et la cartographie de l'herbier de Posidonies et l'étude des communautés de macroinvertébrés de la région de Cap Gammarth (Golfe de Tunis). Il s'agit d'un herbier relativement jeune, superficiel et côtier dont l'état s'améliore au fur et à mesure que l'on s'éloigne de la côte. La zone d'étude présente une grande richesse spécifique nécessitant des mesures de réduction des impacts négatifs.

Mots clés : Golfe de Tunis, Posidonia oceanica, Biodiversité

Introduction

La présente étude qui s'inscrit dans le cadre de la mise en valeur de sites potentiels pour le développement des aires marines en Tunisie a pour objectif de caractériser, sur le plan écologique, une région du Golfe de Tunis, la zone de Cap Gammarth. Ce site présente un intérêt écologique majeur vue la présence d'un herbier de posidonies édifié sur roche mais malheureusement soumis à différentes agressions d'origine naturelle et anthropique. C'est dans ce cadre que nous nous proposons d'étudier l'état de santé de l'herbier ainsi que la biodiversité associée à cet écosystème.

Matériel et méthodes

La description de l'état de l'herbier ainsi que l'étude phénologique (1) et lépidochronologique, a été réalisée *in situ,* grâce à des observations en plongée le long de transects et à partir de prélèvements sur quadrats de $1m^2$ de surface. La cartographie de l'herbier de posidonies ainsi que ses caractéristiques phénologiques a été effectuée au moyen du logiciel Mapinfo 5.0.

L'étude de la biodiversité a porté sur l'analyse du macrobenthos échantillonné sur un quadrat de 30 cm de côté au niveau de 10 stations. L'identification des espèces et le recensement du nombre d'individus par espèce a permis de calculer les indices de diversité de Shannon (2) et Simpson (3). La similarité entre stations est représentée par l'indice de Bray-Curtis (4) et traitée par le logiciel Pastecs (4).

Résultats

L'étude a permis d'établir une carte de distribution de l'herbier de posidonies, associée au degré d'épiphytisme et à l'absence et la présence d'apex. Des cartes représentant les principaux types de végétation marine et leur distribution dans la zone sont également élaborées. La longueur moyenne des feuilles de posidonies varie entre 19,96 cm et 27,45 cm et la largeur entre 0,88 cm à 1,02 cm. La surface foliaire varie de 101,11 cm^2 et 175,77 cm^2. Le pourcentage de feuilles ayant perdu leurs apex est compris entre 54,62% et 74,58 % et celui des feuilles épiphytées entre 51,86 % et 77,06 %.

L'état des feuilles et la surface foliaire sont meilleures dans les stations profondes que dans celles situées en amont du récif barrière.

La croissance annuelle moyenne cumulée des rhizomes varie entre 0,33 et 1,5 cm. Elle est moins importante que celle de la région de Sidi Rais (5).

Le calcul des indices a été réalisé après identification et calcul de l'abondance de près de 200 espèces. La valeur de l'indice de Shannon dépend de la localisation des stations et des caractéristiques du milieu. L'indice est faible dans les stations 2, 3, 4 et 5. Elle est plus grande dans les stations situées dans l'herbier de posidonies et au niveau du substrat sablo vaseux (H varie entre 3,91 et 4,42). Elle est faible dans les stations situées en dehors de l'herbier, en particulier pour la station située au niveau d'un substrat dur dans un milieu confiné et à faible hydrodynamisme (station 4).

Le calcul de l'indice de Simpson a confirmé les résultats déjà trouvé sauf pour la station 7 où l'indice est faible car il y dominance de deux espèces. La station 4 a une diversité spécifique faible mais l'échantillon est homogène.

L'abondance spécifique est grande et les individus uniformément distribués dans les stations 6, 8, 9 et 10.

Le cluster montre que les stations 5 et 8 ainsi que 1 et 2, ayant le même substrat, ont une forte similitude bien qu'elles soient éloignées. La ressemblance entre les stations 3 et 4 est due, sans doute à leur rapprochement.

La station 10, station de référence située hors de la zone d'étude, est isolée. L'isolement de la station 6 est due à un biais d'échantillonnage.

Conclusion

L'état de l'herbier de posidonies s'améliore lorsqu'on s'éloigne de la ligne de côte. L'herbier est relativement jeune. L'élongation orthotrope varie en fonction des années traduisant les variations brusques de l'état du milieu.

La diversité spécifique dans cet herbier est très importante comparativement à d'autres sites du Golfe de Tunis. Le degré de similitude entre stations dépend de leurs caractéristiques abiotiques, du nombre d'espèces communes et fait intervenir la distance géographique.

Suite à cette étude, il est évident que l'herbier de posidonies de la zone de Cap Gammarth nécessite une protection, réalisable avec l'instauration d'une aire marine protégée.

Références

1 - Pergent G., Rico- Raimondino V. et Pergent- Martini C., 1997. Fate of primary production in *Posidonia oceanica* meadows of Mediterranean. *Aquatic Botany*, vol. 59: 307- 321.

2 - Frontier S. et Pichaud-Viale D., 1998. Ecosystèmes, Structures, Fonctionnement, Evolution. Dunod Ed., Paris. 447 p.

3 - Bronikowski A. et Webb C., 1996. Appendix A: A critical examination of rainfall variability measures used in behavioral ecology studies. *Behav. Ecol. Sociobiol.*, Vol. 39: 27- 30.

4 - Grosjean P. et Ibanez F., 2002. PASTECS, manuel de l'utilisation de la librairie de fonctions pour R et pour S+. Package for analysis of space-time Ecological series. 300 p.

5 - El Asmi S., 2003. Contribution à l'étude de l'herbier de posidonies de Sidi Rais: Cartographie, paramètres de vitalité et perspectives de conservation. Mem 3e cycle, INAT. Tunis. 171 p.

RECOVERY AFTER ANTHROPOGENIC DISTURBANCE: EARLY EFFECT OF PROTECTION ON RECOVERY PATTERNS OF HARD SUBTIDAL SESSILE ASSEMBLAGES

Stanislao Bevilacqua [1], Antonio Terlizzi [1] *, Simonetta Fraschetti [1], Giovanni Fulvio Russo [2]

[1] Dipartimento di Scienze e Tecnologie Ambientali, Università di Lecce, CoNISMa, Lecce, Italy - stanislao.bevilacqua@unile.it
[2] Istituto di Meteorologia e Oceanologia, Università di Napoli "Parthenope", Napoli, Italy

Abstract

A manipulative experiment was conducted to explore the effect of protection on recovery dynamics of hard subtidal sessile benthic assemblages affected by date mussel (*Lithophaga lithophaga*) fishery. Preliminary results showed that the recovery of disturbed assemblages was faster in the protected location than in controls. However, the study underlines the need for long-term monitoring experiments in any attempt to assess the potential role of marine protected areas in mitigating the negative effects of human disturbance on coastal biota.

Key words: date mussel fishery, subtidal habitat, multi-layer assemblages, recovery dynamics, MPA

Introduction and methods

Date mussel (*Lithophaga lithophaga*) fishery (DMF) is one of the most harmful anthropogenic activities affecting hard subtidal benthic assemblages in the Mediterranean Sea (1, 2). Despite of this, little is known on recovery dynamics of assemblages in patches disturbed by DMF. On April 2003, we started a manipulative experiment simulating DMF damage at three locations at Punta Campanella (Campania, SW Italy). One of these was located inside a no-take, no-access marine protected area, the other two random-chosen locations served as controls. At each location, six plots were randomly individuated on subvertical rocky walls at 4-6 m depth, three of these were treated and three served as unmanipulated controls. Few days later, a photographic sampling was carried out providing n=5 replicates for each plot. Samples were examined by visual estimates evaluating cover percentage and number of taxa (3).

Results

DMF caused, on average, a decrease of 75% of the average values of total cover recorded in controls and 1/6 of the total number of taxa completely disappeared in manipulated plots. The nMDS ordination of the Bray-Curtis dissimilarity values (Fig. 1a) well separated treatments but also portrayed differences among locations within treatments. Multivariate analyses also revealed that erect algae, massive sponges, vermetids, hydroids and colonial ascidians mostly contributed to separate disturbed and undisturbed assemblages, thus indicating a strong impact of DMF on these taxa. Encrusting and cryptic organisms were apparently less affected by DMF as indicated by their low contribution to the values of dissimilarity between disturbed and undisturbed assemblages. The nMDS ordination of data from the second time of sampling (July 2003) showed that manipulated plots in the protected location aggregated with their respective unmanipulated plots, whilst in control locations manipulated and unmanipulated plots were still clearly separated (Fig. 1b).

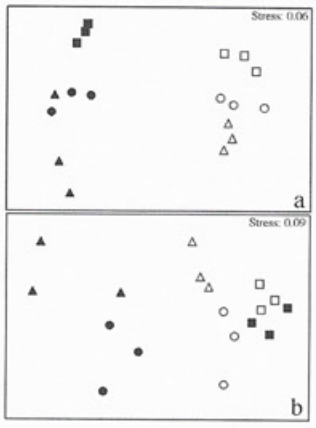


Figure 1a,b.
Non-metric multidimensional scaling ordinations based on Bray-Curtis dissimilarity values of plots' centroids (untransformed data).
(a) 1°Time; (b) 2°Time. Squares = protected location, Circles = Control location 1, Triangles = Control location 2; manipulated plots = filled symbols, unmanipulated plots = empty symbols.

Discussion and conclusion

Local factors could be considered of greater importance in driving recovery dynamics, especially when DMF allows the survival of small colonies and create relative small embedded patches as in our case. In such a situation, vegetative propagation from neighbours and residual pool of taxa escaped to complete destruction may exert an important role in recovery of disturbed assemblages (4). Thus, the importance of differences in growth rates and interspecific relations among the involved taxa could rise against external factors (e.g. larval supply) that, instead, could have a central role when larger areas of substrate are heavily affected by DMF (5). The ecological mechanisms driving an apparently faster recolonization in protected locations are still unknown. Our results suggest that protection has a critical effect on recovery dynamics. This effect tends to accelerate the recovery without changing the structure of pre-existing assemblages. Paradoxically, erect algae, that experienced the greatest DMF impact, were those that recovered faster and mostly contributed to similarity between disturbed and undisturbed assemblages in the second time of sampling but, under the canopy, the other layers of assemblages are far from pristine conditions. It is unlikely that in the protected location assemblages as a whole had recovered completely, due to differences in life cycles, growth rates and distribution of organisms across layers in multi-stratified systems (6). Turf regains space very quickly after disturbance (7) but encrusting and cryptic organisms could be much slower in recovering. Thus, DMF disturbance could act differently across layers, and the recovery of the whole assemblage could occur over a longer period than what needed by the turf layer. Moreover, seasonality and the time of disturbance's occurrence could have significant outcomes on recovery. This study is, therefore, still in progress to monitor the temporal trend of recovery over a longer-time period. Since the integrity of benthic communities is crucial for coastal ecosystems, a deeper understanding of recovery dynamics in areas damaged by DFM with the use of long-term experimental monitoring is needed to integrate the preventive action of authorities with an effective policy of mitigation of human impact on coastal zone.

References

1 - Fanelli G., Piraino S., Belmonte G., Geraci S., and Boero F., 1994. Human predation along Apulian rocky coasts (SE Italy): desertification caused by *Lithophaga lithophaga* (Mollusca) fisheries. *Mar. Ecol. Prog. Ser.*, 110: 1-8.

2 - Naylor E., 1995. Marine Biology. P. 212. *In:* Encyclopaedia Britannica Yearbook 1995. Encyclopaedia Britannica Inc., London.

3 - Dethier M.N., Graham E.S., Cohen S., and Tear L.M., 1993. Visual versus random-point percent cover estimations: 'objective' is not always better. *Mar. Ecol. Prog. Ser.*, 96: 93-100.

4 - Sousa W.P., 2000. Natural disturbance and the dynamics of marine benthic communities. Pp. 85-130. *In:* M.D. Bertness, S.D. Gaines and M.E. Hay (eds), Marine community ecology. Sinauer Associates Inc., Sunderland, Massachusetts.

5 - Connell J.H., and Keough M.J., 1985. Disturbance and patch dynamics of subtidal marine animals on hard substrata. Pp. 125-151. *In:* S.T.A. Pickett and T.S. White (eds), The ecology of natural disturbance and patch dynamics. Academic Press, Orlando, FL.

6 - Airoldi L., 2000. Responses of algae with different life histories to temporal and spatial variability of disturbance in subtidal reefs. *Mar. Ecol. Prog. Ser.*, 195: 81-92.

7 - Airoldi L., 2000. Effects of disturbance, life histories, and overgrowth on coexistence of algal crusts and turfs. *Ecology*, 81: 798-814.

MISE EN EVIDENCE D'UNE FORTE ACTIVITE PHOSPHATASIQUE CHEZ LES LARVES DE CIRRIPEDES

Gérard Boge, Simone Richard *, Leatitia De Sousa
LEPI-PROTEE, Université de Toulon et du Var, La Valette, France - boge@univ-tln.fr

Résumé
Les larves de Cirripèdes sont des organismes zooplanctoniques qui possèdent une activité phosphatasique spécifique particulièrement forte. Elle agit sur des substrats intracellulaires et possède une faible affinité pour le paranitrophényl phosphate. Elle est stimulée par l'eau de mer et notamment par le magnésium et le sodium. Elle est inhibée de façon compétitive par les ions orthophosphate, et présente un optimum à pH 8,2.

Mots clés: phosphatase alcaline, cirripèdes

Introduction

Ce travail a été consacré à la mise en évidence et à l'étude des caractéristiques biochimiques de l'activité phosphatasique d'organismes zooplanctoniques marins : les larves de Cirripèdes. Au cours des précédents travaux, effectués dans divers ports de la région toulonnaise, nous avons constaté que l'activité phosphatasique spécifique du zooplancton présentait des niveaux particulièrement élevés lorsque des larves de Cirripèdes étaient présentes dans le milieu (1, 2). Leur développement présente une forte influence saisonnière, avec des densités maximales entre mai et juillet. A ces périodes, ces abondances restent néanmoins très faibles, et représentent moins de 1% de celles du zooplancton total.

Matériel et méthodes

Des larves de Cirripèdes ont été isolées, sur lesquelles l'activité phosphatasique a été mesurée. Cette activité a été étudiée à 20°C en utilisant le paranitrophényl phosphate de sodium comme substrat. Il a été dissous dans de l'eau de mer préalablement filtrée sur 0.25 µ. Les larves de Cirripèdes ont été isolées individuellement à partir de prélèvements de zooplancton effectués à l'aide d'un filet de 90 µ de vide de maille dans la petite rade de Toulon.

Résultats

Ces organismes possèdent une activité phosphatasique très élevée. Elle est au moins 50 fois plus forte que chez *Oithona nana* qui est le copépode le plus abondant de la rade. Elle présente un pH optimum de 8,2 correspondant au pH de l'eau de mer. Elle est inhibée à plus de 90% quand l'eau de mer est remplacée par de l'eau déminéralisée. Le magnésium et le sodium sont les cations les plus efficaces pour la stimuler. L'effet du sodium pourrait résulter d'une augmentation de la force ionique. Elle est inhibée de manière compétitive par les ions orthophosphate, preuve qu'il s'agit d'une phosphatase alcaline. Elle est surtout intracellulaire et serait peu impliquée dans l'hydrolyse des composés phosphorés de l'eau de mer. Elle agirait par conséquent surtout sur des substrats intracellulaires, ce qui est confirmé par la faible affinité qu'elle présente vis à vis de son substrat. Cette activité pourrait avoir un rôle dans l'élaboration des constituants de l'exosquelette et de l'épiderme, en particulier chez les cypris qui constituent le dernier stade larvaire des cirripèdes avant leur fixation. Elle pourrait également être en rapport avec l'utilisation de réserves métaboliques (3).

Références

1 - Gambin F., Bogé G., Jamet D., 1999. Alkaline phosphatase in a littoral Mediterranean marine ecosystem: role of the main size classes. *Marine Environmental Research*, 47: 441-456.
2 - Jean N., Bogé G., Jamet J. L., Richard S., Jamet D., 2003. Seasonal changes in zooplanktonic alkaline phosphatase activity in Toulon Bay, the role of Cypris larvae. *Marine Pollution Bulletin*, 46: 346-352.
3 - Freeman J . A., Costlow J. D., 1983. The cyprid molt cycle and its hormonal control in the barnacle *Balanus amphitrite*. *Journal of Crustacean Biology*, 3 (2): 173-182.

THE FIRST FIND OF *PORTUNUS PELAGICUS* (DECAPODA, BRACHYURA) IN THE STRAITS OF MESSINA (CENTRAL MEDITERRANEAN SEA)

Antonio Bonanno, Francesca De Domenico, Adriana Profeta and Nunziacarla Spanò*

Dipartimento di Biologia Animale ed Ecologia Marina, Università degli Studi di Messina, S. Agata Messina, Italia - * spano@unime.it

Abstract

Portunus pelagicus was collected during a survey carried out in the Straits of Messina in the autumn of 2002. This is the first find of this species for this area. Four specimens were caught at two different stations at 25 and 40 m depth, respectively, in the soft bottom colonized by *Caulerpa taxifolia*. In this paper the physical characteristics of water and sediment are reported. Finally considerations on the relevant changes in the benthic environment following the settlement of *Caulerpa taxifolia* prairies, are reported.

Key-words: Straits of Messina, Caulerpa taxifolia, Portunus pelagicus

Introduction

Four specimens of the brachyuran crab *Portunus pelagicus* (L.) (Decapoda, Brachyura, Portunidae), 3 male and 1 female, were found along the Sicilian coasts of Straits of Messina (Central Mediterranean Sea) during a research project entitled "Anomalie biotiche e abiotiche nello Stretto di Messina", carried out in the 2001-2003 years. The aim of this project is the benthic modifications caused for invasion of alloctonous species *Caulerpa taxifolia* (Vahl) C. Agardh. This find, the first from the Straits of Messina, contributes to the knowledge of distribution of *P. pelagicus*.

Methods and materials

The sampling was carried out by scuba divers along the Sicilian coasts from Capo Peloro to Torrente Annunziata (Fig. 1). A total of 31 samples was taken at a depth of 7-60 m in the years from 1999 to 2003. For each samples 50dm^3 of sediment were taken, on the surface area of 0.25m^2. Specimens of benthic macrofauna collected were fixed in 70% alcohol solution in the laboratory. At both stations temperature and salinity were measured using a multiparameters probe. Sediment samples collected were used for granulometric analysis (1).

Moreover were carried out video recording by scuba divers, for monitoring the distribution of *Caulerpa taxifolia* in the Straits of Messina.

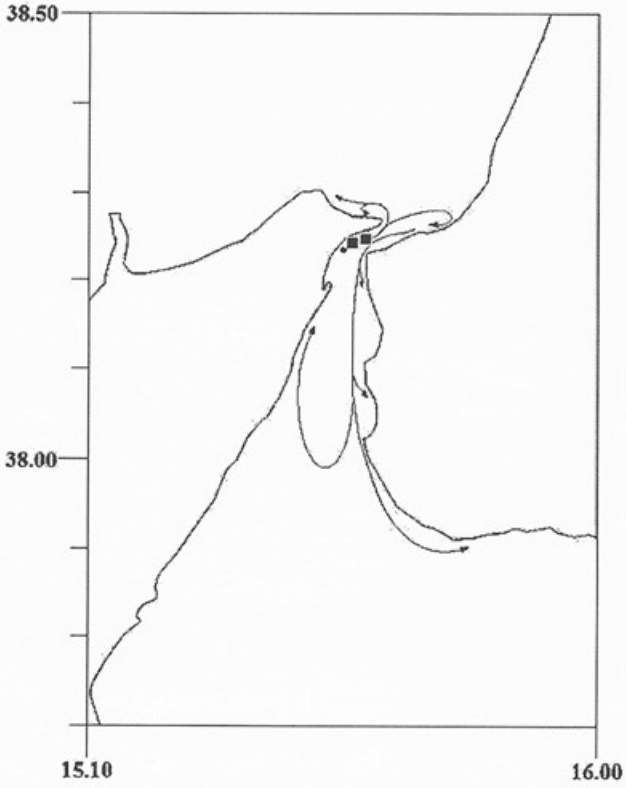


Fig. 1. Monitoring distribution of *Caulerpa taxifolia* in the Straits of Messina in the year 2003. Squares show sampling stations of *Portunus pelagicus*.

Results and discussion

The analysis carried out on the benthic macrofauna found on *Caulerpa taxifolia*, showed 38 species and 369 specimens of crustacea decapoda. In total, four specimens of *Portunus pelagicus* were collected at 31 sampling stations.

The specimens were caught in the northern part of Straits of Messina at 25 and 40 m depth in front of Ganzirri village.

The granulometric features of this site showed coarse sand sediment. The values of salinity and temperature are reported: 37.8% and 26°C respectively for both sites.

The other species of decapods are reported in the same stations: *Alpheus macrocheles, Dardanus arrosor, Eurynome aspera, Parthenope massena* and *Xantho poressa*.

The Straits of Messina represent a junction of the two basin, the Ionian one and the Tyrrhenian one. This is a peculiar environment which the hydrological regime has a fundamental role in the distribution of the benthic populations. Moreover the topography and hydrodynamic level of this area allow the establishment of communities exclusive to the Mediterranean Sea (2; 3).

The presence of *Caulerpa taxifolia* has been reported in The Straits of Messina since 1993 (4; 5).

In general, the investigations in the Straits of Messina on macrozoobenthic communities (crustacea decapoda) of *Caulerpa taxifolia* showed an increase of number of species and specimens. On the contrary the populations, variable and heterogeneous are destructured and still changing (6).

The presence in such sample of atlantic species must be noted, as *Parthenope expansa* and *Pilumnus inermis* already reported in this area (7; 8). It is very important this record of the lessepsian species *P. pelagicus* in the Straits of Messina. The presence of atlantic and lessepsian species in the Straits of Messina is an other evidence of the importance of this zone, which are reported the eastern and western migratory flows.

Acknowledgements. We would like to thank particularly G. Iaria for the diving center OLOTURIA SUB from Messina for their helpful collaboration during the sea operations.

References

1 - Folk R.L. and Ward W.C., 1957. Brazos river bar: study in the significance of grain size parameters. *Journ. Sed. Petr.*. 27 (1): 2-26.

2 - Fredj G. and Giaccone G., 1987. Bionomie des fonds a Laminaires du Détroit de Messine, *Doc. et Trav. IGAL.* 11 : 237-238.

3 - Di Geronimo S.I. and Fredj. G., 1987. Les fonds à *Errina aspera* et *Pachylasma giganteum*, *Doc. et Trav. IGAL.* 11 : 243-247.

4 - Fradà Orestano C., Calvo S. and Ferreri B.M., 1994. First record of *Caulerpa taxifolia* (Vahl) C. Agardh in the southwestern Mediterranean. *Giorn. Bot. Ital.*, 128 (3-4): 813-815.

5 - Fradà Orestano C., Pirrotta M. and Ammirato E., 2001. Spread of *Caulerpa taxifolia* in Sicily and Calabria (Italy). Fourth International Workshop on *Caulerpa taxifolia*, GIS Posidonie publ., Fr., pp. 78-84.

6 - Guglielmo R., Giacobbe S., Spanò N. and Manganaro A., 2002. Comunità macrozoobentoniche associate a *Caulerpa taxifolia* (Vahl) C. Agardh nello Stretto di Messina: primi risultati. *Biol. Mar. Medit.*, in press.

7 - Spanò N., 2002. Presenza di *Parthenope expansa* (Miers, 1879) (Decapoda: Parthenopidae) nello Stretto di Messina. *Biol. Mar. Medit.*, 9 (1).

8 - Giacobbe S. and Spanò N., 2001. *Pilumnus inermis* (Decapoda, Brachyura) in the Straits of Messina and the Southern Tyrrhenian Sea (Mediterranean Sea): distribution and some aspects of its ecology. *Crustaceana*, 74 (7): 659-672.

POPULATION ECOLOGY OF *PHALERIA ACUMINATA* (COLEOPTERA: TENEBRIONIDAE) FROM SANDY BEACHES IN THE MALTESE ISLANDS

Borg Joanna [1] *, Deidun Alan [2], Schembri Patrick J. [3]
Department of Biology, University of Malta, Msida, Malta
apb@orbit.net.mt, alpra1@mail.global.net.mt, patrick.j.schembri@um.edu.mt

Abstract
Populations of the beetle *Phaleria acuminata* from four beaches on the Maltese Islands were sampled for six consecutive seasons to investigate changes in population size, sex ratio, reproductive state and distribution on the shore. The populations on all the beaches showed a small decrease in numbers from spring to summer and a pronounced drop from summer to autumn, with a dramatic increase between winter and spring. Male to female sex ratio varied between 1:1 and 1:1.5. Females of all reproductive stages occurred throughout the year. There were little seasonal differences in distribution of beetles in the wet and dry zones.

Keywords: Phaleria acuminata, population dynamics, sex ratio, sandy shores

Few studies on the population ecology of shore-dwelling tenebrionids have been made. Two species of *Phaleria* (*P. acuminata* and *P. bimaculata*) occur in the Maltese Islands (1), and on some beaches may account for up to 54% of all individuals of macro-invertebrates collected. We investigated aspects of the population ecology of the commonest species *Phaleria acuminata* on four beaches: White Tower Bay and Golden Bay on Malta, and Ramla l-Hamra and Xatt l-Ahmar on Gozo. *Phaleria acuminata* were sampled over six different seasons between October 2001 and March 2003 using a constellation of pitfall traps in the wet and dry zones of the beaches. Sex was determined by dissection and the reproductive state of females was determined by examining the state of the *bursa copulatrix*.

A total of 8842 individuals were collected from the four beaches over the study period. On all the beaches, more individuals were collected in spring and summer than in autumn and winter. The population size on each of the four beaches showed an almost identical pattern with a small decrease in numbers from spring to summer and then a sudden drop from summer to autumn. The second set of autumn and winter samples showed a similar phenology as the first set, although a lower number of beetles were collected. The population increased dramatically during spring especially at Ramla l-Hamra and Xatt l-Ahmar. This contrasts with the results obtained by Carpaneto and Fattorini (2) who found that the Italian *Phaleria acuminata* population they studied had the largest drop in abundance from spring to summer; Aldryhim *et al.* (3) describe a similar pattern in Saudi Arabia.

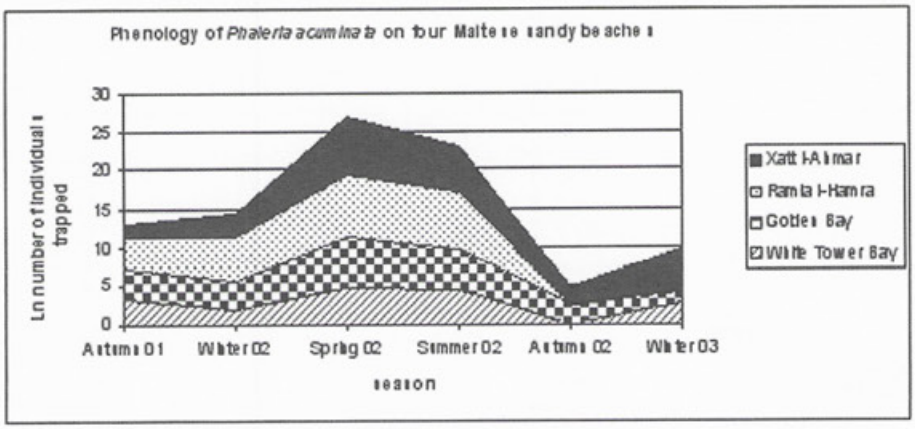
The sex ratio did not vary much at Golden Bay and Ramla l-Hamra; however, at White Tower Bay and Xatt l-Ahmar there were large seasonal variations. In general, more females than males were collected, with a few exceptions: the spring sample from White Tower Bay, the first autumn sample from Golden Bay, and the spring and summer samples from Xatt l-Ahmar, when males outnumbered females. However, there was no significant seasonal variation in sex ratio on any of the beaches (Kruskall-Wallis test). At Xatt l-Ahmar, the overall sex ratio was very close to 1:1 whereas on the other beaches it was approximately 1.5 females for every male. Sex ratio may give an indication of how stressed a population is; the greater the stress, the greater the deviation from a 1:1 ratio, as the population tends to produce more individuals of the energetically economical sex. In this regard it is worth noting that Xatt l-Ahmar is an isolated beach with a low number of visitors whereas the other beaches are very popular recreational resorts especially during summer.

In general, females of all reproductive stages occurred throughout the year, showing that a percentage of the population is reproductive at all times. However, in spring and summer there was an increase in the percentage of females of low reproductive potential, probably representing newly emerged, unmated adults. This correlates well with the increase in numbers of individuals trapped during these seasons, suggesting a peak in emergence during the warmer part of the year.

Krosnov and Shenbrot (4) found that shore-dwelling tenebrionids on Israeli beaches occupied the wet zone in the warmer months and moved upshore towards the dunes during the colder months. In the present study, there was no clear seasonal pattern for either sex in the occurrence of the beetles in the wet and dry zones of the beaches studied. Although more beetles occurred in the wet zone during the warmer months of the year, the difference was not statistically significant.

References

1 - Mifsud D., Scupola A. (1998). The Tenebrionidae (Coleoptera) of the Maltese Islands (Central Mediterranean). *Annali del Museo Civico di Storia Naturale "G. Doria"*, 92: 191-229.
2 - Carpaneto, G. M., Fattorini S. (2001). Spatial and seasonal organization of a darkling beetle (Coleoptera, Tenebrionidae) community inhabiting a Mediterranean coastal dune system. *Italian Journal of Zoology*, 68; 207-214.
3 - Aldryhim, Y. N., Mills C.W., Aldawood A.S. (1992). Ecological distribution and seasonality of darkling beetles (Coleoptera: Tenebrionidae) in the central region of Saudi Arabia. *Journal of Arid Environments*, 23: 415-422.
4 - Krosnov B., Shenbrot G. (1997). Seasonal variation in spatial organization of a darkling beetle (Coleoptera: Tenebrionidae) community. *Environmental Entomology*, 26(2): 178-190.



PRELIMINARY DATA ON SETTLEMENT OF THE FOULING ORGANISMS AT SHELLFISH FARM IN MALI STON BAY, SOUTH-EASTERN ADRIATIC, CROATIA

Ana Bratoš [1] *, Jakša Bolotin [2], Melita Peharda [3], Marija Crncevic [1]

[1] University of Dubrovnik, Dubrovnik, Croatia - * abratos@vdu.hr
[2] Institute of Oceanography and Fisheries, Dubrovnik, Croatia
[3] Institute of Oceanography and Fisheries, Split, Croatia

Abstract

Settlement seasonality of fouling organisms was studied on shellfish collectors, between December 2000 and December 2001. A total of 10 classes and 30 species were determined from collectors submerged for two months, and 15 classes and 41 species from collector submerged for one year, out of which *Pomatoceros triqueter, Ciona intestinalis, Botryllus schlosseri, Bugula neritina* and *Eudendrium racemosum* were present abundantly throughout a year.

Keywords: biofouling, settlement, shellfish farming

Introduction

The Bay of Mali Ston, the highest shellfish production area in the eastern Adriatic, is an extended and ramified bay situated between the mainland and Pelješacpeninsula. The tradition of collection and aquaculture of the European flat oyster *Ostrea edulis* extends for a couple of centuries. The Mediterranean black mussel, *Mytilus galloprovincialis*, is also being farmed in this area. Among the numerous problems related to this farming, biofouling is of special concern. Fouling causes considerable damage to cultivated organisms and may result in enormous losses for producers, affecting bivalve growth and survival, and adding weight and drag on culture equipment [1,2]. Therefore, the study of temporal distribution of fouling organisms was undertaken to improve mussel and oyster aquaculture.

Material and methods

Fouling organisms were allowed to settle on clean PVC mussel juvenile collectors attached to long-lines, from December 2000 to December 2001. Experimental collectors were submerged at 1,5 m depth at different seasons to determine seasonal pattern of species settlement and were removed bimonthly, except one collector that was submerged for one year. Water depth at the site was 8 m, temperature ranged from 8-26 °C [3]. Samples were taken by scraping clean three surfaces of 25 cm^2 from the ribbed collectors. Removed organisms were preserved in 70% ethyl alcohol and taxa were enumerated and identified to species level later on in the laboratory, except diatoms that were identified to the class level.

Results and discussion

The analyzed fouling community in the Bay of Mali Ston consisted of 30 sessile organisms belonging to 10 classes, obtained from collectors that were submerged for two months, and 41 species from 15 classes that were attached to a collector submerged for 12 months (Table 1). Besides Chlorophyta, all classes that were present in bimonthly samples were noticed at the long-term collector. Sponge species, as well as sea urchins, gastropods and the anthozoan *Actinia* were identified only after 12 months of submersion, indicating that these species seem to prefer already fouled surfaces.

Besides Diatoms, only five species were settling throughout the year. The polychaete *Pomatoceros triqueter*, which decreases market value of the mussels, and the ascidian *Ciona intestinalis* were dominant, especially in wintertime. The ascidian *Botryllus schlosseri,* the bryozoan *Bugula neritina* and the hydrozoan *Eudendrium racemosum* were dominant during the warmer season. Other sessile species were present at different times, but were never abundant. Collectors submersed in June and August, sampled in August and October, respectively, were settled by a number of oysters, what correlates with data on distribution of oyster larvae in water column [3]. The only mussel specimen was noticed at the bimonthly collectors that were submersed in August (sampled in October), but samples from a yearly collector show abundant presence of this species; indicating that mussel larvae might prefer surfaces that are already fouled by other species. Interaction in settlement of different species was noted in previous studies. The presence of hydroids enhances tunicates settlement; this assemblage positively influences mussel settling [4]. The presence of bryozoans and tunicates indicates development of flat epibionts that may increase shellfish mortality rate [2]. Further research will quantitatively analyze the temporal and spatial distribution of fouling species on collectors set up in this important aquaculture area.

Table 1. Number of species in fouling community.

Submersion period (months)			2				12
Sampling month	Feb	Apr	Jun	Aug	Oct	Dec	Dec
Schyzophyta							
Diatomeae	+	+	+	+	+	+	+
Phaeophyta	1						1
Rhodophyta	2		1		1	1	3
Chlorophyta	1						
Porifera							
Calcarea							1
Demospongia							1
Cnidaria							
Hydrozoa	2	2	1	1	2	3	3
Anthozoa							1
Echinodermata							
Echinoidea							2
Plathelminthes							
Turbellaria					1	1	1
Annelida							
Polychaeta	1	1	1	1	2	2	6
Tentaculata							
Bryozoa	3	2	2	3	4	5	4
Mollusca							
Gastropoda							3
Bivalvia			1	5	3		7
Tunicata							
Ascidiacea	2	2	2	2			

References

1 - Arakawa K.Y.,1990. Competitors and fouling organisms in the hanging culture of the Pacific oyster *Crassostrea gigas* (Thunerg). *Mar Behav. Physiol.*, 17: 67-94.

2 - Igic Lj., 1981. The fouling of eadible shellfish in Maloston Bay (in Croatian). Pp. 235-251. *In:* Zbornik radova savjetovanja Malostonski zaljev prirodna podloga i društveno valoriziranje. JAZU, Znanstveni savjet za zaštitu prirode. Dubrovnik.

3 - Bratoš A., Bolotin J., Peharda M., and Njire J. 2001. Seasonal distribution of the bivalve *Ostrea edulis* (Linnaeus 1758) larvae in the Bay of Mali Ston. *J. Shellfish Res.* 21(2): 763-767.

4 - Relini G., Geraci S., Montanari M., and Romairone V. 1976. Variazioni stagionali del fouling sulle piattaforme off-shore di Ravenna e Crotone. *Boll. Pesca Piscic. Idrobiol.* 31(1,2): 227-256.

DISTRIBUTION AND TAXONOMIC COMPOSITION OF PHYTOPLANKTON IN A SHALLOW, ADRIATIC ESTUARY (ZRMANJA, JULY 2000)

Burić Z. [1] *, Cetinić I. [1], Caput K. [1], Viličić D. [1]

[1] University of Zagreb, Faculty of Science, Division of Biology, Zagreb, Croatia - * zburic@zg.biol.pmf.hr

Abstract

The abundance and taxonomic composition of phytoplankton was determined in the highly stratified Zrmanja Estuary, eastern Adriatic Sea, Croatia, during the low river inflow (July 2000). Microphytoplankton accumulated in the middle reach of the estuary, were the living conditions were most stabile. Accumulation of nanoplankton, at the head of the estuary, indicated higher microbiological recycling of organic mater. CCA biplot indicated the diatom *Chaetoceros socialis*, as well as cryptophytes and nanoplanktonic dinoflagellates, developing exclusively in the estuary, while the rest of phytoplankton community had freshwater or seawater origin.

Key words: phytoplankton, estuary, Adriatic Sea

Introduction

The karstic Zrmanja River discharges into the Adriatic Sea forming a small, highly stratified estuary. Stratified water column is characterized by the sharp and shallow halocline (1). The concentration of orthophosphates is low and increased downstream in the estuary. Higher concentrations of total inorganic nitrogen (TIN) and silicates (SiO_4) is usually detected in the upper estuary. Concentration and distribution of nutrients indicates oligotrophic conditions in the estuary.

Material and Methods

The research was carried out in upper (Stations Z1, Z2, Z3, Z4, Z4a, Z4b) and middle (Station N1) reach of Zrmanja Estuary (Fig. 1) in July 2000. Phytoplankton samples were taken using 5l Niskin bottles at one meter intervals along the water column. Phytoplankton was preserved in a 2% neutralized formaldehid solution and counted by inverted microscope method (2). Canonical Correspondence Analysis (CCA; 3) was used to display influences of environmental conditions on distribution and taxonomic composition of dominant phytoplankton taxa.

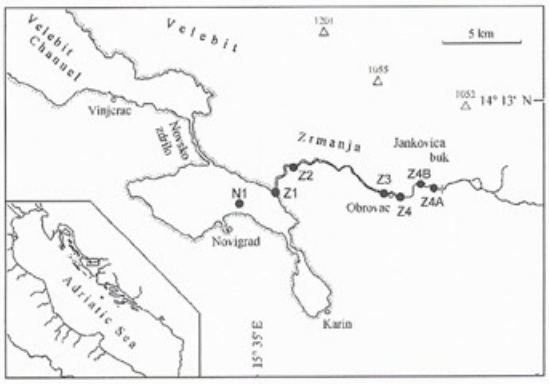


Fig.1. Investigated area.

Results and Discussion

In July 2000, marine microphytoplankton dominated in the community, below the halocline, in middle reach of the estuary (5×10^5 cellsL^{-1}). It was composed of diatoms (51%), dinoflagellates (37%), coccolithophorides (8%), euglenophytes (2%) and chrysophyceae (2 %). The abundance decreased in the upstream direction. At the head of the estuary, at station Z4a, the abundance of freshwater species (*Dinobryon* spp. and pennate diatoms) increased. Freshwater phytoplankton sank to the halocline and died gradually in the seaward direction.

Nanoplankton accumulated at the head of the estuary (6.4×10^5 cells L^{-1}). It was composed of dinoflagellates, coccolithophorides, cryptophytes and green flagellates.

Microphytoplankton reached maximum abundance in the middle reach of the estuary due to most stabile living conditions. On the other hand, in the upper estuary, living conditions are stressful providing adequate growth conditions only for nanoplankton. In the upper estuary, nanoplankton was probably composed of mixotrophic species that participate in the microbiological recycling of organic matter.

The frequent diatom in the estuary was *Chaetoceros socialis*, that usually forms large chains and is thus considered as microphytoplankton. In the Zrmanja estuary it was present as single-cell species, and followed the distribution of other nanoplankton.

Orthophosphates and nitrites are products of microbiological regeneration in the estuary. Nanoplanktonic dinoflagellates (I), cryptophytes (K) and *Chaetoceros socialis* (M) showed high correlation (Fig. 2) with orthophosphates (PO4) and nitrites (NO2), indicating their development exclusively in the estuary.

Green flagellates(L), freshwater pennate diatoms (N) and brackish diatom *Cocconeis scutellum* (B) show high correlation with nitrates (NO3) and silicates (SiO4) indicating their freshwater origin and ability to maintain in the estuary.

The coccolithophorid *Syracosphaera pulchra* (A), as well as the diatoms *Proboscia alata* (D) and Leptocylindrus danicus (C) showed high correlation with salinity (S) and ammonium (NH4), indicating their seawater origin.

Nanoplanktonic coccolithophorides (J), the diatoms *Cyclotella striata* (F), *Pseudo-nitzschia* sp. (E) and the dinoflagellate *Mesoporos perforatus* (G) showed negative correlation with the rest of the estuary community, preferring lower temperatures (T) and higher salinity.

Conclusion

According to CCA biplot, nanoplankton was the most characteristic phytoplankton in the upper Zrmanja estuary, while microphytoplankton came either from the sea or from the freshwater accumulations above the estuary. Freshwater species mostly die in the estuary, due to stressful environmental conditions along the salinity gradient. Phytoplankton community in the Zrmanja estuary is composed mostly of species that can tolerate stressful environmental conditions.

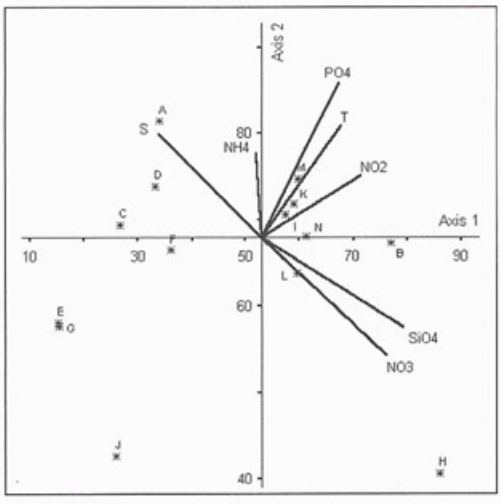


Fig. 2. CCA ordination biplot. Species and enviromental labes are listed in the text. Environmental variables are displayed as lines.

References

1 - Burić Z., Caput K., Olujić G., Viličić D, 2003. Distribution of phytoplankton and nutrients in the river Zrmanja estuary (July 2000). Proceedings, 3rd Croatian conference on waters, Osijek, 28-31 May 2003, pp. 197-204.

2 - Utermöhl, H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton Methodik. *Mitt. Int. Ver. Theor. Angew. Limnol.* 9, 1-38.

3 - Ter Braak, C. J. F., 1995. Ordination. In: Jongman, R. H. G., ter Braak, C. J. F., van Tongeren, O. F. R., Data analysis in community and landscape ecology. University Press, Cambridge.

ÉTUDE DE LA DIVERSITÉ GÉNÉTIQUE ET PHÉNOTYPIQUE CHEZ LA GORGONE SYMBIOTIQUE MÉDITERRANÉENNE *EUNICELLA SINGULARIS* (ESPER, 1791)

Chiara Caligara [1], Didier Forcioli [1], Pierre Laurent Merle [1], Patrice Francour [2] et Denis Allemand [1, 2 *]

[1] UMR UNSA - INRA 1112 "Réponse des organismes aux stress environnementaux Université de Nice-Sophia Antipolis, Nice, France - forcioli@unice.fr

[2] E.A. 3156 « Gestion de la Biodiversité », Université de Nice-Sophia Antipolis, Nice, France - francour@unice.fr

[3] Centre Scientifique de Monaco, Monaco - * allemand@centrescientifique.mc

Abstract

Par leur diversité, les gorgones (Cnidaires, Octocoralliaires) représentent sans aucun doute une des plus importantes richesses de la mer Méditerranée. Parmi elles, on rencontre des gorgones symbiotiques comme *Eunicella singularis*, possédant à l'intérieur de leurs tissus des Dinoflagellés communément appelés zooxanthelles. Nous nous sommes interrogés sur l'importance de cette symbiose pour la survie des Cnidaires lors de fluctuations environnementales.

Mots clés : Symbiose, Cnidaires, Zooxanthelles, PCR-RFLP, ADNr

Parmi de nombreuses autres espèces d'invertébrés, *Eunicella singularis* a subi de fortes mortalités en 1999, associées à une augmentation de la température des eaux (1; 2). Au travers d'*Eunicella singularis*, nous envisageons donc d'évaluer le rôle de la symbiose en milieu tempéré face à des perturbations soudaines de l'environnement.

Un premier travail descriptif et de mise en place d'outils moléculaires était nécessaire. En effet, seuls les cnidaires symbiotiques tropicaux ont été bien décrits. Ils abritent des populations mixtes de symbiotes et semblent capables d'en manipuler la composition dans certaines limites, pour faire face aux changements environnementaux (3).

Nous avons donc entamé une analyse de la diversité génétique des symbiotes d'*Eunicella singularis* (par PCR-RFLP de l'ADNr), ainsi qu'une caractérisation biologique de cette symbiose (densité en symbiotes et concentration en chlorophylle selon la profondeur) sur un échantillon de 120 individus prélevés à deux profondeurs sur 4 sites différents. Les résultats préliminaires obtenus semblent décrire un modèle original de symbiose en Méditerranée, différant tant en nature qu'en fonctionnement des modèles tropicaux.

E. singularis semble n'abriter qu'un seul clade de zooxanthelle, le clade A, et des séquençages de la grande sous unité ribosomique indiquent que ces symbiotes appartiennent au sous clade A1, typique des eaux tempérées (4). Enfin, une étude par PCR-RFLP de cette grande sous unité ribosomique a mis en évidence une faible variabilité génétique inter sites (Fig. 1).

Les analyses biologiques ont montré que quel que soit le site, les individus provenant des populations de profondeur abritaient une plus faible densité de symbiotes, et une plus faible quantité de chlorophylle (Fig. 2). Ceci tendrait à démontrer que, contrairement au coraux tropicaux, *E. singularis* ne compense pas la baisse de luminosité accompagnant l'augmentation de profondeur. Ceci indiquerait un rôle trophique différent des zooxanthelles pour cette espèce méditerranéenne.

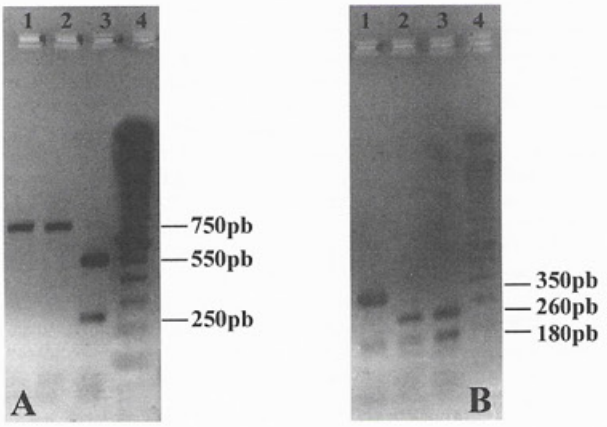


Fig. 1.
A) Produits de digestion de la grande sous unité ribosomique par l'enzyme de restriction *DpnII*. Puits 1 : Individu Banyuls 2, Puits 2 : Individu Banyuls 3, Puit 3 : Individu Banyuls 1, Puits 4 : Marqueur de poids moléculaire. Tous les autres individus de Banyuls, de Giens et Méjean avaient le même profil que l'individu Banyuls 1.
B) Produits de digestion de la grande sous unité ribosomique par l'enzyme de restriction *DdeI*. Puits 1 : Individu Banyuls 2, Puits 2 : *Stylophora pistillata*, Puits 3 : *Galaxea fascicularis*, Puits 4 : Marqueur de poids moléculaire. Tous les individus de Banyuls, Giens et Méjean avaient un profil identique à celui de Banyuls 2.

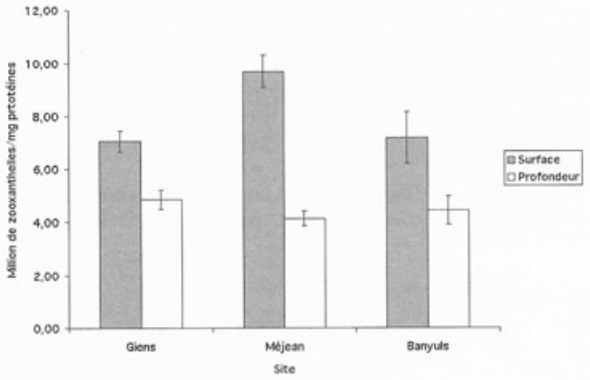


Fig. 2. Nombre de zooxanthelles en fonction de la profondeur et du site d'échantillonnage.
Les valeurs correspondent aux moyennes ± ES avec n=7 réplicats par site et par profondeur. Les donnés ont été testées avec un ANOVA a 2 facteurs : Site, F = 0,495, NS; Profondeur, F = 12,6444, p <0,005; Interaction, F = 1,10059, NS.

Enfin, il est intéressant de noter que le site de Banyuls, qui n'avait pas été touché par les fortes de mortalités de 1999 malgré l'augmentation générale de la température des eaux, est un site dans lequel les gorgones abritent moins de zooxanthelles, et contiennent le moins de chlorophylle.

Références

1 - Perez, T., Garrabou, J., Sartoretto, S., Harmelin, J.G., Francour, P., Vacelet, J., 2000. Mass mortality of marine invertebrates: an unprecedented event in the Northwestern Mediterranean. *Comptes Rendus de l'Académie des Sciences,* Série III, Vie Vol 323, Issue 10: 853-865.

2 - Cerrano, C., Bavestrello, G., Bianchi, C.N., Cattaneo-Vietti, R., Bava, S., Morganti, C., Morri, C., Picco, P., Sara, G., Schiaparelli, S., Siccardi, A., Sponga, F., 2000. A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. *Ecology letters,* 3: 284-293.

3 - Baker, A.C., 2001. Reef corals bleach to survive change. *Nature*, 411: 765-766.

4 - Savage, A.M., Goodson, M.S., Visram, S., Trapido-Rosenthal, H., Wiedenmann, J., Douglas, A.E., 2002. Molecular diversity of symbiotic algae at the latitudinal margins of their distribution : dinoflagellates of the genus *Symbiodinium* in corals and sea anemones. *Marine Ecology Progress Series,* 244: 17-26.

ANNUAL VARIABILITY IN THE DISTRIBUTION OF SURFACE NUTRIENTS AND PHYTOPLANKTON IN THE OMBLA RIVER ESTUARY

Marina Caric * and Nenad Jasprica

Institute of Oceanography and Fisheries, Dubrovnik, Croatia - * caric@labdu.izor.hr

Abstract

Karstic fresh waters enrich the Ombla River estuary with nutrients, especially with NO_3, PO_4 and SiO_4. The concentration of all nutrients decreased from the upper to the lower reaches of the estuary. Peaks of phytoplankton occurred in May and August. The phytoplankton abundance, as with nutrients, decreased towards the lower reaches of the estuary.

Key words: hydrography, nutrients, phytoplankton, estuary, Adriatic Sea

Introduction

The highly stratified and low tidal, 4 km long estuary of the Ombla River is located on the Adriatic coast near Dubrovnik. The region is influenced by karstic fresh and marine waters. This paper aims at determining the annual variability in the distribution of surface nutrients and phytoplankton abundance along the longitudinal axis of the Ombla river estuary.

Results and Discussion

Samples for the analysis of hydrographic, chemical and biological parameters were collected at three stations (Ombla-1, 6 m deep; Ombla-2, 15 m; Ombla-3, 25 m) along the estuary, during 17 cruises from November 1999 to November 2000. Parameters were determined by standard oceanographic methods (1, 2).

Annual variations in the mean values of investigated physico-chemical parameters as well as phytoplankton abundance are presented in Figures 1, 2 and 3.

Temperatures rose from March to end-May and were more or less constant until September. In October, the water column began to cool.

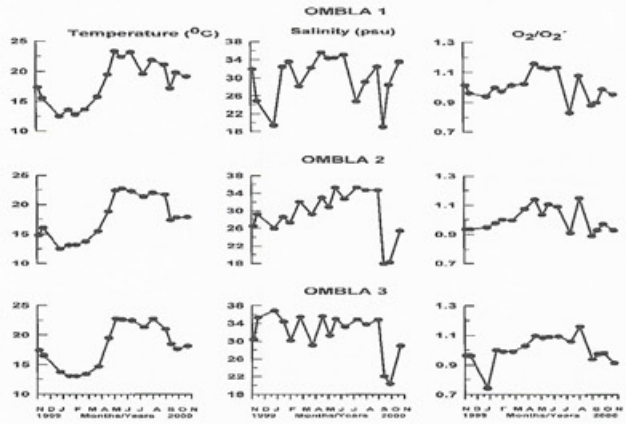


Fig. 1. Annual distribution of temperature, salinity and oxygen saturation (average).

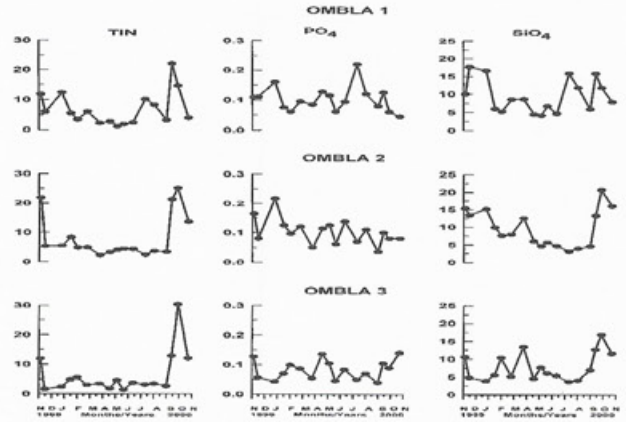


Fig. 2. Annual distribution of nutrients (average, mmol dm^{-3}).

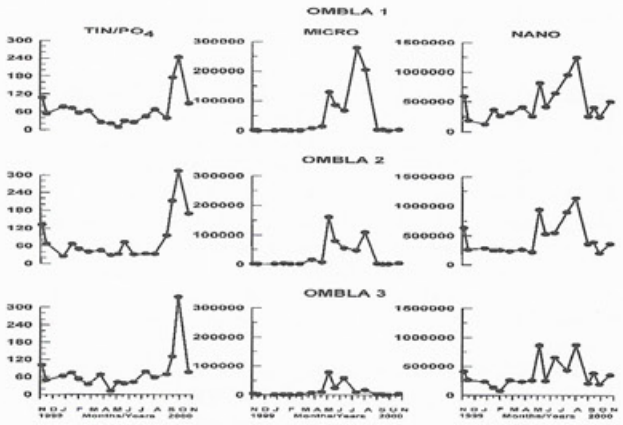


Fig. 3. Annual distribution of Redfield ratio, microphytoplankton and nanophytoplankton abundance (cells/L), (average).

The minimal salinity value was 17.94 psu, indicating a noticeable influx of seawater throughout the entire estuary. The oxygen saturation indicated a good aeration.

The concentration of all nutrients decreased throughout the estuary for most of the year. The Redfield ratio (TIN/ PO_4) values were appropriate for phytoplankton growth from April to August, and means were as follows: 27 (Ombla-1), 31 (Ombla-2), 38 (Ombla-3). The Redfield ratio increased throughout the estuary, as compared to nutrients.

The first peaks of microphytoplankton (cells longer than 20 µm, MICRO), and nanophytoplankton (cells 2-20 µm, NANO), occurred during end-May. This was a time when temperatures reached their high rising value, 22.45 ^{0}C. The PO_4 concentrations were higher than 0.1 mmol dm^{-3}, and the Redfield ratio values were 14 (Ombla-1), 19 (Ombla-2) and 34 (Ombla-3). The MICRO population was composed of dinoflagellates (>89%), mostly *Prorocentrum triestinum*. Second peaks of MICRO and NANO appeared at end-August. The concentration of all nutrients at the Ombla-1 station was high: TIN-10.27, PO_4-0.22, SiO_4-15.91, decreasing towards the lower reaches of the estuary. At Ombla-3 station, it was: TIN-3.55, PO_4 0.07, SiO_4-4.12 (mmol dm^{-3}). The Redfield ratio values were 34, 37 and 39. The MICRO population (>85%) was made up of the dinoflagellates, mostly *Scrippsiella trochoidea*.

It is generally assumed that, in estuaries, primary production decreases in the landward direction (3). In the Ombla River estuary the phytoplankton population density decreased towards the lower reaches of the estuary. A probable reason could be the decrease of nutrients and the increase of the Redfield ratio.

References

1 - Strickland J.D.H. and Parsons T.R., 1972. A practical handbook of seawater analysis. *Bull. Fish. Res. Bd. Can.*, 167, 310 p.

2 - Utermöhl, H., 1958. Zur Vervollkommnung der quantitativen Phytoplankton Methodik. *Mitt. int. Ver. Theor. Angew. Limnol.* 9: 1-38.

3 - Heip, C.H.R., Goosen, N. K., Herman, P. M. J., Kromkamp, J., Middelburg, J. J., Soetaert, K. 1995. Production and consumption of biological particles in temperate tidal estuaries. *Oceanography and Marine Biology Annual Review* 33: 1-149.

EVALUATION A COURT TERME DE L'ETAT MACROZOOBENTHIQUE DE LA LAGUNE DE SMIR (MAROC)

Abdellatif Chaouti

Université Mohammed V, Institut Scientifique, Rabat, Maroc - achaouti@hotmail.com

Résumé

Le macrozoobenthos de la lagune méditerranéenne de Smir (NW Maroc) a été étudié à partir d'un échantillonnage bimestriel de mai 1999 à novembre 2000. Le stress imposé par les conditions saisonnières dans la lagune agit sur la structure interne du peuplement. L'hiver et le printemps semblent être les périodes favorables pour la macrofaune. La lagune abrite un peuplement paucispécifique, juvénile avec des diversités inférieures à 3 bits et caractérisé par une organisation simple.

Mots clés : Mediterranean, Lagoon, Soft bottom, Macrozoobenthos

Introduction

La lagune de Smir (N 35°43' et W 5°20') a une superficie de 3 km^2 et une profondeur moyenne de 1.5 m. Elle reçoit par un chenal dit « chenal des marais » (1) les eaux provenant des marais qui s'étendent entre le plan d'eau lagunaire et la localité de M'diq. Elle communique avec un port de plaisance puis avec la mer à travers un goulet et subit régulièrement les mouvements de la marée de 1 m d'amplitude moyenne.

Résultats et discussion

Le modèle DIMO (2) indique une dynamique à court terme (Fig. 1) qui s'apparente, au sens de Qinghong (2), à un type 2 « evenness type » ; les valeurs moyennes de l'équitabilité (J') restent en général comparables alors que celles de la richesse spécifique (S) et l'indice de Shannon-Wiener (H') varient d'un mois à l'autre. Les valeurs de H' restent faibles et sa variabilité temporelle paraît être fonction de S. L'examen de la dispersion du nuage de points relevés (Fig. 1) indique un peuplement mieux structuré et plus stable en printemps-début été.

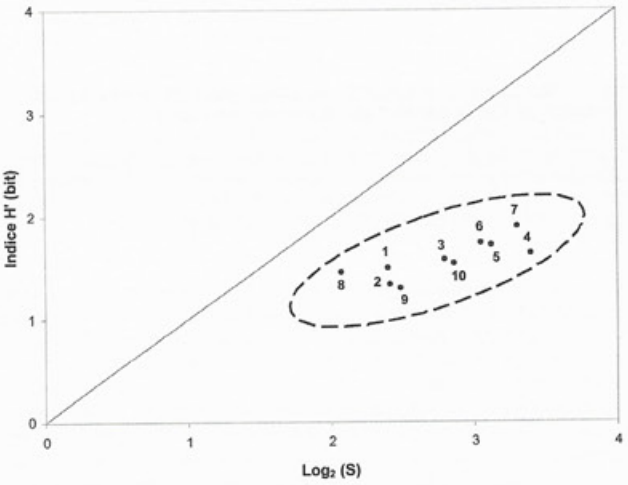


Fig. 1. Projection dans un plan bidimensionnel, de l'évolution à court terme de richesse spécifique Log2 (S), indice H' et équitabilité J' du macrobenthos de la lagune de Smir.
1 : mai 1999 ; 2 : juillet 1999 ; 3 : septembre 1999 ; 4 : décembre 1999 ; 5 : janvier 2000 ; 6 : mars 2000 ; 7 : mai 2000 ; 8 : juillet 2000 ; 9 : septembre 2000 ; 10 : novembre 2000.

Les faibles amplitudes des variations de H' et J' sont typiques d'un peuplement relativement stable.

La baisse de H' pendant les périodes estivales (Fig. 1) se justifie comme une première étape de structuration au cours de laquelle une ou deux espèces montrent une forte dominance. Par contre, les périodes hivernale et printanière sont caractérisées par des indices optimaux (Fig. 1) qui correspondent à une période où le nombre d'espèces est maximal et la hiérarchie de dominance est faible et des équitabilités élevées (jusqu'à 0.59 en mai 2000).

L'évolution des groupes écologiques (GE) (3) d'espèces de polluosensibilité variable durant la période d'étude (Fig. 2) indique une prédominance des espèces tolérantes (GEIII) suivie par les espèces sensibles (GEI). Le GEI représenté par 15 espèces, indique une augmentation depuis fin printemps jusqu'à l'hiver 1999 et qui est principalement due à *Melita palmata*. Il se maintient durant la période entre l'hiver et fin printemps 2000, marque une chute en été de 54.0% (soit 2054 ind./m^3) à 23.5% (soit 179 ind./m^3) de l'effectif total de juillet 2000, puis remonte vers fin été-début automne (Fig. 2). Le groupe des tolérantes (14 espèces), montre une évolution à l'encontre du GEI en accusant une baisse progressive depuis le début du suivi jusqu'à fin printemps. Après une augmentation de ses proportions en juillet, le GEIII, continue sa décroissance jusqu'à l'automne suivant où il recèle 59.0% de l'effectif total du mois considéré. Cette évolution des GE est caractérisée par celle des indices biotiques (Fig. 2) variant entre 0 et 2 et témoignant d'un état de déséquilibre (IB2) plus prononcé qu'un état normal (IB0). Pourtant, une particularité se dégage de cette analyse ; il s'agit de la coexistence du GEIII et GEI en proportions relativement équivalentes pendant toute la période hiverno-printanière, d'où le double indice biotique 0–2 (Fig. 2) attribué au peuplement en cette période, preuve d'un état de déséquilibre.

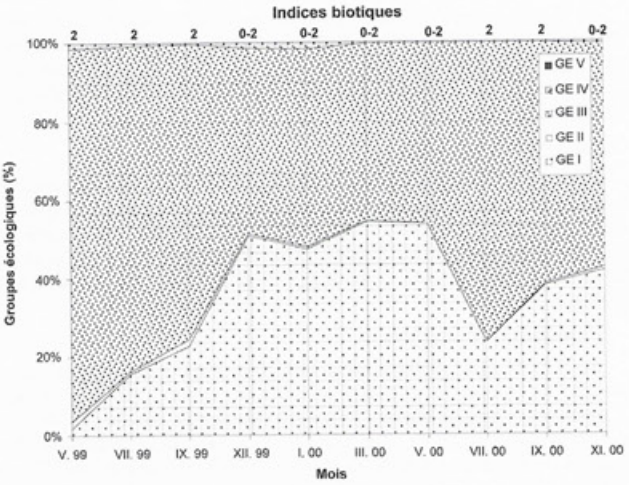


Fig. 2. Variabilité temporelle du modèle de bioévaluation des structures benthiques.
GE I : sensibles ; GE II : indifférentes ; GE III : tolérantes ; GE IV : opportunistes de 2ème ordre. Le GE V des opportunistes de 1er ordre n'existe pas.

Références

1 - Chaouti A., Bayed A., and Benazzou T., 2001. Données préliminaires sur la diversité spécifique et fonctionnelle du zoobenthos de la lagune de Smir (Maroc). *Rapp. Comm. int. Mer Médit.*, 36 : 372.

2- Qinghong L., 1995. A model for species diversity monitoring at community level and its application. *Environmental monitoring and assessment*, 34 : 271-284.

3- Hily C., 1984. Variabilité de la macrofaune benthique dans les milieux hypertrophiques de la rade de Brest. Thèse Doctorat d'Etat. Univ. Bretagne Occidentale, Brest (France), 696 p.

L'ÉCOSYSTEME LAGUNAIRE DE SMIR (MAROC) : HYDROLOGIE ET HYDRODYNAMIQUE

Abdellatif Chaouti
Université Mohammed V, Institut Scientifique, Rabat, Maroc - achaouti@hotmail.com

Résumé

Le régime hydrologique de la lagune de Smir est marqué par de grandes fluctuations particulièrement de salinité et de température. Il est la résultante de facteurs hydrodynamiques (marées et apports continentaux), auxquels s'adjoignent des facteurs, physique (évaporation), topographique (profondeur) et physiologique (photosynthèse des algues, phanérogames et macrophytes).

Mots clés : Lagoon, Hydrology, Hydrodynamic

Introduction

La lagune côtière de Smir est située au sud du détroit de Gibraltar (N 35°43' et W 5°20') (1). Elle a subi un aménagement qui a contribué à la modification de son hydrologie et son hydrodynamique, à la disparition de certaines espèces de flore et de faune et à une réduction considérable de sa superficie.

Matériel et méthodes

Des suivis journaliers ont été réalisés pour les eaux entrantes et sortantes au niveau de deux stations fixes. L'une est située au goulet de la lagune (N 35°43'151" et W 05°20'256") et l'autre au niveau du chenal des marais (N 35°42'106" et W 05°20'249"). La variation du niveau de l'eau est suivie dans une station au milieu du port de plaisance.

Résultats et discussion

Au flot, les eaux marines euhalines pénètrent par le goulet et envahissent la lagune en refoulant vers l'intérieur les eaux lagunaires n'ayant pu s'écouler hors de la lagune pendant le jusant. Ces dernières se mélangent, leurs salinités s'homogénéisent et atteignent des valeurs voisines de celle de la mer (36.3 PSU). Ces eaux (12°C en hiver et 16°C au printemps) venant de la mer s'étalent dans cette cuvette de faible profondeur et se réchauffent sous l'action de l'ensoleillement et du brassage avec les eaux chaudes descendues des marais. Le pH et l'oxygène dissous montrent des évolutions parallèles avec la température. Ils indiquent des valeurs caractéristiques des eaux marines et varient de 7.9 à 8.3 et de 8.5 à 12.0 mg/l respectivement.

Au jusant, les eaux traversant le goulet sont plus salées et plus chaudes que celles qui l'ont traversé au flot. L'oxygène et le pH suivent la même tendance que la température. Ils affichent des maxima respectivement de 8.8 et 12.9 mg/l en automne avec des températures maximales de l'ordre de 19.3°C et qui atteignent 26.1°C en été.

Pendant le reflux, le chenal achemine des eaux oligohalines (salinité entre 3.7 et 4.5 PSU et conductivité entre 6.9 et 8.0 ms/cm). Ces eaux relativement chaudes ont une température moyenne de 20°C, de faibles alcalinités (7.6 < pH < 7.8) et sont faiblement oxygénées (3.7 à 6.5 mg/l). Elles se mélangent avec les eaux poly-euhalines de la lagune et constituent les eaux chaudes mésohalines. Ces eaux occupent toute la zone du débouché du chenal et avancent dans la lagune pour donner naissance aux eaux polyhalines dans les parties aval et centrale. Les eaux marines euhalines parcourent toute la lagune, se réchauffent et s'oxygènent par la photosynthèse. Elles repoussent les eaux bloquées dans la partie amont de la lagune vers le haut du chenal. Une fois mélangées avec ces dernières, leur salinité augmente de 8.3 à 19.2 PSU et leur température de 22.5 à 24.3°C.

Le pH et l'oxygène évoluent avec la température au niveau du chenal en accusant des amplitudes assez importantes et variant en fonction de la saison.

Pour les étales de basse mer, le retard enregistré dans la lagune varie de 1 h 45 min (printemps) jusqu'à 3 heures (automne) et de 45 minutes (hiver) à 1 h 44 min (printemps) pour la pleine mer par rapport aux horaires officiels. Pour se vidanger, la lagune met donc plus de temps que lorsqu'elle se remplit, surtout pendant les marées de vives eaux. Ce constat s'est concrétisé pendant le suivi journalier des niveaux de marées (Fig. 1). Pour le chenal principal, le retard à marée basse par rapport à celle donnée par l'annuaire des marées, atteint 6 h 12 min et il est de 3 h à marée haute. Les étales de marées n'y durent que 5 à 10 minutes alors qu'au niveau du chenal, elles sont très rapides.

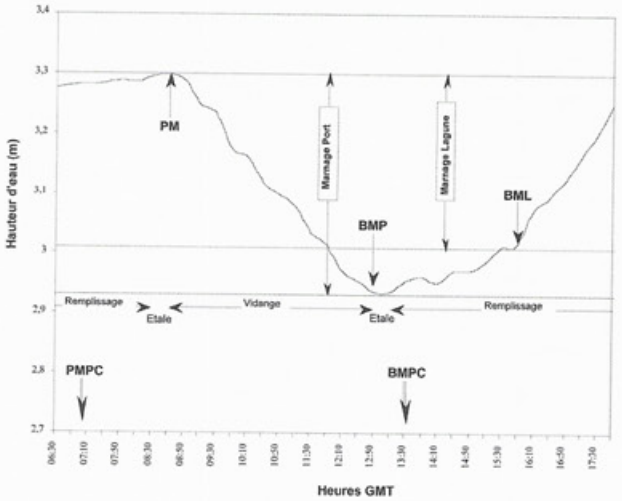


Fig. 1. Variations de niveaux d'eau enregistrées au milieu du port de plaisance de Kabila pendant une marée de vives eaux.
Les flèches doubles indiquent les heures de pleines mers (PMPC) et de basses mers (BMPC) pour le port de Casablanca. Les flèches simples indiquent ces mêmes horaires observés lors des mesures de niveaux d'eau sur terrain. BMP : marée basse dans le port ; BML : marée basse pour la lagune ; PM : pleine mer observée dans la lagune et le port.

De même, les courants du flot et du jusant apparaissent à la suite d'une étale brève (environ 10 min). Les deux étales sont séparées de 4 h 20 min dans le port et de 7 h 10 min dans la lagune. Ceci dénote un décalage horaire à marée basse entre le port et la lagune qui est en relation avec la différence de niveau et l'exiguïté du goulet. La lagune se trouve, en effet, à un niveau plus élevé que celui du port. L'eau, en revanche, pénètre par la forte poussée du flot marin avec une remontée simultanée du niveau d'eau dans le port et la lagune. Ceci minimise le retard et favorise une seule et même étale de pleine mer. Par contre, au jusant, le volume d'eau appréciable entré par le flot dans la lagune, n'arrive pas à être facilement évacuée par le goulet très étroit. Ceci explique le retard à marée basse noté dans la lagune par rapport à celui observée dans le port de plaisance. Cette dénivelée engendre aussi une différence de marnage qui est inférieure à 0.5 m en automne 2000; il est de 0.37 m au niveau du port et de 0.28 m au niveau de la lagune.

Références

1 - Bayed A., et Chaouti A., 2001. Caractérisation physico-chimique des eaux de la lagune de Smir en été. *Rapp. Comm. int. Mer Médit.*, 36 : 356.

BIOÉVALUATION DE L'ÉTAT DE SANTÉ DES PEUPLEMENTS MACROZOOBENTHIQUES D'UN ESTUAIRE ATLANTIQUE MAROCAIN: ESTUAIRE DU BOU REGREG

E. Cherkaoui [1] * et A. Bayed [2]

[1] Ecole Supérieure de Technologie, Université Mohammed V, Salé, Maroc - * echerkaoui@yahoo.fr
[2] Institut Scientifique, Université Mohammed, Agdal, Rabat, Maroc

Résumé

Les états de santé de la macrobenthique de l'estuaire du Bou Regreg sont identifiés grâce à l'utilisation des groupes écologiques et des indices biotiques. Les peuplements intertidaux et subtidaux montrent deux indices biotiques (0 et 2).

Mots clés : Maroc, Estuaire, Bou Regreg, Indices biotiques

Introduction

L'estuaire du Bou Regreg est situé sur la côte atlantique marocaine entre les deux villes Rabat et Salé à 34°00' nord et 06°50' ouest (Fig. 1). Cet estuaire est très pollué à cause l'existence de plusieurs rejets d'eaux usées domestiques et industrielles qui se déversent directement dans le cours d'eau.

Echantillonnage

L'échantillonnage de la faune est réalisé de façon bimensuelle entre mars 1998 et janvier 1999. En zone intertidale, au niveau de 12 stations (stations: A à N), le moyen utilisé est la bêche plate et la surface échantillonnée est le 1/4m^2. En zone subtidale l'échantillonnage est réalisé au niveau de 8 stations (numérotés de 1 à 8) grâce à une drague conique de type *Rallier et Baty*. Le tamisage a été effectué sur place au moyen d'un tamis de 1 mm^2 de vide de maille. Le refus est fixé au formol à 8%. Au laboratoire, la totalité de la faune est trié est conservée a l'alcool 70°.

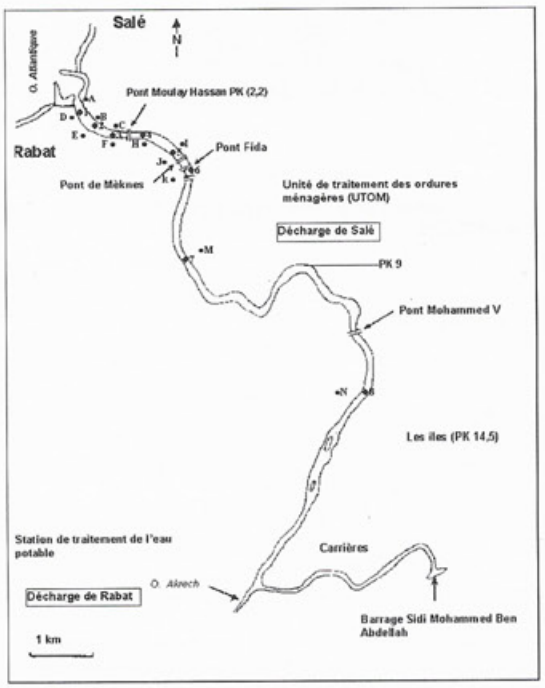


Fig. 1. Situation géographique de l'estuaire du Bou Regreg et localisation des stations d'échantillonnage.

Matériel et méthodes

La méthode des groupes écologiques et des indices biotiques (1, 2, 3, 4) a été réalisée pour évaluer l'état de dégradation des peuplements. Elle est basée sur le regroupement des espèces en cinq groupes de polluo-sensibilté différente. Les espèces de chaque groupe ont le même comportement écologique face à la pollution organique et présentent des profils d'abondances similaires sur le gradient.

Résultats et discussion

Au niveau des deux zones, intertidale et subtidale, il y a présence de quatre groupes écologiques dont seulement deux qui sont bien représentés le long de l'estuaire (GEI et GEIII).

Le groupe des espèces sensibles (groupe I) est majoritaire avec plus de 70% pour les stations A et D dans la zone intertidale et les stations 1 et 2 de la zone subidale. Le groupe III dominant les stations restantes avec plus de 75% et de même en abondance.

Selon la méthode des Indices Biotiques (IB) (4), le peuplement de cette partie de l'estuaire est donc normal (IB0) au niveau de la partie avale sans signe de dégradation d'origine organique. Tandis que pour le reste de l'estuaire le peuplement est en état déséquilibré (IB2).

Ce modèle a donc la possibilité de mettre en évidence, pour ne pas dire qualifier, les premières modifications des équilibres dans l'écosystème estuarien. Il s'agit de détecter les effets de l'enrichissement en matière organique sur la modification de la composition spécifique des peuplements benthiques.

L'évaluation de l'état de santé de l'écosystème benthique des deux zones, intertidale et subtidale, de l'estuaire du Bou Regreg montre deux états : un état normal (IB0) localisé dans la partie avale et un état déséquilibré (IB2) pour le reste de l'estuaire. Cependant, l'état normal s'étale sur une distance plus grande en zone subtidale qu'en zone intertidale. Ceci est dû à l'action de l'hydrodynamisme et du courant dans la première zone, ce qui assure le renouvellement de l'eau du fond et limité les effets d'enrichissement en matière organique.

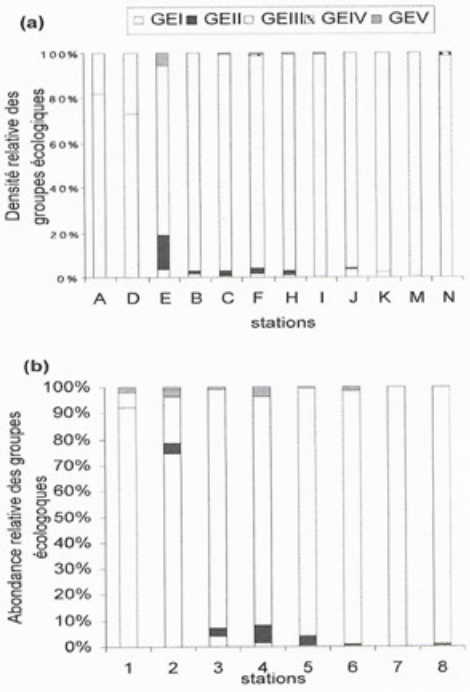


Fig. 2. Représentation des groupes écologiques (%) dans la zone intertidale (a) et la zone subtidale (b).

Références

1 - Afli M., Chenier F., 2002. Etat de santé de la macrofaune benthique et rôle des espèces invasives dans le golfe de Morbihan (Bretagne, France). *Vie Milieu*, **52**: 43-57.

2 - Afli M., Glémarec M., 2000. Fluctuation à long-terme des peuplements macrobenthiques de la partie orientale du golfe du Morbihan (Bretagne, France). *Cah. Biol. Mar.*, **41**: 67-89.

3 - Glémarec M., Hily C., 1981. Perturbations apportées à la macrofaune benthique de la baie de Concarneau par les effluents urbains et portuaires. *Acta Œcologica, Œcol. Applic.*, **2**, 2: 139-150.

4 - Grall J., Glémarec M., 1997. Bioévaluation des structures benthiques en rade de Brest. *Ann. Inst. océanogr.*, Paris, **73** (1) : 7-16.

LA STRUCTURE TAXONOMIQUE DE L'ESTUAIRE DU BOU REGREG APRÈS LA CONSTRUCTION DU BARRAGE SIDI MOHAMMED BEN ABDELLAH

E. Cherkaoui [1] * et A. Bayed [2]

[1] École Supérieure de Technologie de Salé, Salé Medina, Maroc - * echerkaoui@yahoo.fr
[2] Institut Scientifique de Rabat, Rabat-Agdal, Maroc

Résume

Le peuplement macroozoobenthique de l'estuaire de Bou Regreg est composé de 54 espèces dans la zone subtidale et 41 espèces en zone intertidale. Ce peuplement est dominé par trois taxa: les polychètes, les mollusques et les crustacés.

Mots clés : Estuaire, Bou Regreg, Macrofaune benthique, structure taxomonique

Introduction

L'Oued Bou Regreg constitue un milieu naturel exceptionnel ayant favorisé l'implantation des populations et le développement d'activités socio-économiques. Ceci a malheureusement fragilisé et agressé ce milieu. De plus l'installation du barrage a perturbé l'écosystème estuarien. Le présent travail est consacré à l'établissement de la diversité taxonomique de la macrofaune benthique de l'estuaire du Bou Regreg au niveau de la zone intertidale et la zone subtidale.

Matériel et méthodes

L'estuaire du Bou Regreg est situé sur la côte atlantique marocaine entre les deux villes de Rabat et Salé (Fig. 1). Il s'étend sur 23 km et est limité en amont par le barrage Sidi Mohammed Ben Abdellah, sa largeur moyenne étant de 150 m (Fig. 1).

L'échantillonnage de la faune a été réalisé sur 12 stations intertidales (stations A à N) et 8 stations au niveau de la zone subtidale (Fig. 1) lors de six campagnes de prélèvements qui s'étalent de mars 1998 à janvier 1999. Le moyen utilisé pour la zone intertidale est une bêche plate et la surface prélevée est de 1/4m^2. En zone subtidale, le moyen utilisé est la drague conique.

Le tamisage a été effectué sur place au moyen d'un tamis de 1 mm^2 de vide de maille. Le refus est fixé au formol à 8%. Au laboratoire, ce refus est trié et la faune est isolée et conservée dans l'alcool 70° avant les opérations d'identification et de comptage.

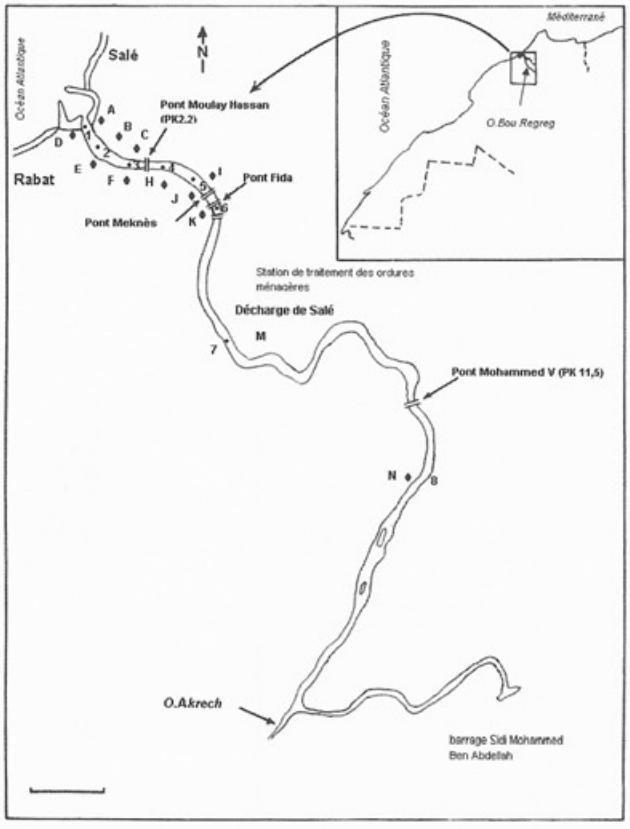


Fig. 1. Situation géographique de l'estuaire de Bou Regreg et localisation des stations d'échantillonnages.

Résultats et discussion

Le peuplement de la macrofaune benthique reste plus diversifié dans la zone subtidale (54 espèces) que la zone intertidale (41 espèces). Ce peuplement est dominé qualitativement par trois groupes zoologiques: les polychètes, les crustacés et les mollusques. Cependant ce sont les polychètes qui restent les mieux représentés avec 39% en zone intertidale et 41% en zone subtidale (Fig. 2).

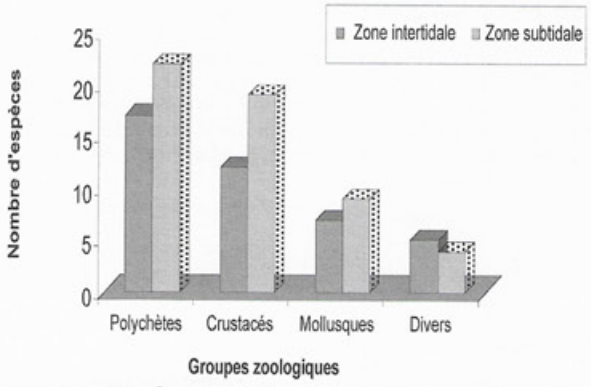


Fig. 2. Représentation des groupes zoologiques dans la zone intertidale et la zone subtidale.

Sur le plan quantitatif, ce sont les mollusques qui prédominent avec 52% en zone intertidale et 68 % en zone subtidale suivi des polychètes avec respectivement 28 % et 10% et des crustacés avec 19% et 22%. La densité totale reste influencé par l'existence de quatre espèces, *Hediste diversicolor*, *Scrobicularia plana* et *Cyathura carinata* qui prédominent le peuplement intertidal avec 49 à 99%, *C. orientale* existe seulement au niveau de la station N. Cependant, en zone subtidale la densité totale est influencée par l'existence de cinq espèces, *C. edule*, *S. plana*, *H. diversicolor*, *S. dekhuyzeni* et *C. carinata* qui prédominent le peuplement avec 70 à 99%.

La richesse spécifique a subi une diminution après la construction du barrage pour les deux zones de l'estuaire intertidale et subtidale.

La zone subtidale est plus diversifiée que la zone intertidale. Ces deux zones ont 33 espèces en commun avec une similitude de l'ordre de 54% sur le plan qualitatif.

Les polychètes, les crustacés et les mollusques par leurs richesses spécifiques et leurs abondances forment la structure du peuplement benthique de l'estuaire de Bou Regreg.

Les données quantitatives montrent que les variations de la densité totale (abondance totale) sont dues essentiellement aux espèces dites de type estuarien à large valence écologique (euryèces) comme *S. plana*, *C. edule* et *H. diversicolor* (tolèrent différents types de sédiment et ayant une large gamme de salinité et reste indifférent au taux de la pollution). La successive en richesse spécifique des polychètes, crustacés et mollusques caractéristique l'estuaire du Bou Regreg après la construction du barrage. Cette succession reste comparable à celle enregistrée au niveau de l'estuaire de la Seine (Atlantique français) (1) et l'estuaire de Lorient (2).

Références

1 - Desprez M., 1981. Etude du macrozoobenthos intertidal de l'estuaire de la Seine. Thèse Doctorat 3ème cycle, Univ. Rouen (France) : 186 p.
2 - Le Bris H., 1988. Fonctionnement des écosystèmes benthiques côtiers au contact d'estuaires : la rade de Lorient et la baie de Vilaine. Thèse Doctorat 3ème cycle, Université de Bretagne Occidentale, Brest : 311 p.

ON THE OCCURRENCE OF AMPHIOXUS (*BRANCHIOSTOMA LANCEOLATUM*, PALLAS, 1744) IN THERMAIKOS GULF (GREECE)

Chintiroglou C. *, Kousteni V. and Antoniadou C.

Aristotle University, School of Biology, Department of Zoology, Thessaloniki, Greece - * chintigl@bio.auth.gr

Abstract

This study deals with the "Amphioxus sand" community in Thermaikos Gulf. 4767 individuals, classified at 75 species, were collected with quantitative sampling over a 2-year period. Gastropoda and Polychaeta were the dominant taxa, both in terms of species richness and numerical abundance. The degradation of this community was evident in its structure and related to the increasing organic pollution in the broader study area.

Introduction

Besides the intense quantitative research on soft substrate communities, little is known about the *Branchiostoma lanceolatum* facies, often called as "Amphioxus sand" (1). Most of the relevant information derives from studies in the Western Mediterranean and the Adriatic (1,2,3), as there is only one reference from the Eastern basin (4) and the Black Sea (5). Recently, the "Amphioxus sand" community have been detected in Thermaikos gulf, offering an opportunity to study its structure under conditions of organic pollution.

Materials and Methods

Data Collection - Analysis

After preliminary sampling at the NE side of Thermaikos Gulf the "Amphioxus sand" community was found at 2 sites at a depth ranging from 3 to 10 m. Sampling was carried out twice each year (August and January) from summer 2001 to winter 2003. 3 to 5 replicates were collected by SCUBA diving with a corer sampler (3180 cm^3) at each period (6).

Common biocoenotic methods were employed to analyze the data, e.g. population density, mean dominance, frequency, Margalef's richness, Shannon-Wiener and Pielou's evenness (1,4).

Numerical abundance data were analyzed by ANOVA, in order to examine the effect of three different factors: a) site, b) season and c) year of sampling.

Results and Discussion

Overall 4767 individuals were counted, belonging to 75 species. From these species 55 were "common" (15 Polychaeta, 36 Mollusca, 4 Crustacea), according to population density values and their frequency, exceeding 60% (Table 1). Gastropods dominate in the first year and polychaetes in the second. The dispersion of Gastropoda and Bivalvia was unequal in time for the first group, and in both time and space for the second. All diversity indices showed high values (Table 1).

Comparing our results with relevant descriptions we can note the diversified composition of the "Amphioxus sand" (Table 1). This community normally extends on gravel and coarse sand with shell fragments, often containing big populations of venerupid bivalves. However, muddy areas have expanded during the last decade as a result of increasing eutrophication and organic pollution, causing a considerable decrease in *B. lanceolatum*'s population density and also a change on its community structure. In the 1970, the "Amphioxus sand" community was common in Thermaikos Gulf, but today its presence is limited. *B. lanceolatum* is still traced, but its community structure is altered, since most of the species are related to organic pollution.

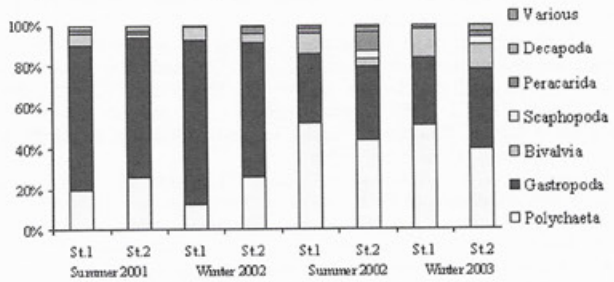


Table 1. Mean abundance (A/m^3) of the common species, total number of individuals (N), species richness (S), Margalefs' index (d), Shannon-Wiener (H) and Pielous' Evenness (J).

Taxa	Summer 2001 St.1	Summer 2001 St.2	Winter 2002 St.1	Winter 2002 St.2	Summer 2002 St.1	Summer 2002 St.2	Winter 2002 St.1	Winter 2002 St.2
Polychaeta								
Aonides oxycephala				628.9		277	465	101
Aricidea fragilis	20.96	104.8			69.2	12.6	12.6	
Cauleriella bioculata								62.9
Capitela capitata	1090	2201	388	870	277	723	616	327
Chone filicaudata		733.8	94.3	10.48	220	81.8	101	56.6
Eunice vittata	41.93		21	62.89	12.6	37.7	44	18.9
Glycera tridactyla	41.93	524.1	31.4	115.3	75.5	25.2	37.7	94.3
Lumbrineris gracilis	157.2	209.6	31.4	62.89	44	88.1	56.6	25.2
Maldane glebifex					25.2	62.9		18.9
Mellina palmata						88.1	12.6	62.9
Notomastus latericeus	73.38	1468		10.48	6.29	69.2		25.2
Pista cristata					75.5			6.29
Piromis eruca			199	52.41				
Protodorrillea kefersteini	10.48	1468	566	272.5			6.29	18.9
Syllis prolifera	83.86	104.8	105	62.89				
Mollusca								
Alvania cimex	115.3	209.6	62.9	20.96	37.7	6.29	69.2	12.6
Alvania montagui	41.93	524.1			12.6			
Bittium reticulatum	2987	20650		482.2	1352	1918	478	415
Caecum trachea			62.9				37.7	88.1
Cerithium vulgatum	10.48	209.6			6.29	6.29		
Chrysallida doliolum	31.45	419.3			18.9	113		6.29
Cytharella coarctata	125.8	733.8			151	239		
Gibbula adansoni	503.1	5660		146.8	6.29	12.6		
Hadriana oretea	115.3	419.3			6.29	31.4		
Lunatia catena		314.5			12.6	81.8		
Manronia crassa	10.48	209.6			37.7			
Nassarius incrassata	62.89	209.6	21	10.48	18.9	119	151	50.3
Nassarius limata	52.41				50.3	145		
Nassarius ret. mamillata		209.6		10.48	6.29	18.9	18.9	18.9
Neverita josephinae			73.4		6.29		44	12.6
Pusinilla radiata	1247	9644	126	136.3	428	874	220	151
Smaragdia viridis	31.45	314.5	105	73.38		12.6		
Tricolia pullus pullus	209.6	3459	220	62.89	6.29	6.29	12.6	
Turbonilla lactea		314.5		10.48	12.6	81.8	31.4	12.6
Dentalium dentale							119	81.8
Abra alba	10.48		10.5	52.41			37.7	75.5
Corbula gibba			21				12.6	25.2
Donax variegatus		104.8	21				6.29	
Dosinia lupinus		628.9				6.29		6.29
Gastrana fragilis				262.1				
Lucinella divaricata	52.41		31.4	188.7	6.29	50.3		18.9
Macoma cumana	31.45				6.29	25.2		
Modiolus barbatus	104.8	838.6	62.9	10.48		31.4		
Mysia undata			73.4				12.6	31.4
Nucula nitida				41.93	12.6			18.9
Nucula sulcata			10.5		12.6	69.2	18.9	25.2
Parvicardium exiguum		209.6						
Psammobia depressa		524.1	10.5		12.6			
Tellina planata	220.1	419.3		10.48		44	6.29	44
Venerupis aurea aurea	10.48	419.3						
Venus verrucosa	20.96	104.8	10.5	20.96				
Crustacea								
Ampelisca diadema				10.48	25.2	138	50.3	12.6
Elasmopus rapax	41.93	104.8				6.29	182	12.6
Cestopagurus timidus	52.41	104.8		52.41	56.6	18.9	18.9	6.29
Pisidia longimana	104.8		21		18.9	6.29	25.2	62.9
N	764	527	1002	945	762	506	409	338
S	51	56	48	68	39	54	41	47
			7.47					
d	7.53	8.77		9.78	6.76	8.51	6.65	7.9
H	3.42	3.54	353	3.89	4.2	4.19	4.07	4.44
J	0.60	0.60	0.62	0.64	0.79	0.73	0.76	0.79

References

1 - Guille, A., 1970. Bionomie benthique du plateau continental dc la côtc catalane française. II. Les communautés de la macrofaune. *Vie Milieu*: 21, 149-280.

2 - Gamulin-Brida, H. 1974. Biocénoses benthiques de la mer Adriatique. *Acta Adriatica*. 15(9): 1-103.

3 - Relini, G., Ardizzone, G.D., Belluscio, A., 1986. Le biocenosi bentoniche costiere delle Cinque Terre (Mar Ligure Orientale). *Boll. Mus. Ist. Biol. Univ. Genova* 52: 163-195.

4 - Dounas, K., Macrobenthic assemblages of soft substrate in Strymonikos Gulf. Thesis. Aristotle University, Thessaloniki, Greece, 1-185 p.

5 - Konsulova, T., 1992. Seasonal structure and ecological status of Varna Bay (Black Sea) sandy and muddy macrozoobenthic coenoses. *Rapp. Comm. Int. Mer Médit.*, 33/ 42.

6 - Stirn, J., 1981. Manual of methods in Aquatic environment research. Part 8. Ecological assessment of pollution effects. *F.A.O. Fisheries Technical Paper*, 209: 1-190.

CONTRIBUTION TO THE KNOWLEDGE OF THE MACROBENTHIC BIODIVERSITY OF VOULIAGMENI LAGOON (ATTICA, GREECE)

C.C. Chintiroglou, C. Antoniadou, P. Damianidis * and A. Diapoulis
Aristotle University of Thessaloniki, School of Biology, Dept. of Zoology, Thessaloniki, Greece

Abstract

This study deals with the macrobenthic biodiversity of the tectonic lagoon Vouliagmeni in Attica, Greece, where 12 flora and 24 fauna species are put on record for the first time. The macrobenthic diversity is similar to other Mediterranean lagoons, with some exceptions, most probably new species. The relevant literature is reviewed and the taxonomic status of certain species is discussed and revised. With its atypical geomorphology and the presence of endemic species, the Vouliagmeni Lagoon is of great interest in studies of lagoonal ecosystems.

Keywords: Macrobenthos, Biodiversity, Lagoons

Introduction

Vouliagmeni Lagoon has been the subject of geological research since the end of the 19th century [1]. However, the study of the biotic and abiotic environment of the Lagoon has not started until recently. The Vouliagmeni Lagoon (=VL) was created when the roof of a large underground cave collapsed as powerful earthquakes stroke the region about 2000 years ago [1]. Similar observations were made in studies of a rocky island in the Adriatic Sea [2]. These facts indicate that VL is of tectonic origin (=Tectonic laguna), according to the classification of lagoonal ecosystems [3].

The information about the living world of VL is limited. The biological research started after Doumenc *et al.* [4] had described *Paranemonia vouliagmeniensis*, a new species of sea anemone, endemic in the lagoon. Chintiroglou *et al.* [5] were the first to study the population dynamics and feeding habits of this anemone. This study gives some preliminary results on the faunal and floral macrobiodiversity of the lagoon.

Materials and Methods

Common techniques of qualitative, semiquantitative and quantitative sampling were employed to evaluate the macrobenthic biodiversity [6] [7]. The physico-chemical factors were also measured.

Results and Discussion

The physico-chemical parameters show minimal annual fluctuation. Temperature never drops below 18°C, whereas it reaches 29°C in summer. Salinity varies around 17‰ and pH around 7.

Flora

Two phanerogames were collected and identified [*Scyrpus maritimus* Linnaeus and *Ruppia cirrhosa* (Petagna) Grande] and ten algae: six Rhodophyceae [*Chroodactylon ornatum* (C. Agardh) Basson, *Gelidium* sp., *Lophosiphonia scopulorum* (Harvey) Wormsley, *Lophosiphoria cristata* Falkenberg, *Polysiphonia tenella* (C. Agardh) Ambrom and *Griffithsia* sp.] and four Chlorophyceae (*Chaetomorpha* sp1, *Chaetomorpha* sp2, *Ulothrix* sp., *Rhizoclonium* sp). These species are typical in brackish and fresh water with wide geographical distribution [2] [8]. *Ulothrix* and *Chaetomorpha* are reported to live in fresh water and they frequently form green masses in spring and autumn.

Fauna

Porifera: Two *Cliona* species were found (*Cliona* sp1 and *Cliona* sp2). The first was found on limestone substrate, at 3 m depth. The second, found in small quantities, covered small algal parts. Sponges are generally absent from the relevant literature.

Cnidaria: The only species found in great abundance [9] was *Paranemonia vuliagmeniensis* Doumenc, England & Chintiroglou 1987.

Annelida: Four polychaetes were found, *Hediste diversicolor* (O.F. Muller, 1776), *Spio* sp., *Capitella capitata* (Fabricius, 1780) and *Manayunkia* sp. and one oligochaete *Limnodrilus* sp., all very common in brackish waters [8] [10]. *Manayunkia* sp. is relative to *Manayunkia estuarina* (Bourne 1883), a brackish waters species. However, the *Manayunkia* sp. specimens showed morphological dissimilarities from the typical *Manayunkia estuarina*, therefore their taxonomic status is still unclear.

Mollusca: Three gastropods and two bivalves were found. *Acteum* sp. and *Caecum* sp. were few and not properly identified. The gastropod *Hydrobia acuta* (Draparnaud, 1805) and the bivalves *Cerastoderma glaucum* (Poiret, 1789) and *Abra ovata* (Philippi, 1836) are common of brackish water assemblages [8] [10] [11].

Crustacea: Five crustaceans were identified: 3 amphipods (a) *Corophium acutum* Chevreux, 1908, (b) *Microdeotopus anomalus* (Rathke, 1843) (c) *Gammarus aequicauda* (Martynov, 1931), the isopod *Lekanesphaera hookeri* (Leach, 1814) and one cirriped, *Balanus amphitrite* Darwin, 1854. They are all very common in brackish waters and show a wide geographical distribution [8] [10].

Pisces: Three species were found: *Zebrus* sp. (Gobiidae), *Mollienisia* sp. and *Mugil* sp. (possibly *M. cephalus*, one individual). The first, which is very common in brackish waters [12], lives on the bottom (4 m depth) in small or bigger schools, depending on the season and the reproductive needs. The presence of *Mollienisia* sp. in VL is quite untypical, since this is a S. American aquarium fish [13]. This species was obviously transferred to the lagoon, for unknown reasons, but has settled well, as big schools of juveniles were frequently observed, following the older down to 5 m depth.

Some of the species were previously reported with different names [4] [5], apparently due to mistaken identification. Here, the accurate names are restored in brackets: *Pusillina* radiata (=*Hydrobia acuta*), *Parvicardium ovale* and *Cerastoderma edule* (=*Cerastoderma glaucum*), *Sphaeroma serratum* (=*Lekanosphaera hookeri*), *Corophium orientale* (=*Corophium acutum*) and *Zostera noltii* (=*Ruppia cirrhosa*).

The fauna and flora of VL are similar as in other Mediterranean lagoons. However, certain facts such as the endemism of some species, the unvaried abiotic factors and the special geomorphology of the area, make this lagoon a unique monument of nature, which stimulates great interest in research and management studies.

References

1 - Papapetrou-Zamanis A., 1969. Le Lac de Vouliagmeni (Attiki). *Annls geol. Pays Hell.*, 21 : 210-216.

2 - Grubelic I, Boris A., and Span A., 1998. Benthic flora and fauna in a submarine cave in the central Adriatic Sea. *Rapp. Comm. int. Mer. Médit.*, 35 (2): 446-447.

3 - Guerloget O., and Perthuisot J.P., 1992. Paralic ecosystems biological organization and functioning. *Vie Millieu*, 42: 215-251.

4 - Doumenc D., England K., and Chintiroglou C., 1987. A new species of sea anemone in the genus *Paranemonia* Calgren (Anthozoa, Actiniaria) from the Aegean Sea. *Zoologica Scripta* 4: 271-275.

5 - Chintiroglou C., Valkouma Th., and Culley M., 1996. Biological studies in Athens Lake Vouliagmeni: I. The allometry of feeding and body size in a population of the sea anemone *Paranemonia vouliagmeniensis* Doumenc *et al.* 1987 (Actiniaria:Anthozoa). *J. Mar. Biol. Ass. UK*, 76: 603-616.

6 - Stirn J., 1981. Manual of methods in aquatic environment research. Part 8: Ecological assessment of pollution effects (Guidelines for the F.A.O. (GFCM)/UNEP joint Coordinated Project on Pollution in Mediterranean). *F.A.O Fisheries Technical Paper*, 209: 1-190.

7 - Chintiroglou C., and Koukouras A., 1992. A population of the sea anemone *Anemonia viridis* (Forskal *et al.*, 1775) and its associated flora and fauna in North Aegean Sea. *Int Rev. ges. Hydrobiol.* 77(3): 483-495.

8 - Barnes R.S.K., 1980. Coastal lagoons. The natural history of a neglected habitat. Cambridge Studies in modern biology. 1. Cambridge University Press, Cambridge, 105 p.

9 - Chintiroglou C., Antoniadou C., and Damianidis P., 2000. Spatial dispersion and density of the *Paranemonia vouliagmeniensis* population in Vouliagmeni Lagoon. *J. Mar. Biol. Ass. UK*, 80, 941-942.

10 - Reisopoulou S., Thessalou-Legaki M., and Nikolaidou A., 1996. Assessment of disturbance in Mediterranean lagoons: an evaluation of methods. *Mar. Biol.* 125:189-197.

11 - Gontikaki E., Antoniadou C., and Chintiroglou C., 2003. Population structure of *Cerastoderma glaucum* and *Abra ovata* in Vouliagmeni Lagoon (Attiki) *J. Mar. Biol. Ass. UK*, 80, 1095-1097.

12 - Bauchot M.L., and Pras A., 1980. Poissons marins d'Europe. Delachaux & Niestle, pp. 427.

13 - Vogel Z., Brazda V., and Brazda P., 1965. Poissons d'aquarium. Atlas illustré. Gründ, Paris, pp. 215.

METHODOLOGICAL CRITERIA FOR ENVIRONMENTAL MONITORING OF AN OFFSHORE PLATFORM IN THE CENTRAL ADRIATIC SEA

A.M. Cicero *, M. Gabellini, C. Maggi, O. Nonnis, B. Trabucco, C. Virno Lamberti
ICRAM- Via di Casalotti, 300, 00166 Rome, Italy - c.virno@icram.org

Abstract
In order to assess the potential environmental impacts due to the installation of an offshore gas platform, the Central Institute for Marine Research (ICRAM) worked out a long-term monitoring plan. The plan encompasses multidisciplinary investigations aimed at evaluating possible biotic and abiotic environmental alterations. The present work reports on the methodological approach used in the study.

Keywords: monitoring, offshore platform, multidisciplinary study

The Eni S.p.A - Agip Division delivered, on 1999 to the Italian Ministry of Environment, the results the environmental impact study (1) regarding the potential effects on the atmosphere, marine ecosystem and seascape of the installation of the offshore platform "Emilio". The Ministry of Environment, after the evaluation of the study, gave the authorization to get under way the project.

The project foresaw the installation of the platform "Emilio" and two connection alongside pipelines (13 km long) to "Eleonora" platform, in an area of the Central Adriatic Sea (Italy) approximately 29 km from S. Benedetto del Tronto coastline.

The production cycle for the exploitation of the liquid petroleum gas field is expected to be approximately 10 years, mostly during the period 2001-2005.

Following the instructions of the Ministry of Environment, the drilling and production operations were carried out using low-impact technologies and ensuring that no discharges of produced waters or others oil-containing wastes were occurring.

In addition, Ministry of Environment requested to perform a long term monitoring study in accordance with the prescriptions of the ministerial decree DEC/VIA/5222 (2).

The ENI S.p.A. funded the Central Institute for Marine Research (ICRAM) to elaborate a monitoring plan to assess the environmental impacts on the marine ecosystem of the offshore structure.

A four-years monitoring plan was proposed by ICRAM and started up in December 2002.

A multidisciplinary approach was considered the most suitable to identify areas where contamination is responsible for ecosystem degradation and to monitor long-term effects of anthropogenic activities (3;4).

The proposed monitoring plan, takes into consideration a variety of biotic and abiotic parameters, encompassing chemical and physical analyses of water and sediments, benthic fauna analysis, bioaccumulation testing, fish stock assessment and indirect acoustic investigations.

Bearing in mind that a sampling design may play an important role in environmental impact assessment for detecting significant changes due to anthropogenic disturbances, an *ad hoc* sampling plan, was proposed.

In the area surrounding the platform a "gradient" sampling design was elaborated, allocating stations according to distance rather than using a randomized placement of stations. This sampling design seemed to be more appropriate to highlight environmental changes when the point source of disturbance is known (5).

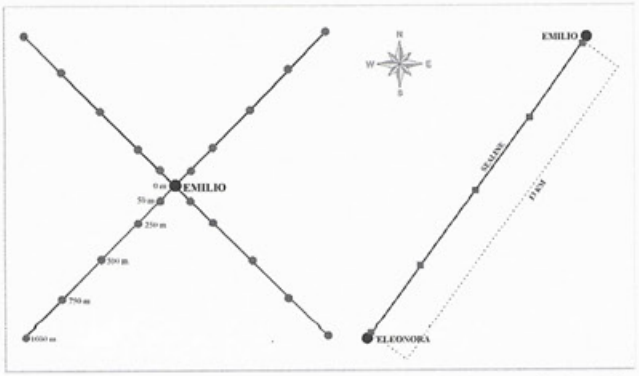


Fig. 1. The proposed sampling design in the "Emilio" area and along the sealines.

A total of 28 stations were fixed; 21 were located around "Emilio" along two orthogonal transepts, one of which oriented in the direction of the NW-SE dominant current, 3 stations were in a presumably undisturbed site and 4 along the sealines (Fig. 1).

Two sampling surveys were planned for each year, aimed at collecting data on water column, benthic fauna and sediments; one was scheduled for the spring season and the second for summer, for detecting possible natural fluctuations due to seasonal variability.

In every sampling station, the following parameters have been selected for the investigation (Tab. 1). Mussels (*Mytilus galloprovincialis*) bioaccumulation testing was planned in the same period above mentioned; samples should be collected on the four platform legs at two different depth (near the water surface and at –12 m, corresponding to the lower limit of the presence of the organisms). Bioaccumulation results can provide relevant information on the real environmental risk and bioavalability of some contaminants (As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Zn, PAHs, PCBs, TBT).

Tab. 1. Parameters to investigate on the samples collected during the two seasonal campaigns.

Matrix	Parameters
Water column	Acoustic current profiler, temperature, pH, salinity, transparency, dissolved oxygen, Chlorophyll a, nutrients, particulate matter
Sediments	Grain size, heavy metals (As, Ba, Cd, Cr, Cu, Hg, Ni, Pb, Zn), PAHs, PCBs, TBT, TOC, % water
Biota	benthic fauna study

Studies on fish population are to be conducted every month in proximity of the platform. Such investigations should allow to assess possible impacts of the platform on biodiversity.

The acoustic investigations, consist of a Side Scan Sonar survey to study the morphological characteristics of the bottom in an area of 4 km^2 surrounding the Emilio platform and along the sealines (13 km^2); in addition, a Multibeam study for a detailed bathymetric survey (only in the 4 km^2 area), was proposed.

Periodic R.O.V. (Remotely Operated Vehicle) investigations and scuba diving surveys in the area around the platform were also planned to monitor the biocoenoses existing along the platform legs.

In relation with the results of the first year, the monitoring plan in the succeeding years could be revisited.

The proposed methodological approach, based on a long-term multidisciplinary study, will allow to collect integrated data, thus providing environmental information particularly useful for the public administration and decision makers for the protection of the marine ecosystem.

References

1 - ENI S.p.A., 1999. Progetto Emilio (Concessione B.C3.AS). Studio di impatto ambientale, 232 p.
2 - DEC/VIA/5222, 2000. Ministero dell'Ambiente, 12 p.
3 - Chapman P.M., 1990. The Sediment Quality Triad approach to determining pollution-induced degradation. *Sci Tox. Environ.* 97 (8): 815-825.
4 - Chapman P.M, Paine M.D. Arthur A.D. and Taylar L.A., 1996. A Triad study of sediment quality associated with a major relatively untreated marine sewage discharge. *Mar. Poll. Bull.* 32 (1): 47-64.
5 - Ellis J.I. and Schneider D.C., 1997. Evaluation of a gradient sapmling design for environmental impact assessment. *Environmental Monitoring and Assessment* 48: 157-172.

NEW RECORDS OF POLYCHAETES FROM THE TURKISH AEGEAN COAST

Melih Ertan Çinar, Zeki Ergen * and Ertan Dağli

Ege University, Faculty of Fisheries, Dep. of Hydrobiology, Izmir, Turkey - cinar@sufak.ege.edu.tr

Abstract

A total of 35 polychaete species new to the Turkish fauna were collected during the surveys carried out to determine effects of fish farming on the zoobenthos in the Aegean Sea. Of the species encountered, *Fimbriosthenelais zetlandica*, *Eulalia mustela* and *Chaetozone gibber* are also new records for the eastern Mediterranean. In addition, 8 species were reported for the first time from the Turkish Aegean coast.

Keywords: polychaetes, new records, ecology, Aegean Sea

Introduction

The first taxonomic study on polychaetes on the Turkish coasts was carried out by Colombo (1), who listed a total of 23 species from the Dardanelles and the Sea of Marmara. Todate, a total of 435 species have been recorded from the Turkish coasts.

Material and Methods

A total of 24 samples were collected at 6 stations in the Aegean Sea for evaluating impacts of fish farming activities on the distribution of zoobenthos (Fig. 1). The species were collected by an anchor dredge, except for the species from station 6 that was sampled by scuba-diving. The samples were sieved through a 0.5 mm mesh, fixed with 10% formalin and preserved in 70% ethanol. The species were deposited in the Museum of Faculty of Fisheries, Ege University, Turkey (ESFM).

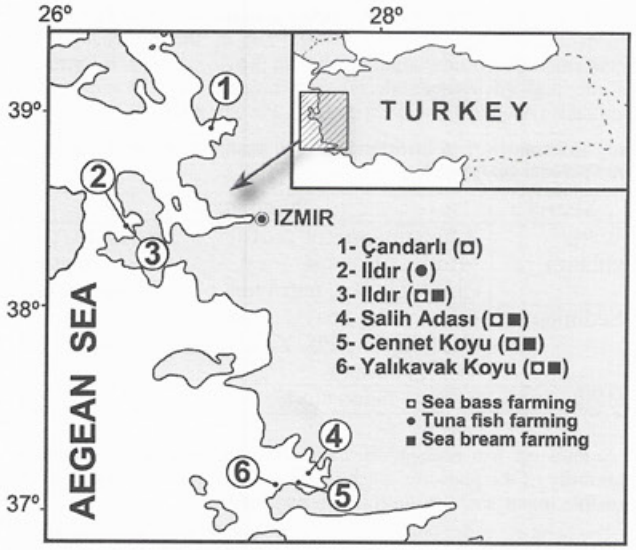


Fig. 1. Sampling sites in the Aegean Sea.

Results

Faunistic analysis of benthic material yielded a total of 35 polychaete species new to the Turkish fauna (▼) and 7 species new to the Turkish Aegean Sea fauna (●). Of the newly-recorded species, three are also new species to the eastern Mediterranean fauna (■). These species as well as their registration numbers in the Museum, number of individuals and sampling data are as follows: ▼ *Harmothoe gilchristi* Day, 1960 [ESFM–POL/02–3, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Malmgreniella ljungmani* (Malmgren, 1867) [ESFM–POL/02–1, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ■ *Fimbriosthenelais zetlandica* (McIntosh, 1876) [ESFM–POL/02–4, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Euthalenessa oculata* (Peters, 1854) [ESFM–POL/02–38, 8.5.2002, Station 4, 26 m, sand, 1 specimen], ▼ *Arichlidon reyssi* (Katzmann, Laubier & Ramos, 1974) [ESFM–POL/02–52, 22.11.2002, Station 1, 50 m, coralligenous substrate, 40 specimens], ▼ *Eulalia tripunctata* McIntosh, 1874 [ESFM–POL/02–6, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ■ *Eulalia mustela* Pleijel, 1987 [ESFM–POL/03–1, 24.2.2003, Station 2, 45 m, mud, 4 specimens], ▼ *Paranaitis kosteriensis* (Malmgren, 1867) [ESFM–POL/03–10, 1.5.2003, Station 2, 45 m, muddy sand, 3 specimens], ▼ *Phyllodoce maculata* (Linnaeus, 1767) [ESFM–POL/02–46, 6.2.2002, Station 4, 9 m, *Posidonia oceanica* Delile, 2 specimens], ● *Phyllodoce mucosa* Oersted, 1843 [ESFM–POL/02–5, 22.11.2002, Station 1, 35 m, muddy sand, 3 specimens; ESFM–POL/03–11, 1.5.2003, Station 2, 45 m, sandy mud, 1 specimen], ▼ *Pseudomystides limbata* Saint-Joseph, 1888 [ESFM–POL/02–39, 8.5.2002, Station 4, 26 m, sand, 1 specimen], ▼ *Pilargis verrucosa* Saint-Joseph, 1899 [ESFM–POL/02–53, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Sphaerodoridium claparedii* (Greeff, 1866) [ESFM–POL/02–18, 22.11.2002, Station 1, 50 m, coralligenous substrate, 2 specimens], ▼ *Sphaerodoropsis minuta* (Webster & Benedict, 1887) [ESFM-POL/02-20, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Syllis parapari* (San Martín & López, 2000) [ESFM–POL/01–42, 21.10.2001, Station 4, 13 m, *P. oceanica*, 3 specimens], ▼ *Aglaophamus rubella* (Michaelsen, 1896) [ESFM–POL/03–2, 9.6.2003, Station 2, 50 m, muddy sand, 1 specimen], ● *Nepthys cirrosa* Ehlers, 1868 [ESFM–POL/02–17, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ● *Nepthys hystricis* McIntosh, 1900 [ESFM–POL/01–39, 21.10.2001, Station 3, 13 m, *P. oceanica*, 4 specimens], ▼ *Glycera alba* (O. F. Muller, 1776) [ESFM–POL/01–40, 21.10.2001, Station 4, 13 m, *P. oceanica*, 1 specimen], ▼ *Glycera lapidum* Quatrefages, 1865 [ESFM–POL/02–51, 8.5.2002, Station 4, 8 m, *P. oceanica*, 1 specimen], ● *Glycera tesselata* Grube, 1863 [ESFM–POL/02–23, 22.11.2002, Station 1, 50 m, coralligenous substrate, 10 specimens], ▼ *Glycinde nordmanni* (Malmgren, 1865) [ESFM–POL/02–24, 22.11.2002, Station 1, 50 m, coralligenous substrate, 2 specimens], ▼ *Goniada maculata* Oersted, 1843 [ESFM–POL/03–3, 9.6.2003, Station 2, 50 m, sand, 6 specimens], ▼ *Scolelepis tridentata* (Southern, 1914) [ESFM–POL/03–4, 24.02.2003, Station 2, 45 m, mud, 1 specimen], ▼ *Magelona alleni* Wilson, 1958 [ESFM–POL/02–48, 06.02.2002, Station 4, 25 m, mud, 1 specimen] ▼ *Magelona minuta* Eliason, 1962 [ESFM–POL/03–5, 24.02.2003, Station 2, 45 m, sand, 14 specimens], ▼ *Acrocirrus frontifilis* (Grube, 1860) [ESFM–POL/02–54, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Macrochaeta clavicornis* (M. Sars, 1835) [ESFM–POL/02–41, 6.2.2002, Station 4, 14 m, *P. oceanica*, 1 specimen], ▼ *Scalibregma celticum* Mackie, 1991 [ESFM–POL/02–32, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ● *Armandia cirrosa* Philippi, 1861 [ESFM–POL/02–33, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Ophelia roscoffensis* Augener, 1910 [ESFM–POL/02–43, 6.2.2002, Station 4, 14 m, *P. oceanica*, 1 specimen], ▼ *Tachytrypane jeffreysii* McIntosh, 1879 [ESFM–POL/01–43, 21.10.2001, Station 4, *P. oceanica*, 9 m, 1 specimen], ▼ *Mediomastus fragilis* Rasmussen, 1973 [ESFM–POL/02–34, 22.11.2002, Station 1, 50 m, coralligenous substrate, 1 specimen], ▼ *Neopseudocapitella brasiliensis* Rullier & Amoureux, 1979 [ESFM–POL/01–41, 21.10.2001, Station 4, 20 m, *P. oceanica*, 1 specimen], ■ *Chaetozone gibber* Chambers, 1994 [ESFM–POL/03–6, 1.5.2003, Station 2, 45 m, sand, 2 specimens], ● *Amage adspersa* (Grube, 1863) [ESFM–POL/96–37, 6.6.1996, Station 3, 12 m, *P. oceanica*, 2 specimens], ● *Amage gallasi* Marion, 1875 [ESFM–POL/02–11, 22.11.2002, Station 1, 35 m, muddy sand, 1 specimen], ▼ *Hypsicomus stichophthalmos* (Grube, 1963) [ESFM–POL/02–55, 22.11.2002, Station 1, 50 m, sandy mud, 1 specimen], ▼ *Euchone rosea* Langerhans, 1884 [ESFM–POL/03–7, 24.02.2003, Station 2, 45 m, muddy sand, 6 specimens], ▼ *Pseudofabricia aberrans* Cantone, 1970 [ESFM–POL/02–56, 9.6.2002, Station 2, 50 m, muddy sand, 1 specimen], ▼ *Pseudofabriciola longipyga* Fitzhugh, Giangrande & Simboura, 1994 [ESFM–POL/03–9, 24.2.2003, Station 2, 45 m, muddy sand, 1 specimen] and ▼ *Pseudofabriciola analis* Fitzhugh, Giangrande & Simboura, 1994 [ESFM–POL/03–8, 1.5.2003, Station 2, 45 m, muddy sand, 1 specimen].

References

1 - Colombo A., 1885. Racolte Zoologische eseguite dal R. Piroscafo Washington nella campagne abissale talassografica dell'anno 1885. *Rivista Marittima*, 22-53.

MAPPING DISTRIBUTION OF BIODIVERSITY IN MARINE RESERVES

Paolo D'Ambrosio, Giuseppe Guarnieri, Simonetta Fraschetti *, Antonio Terlizzi, Simona Bussotti
Dipartimento di Scienze e Tecnologie Ambientali, Università di Lecce, CoNISMa, Lecce, Italy – giuseppe.guarnieri@unile.it

Abstract

An adequate knowledge of habitat and assemblage distribution has important consequences in conservation and management of Marine Protected Areas. A fine-scale study of two MPAs located in Apulia is here reported to analyse existing protection schemes and to assess if habitats and communities are properly represented in the differently protected zones and if the no-take and no-access zones are representative of the general reserve. Results emphasize that, at present, zoning is totally arbitrary in both MPAs with the consequences that detailed information on the distribution of the biota could greatly increase current zonation patterns.

Keywords: Marine Protected Areas, zoning plan, biodiversity, GIS

Introduction and Methods

A number of papers have already discussed the general lack of baseline information on biodiversity distribution in coastal marine habitats and especially within Marine Protected Areas (1, 2). This general lack of knowledge has important consequences since it prevents either an adequate zoning schemes and the potential identification of networks of habitat and communities representative at regional scale (3). A better knowledge in this field might also avoid possible sources of habitat confounding when experimental designs needing the selection of appropriate controls are used to demonstrate effectiveness of protection.

The aim of the paper is to map the distribution of habitat and communities in order to assess if they are properly represented in the differently protected zones and if the no-take and no-access zones are representative of the general reserve.

Data are reported from a series of extensive field surveys carried out in last the three years in the MPAs of Torre Guaceto and Porto Cesareo (Apulia, Italy). Both MPAs are divided in three zones (namely: A, B, C) varying with respect to the degree of restriction of human activities. Here direct observation methods, such as beach transects and SCUBA diving surveys (using global position system GPS) were adopted. Data were then imported in a GIS to create thematic maps.

Results

The MPA of Torre Guaceto (40°42'N; 17°48'E) has a surface of about 2.207 ha and is embedded within a human-dominated landscape. This MPA exhibits complex spatial patterns being characterized by a set of very different habitats (from bioconstructors to seagrasses). However, the proportion of habitat types targeted for full protection is not adequately represented. The lack of an adequate knowledge before the institution prevented appropriate decisions about reserve boundaries, with the consequences that precoralligenous and coralligenuos formations and *Posidonia oceanica* meadows are not included in the no-take no access zone (Fig. 1).

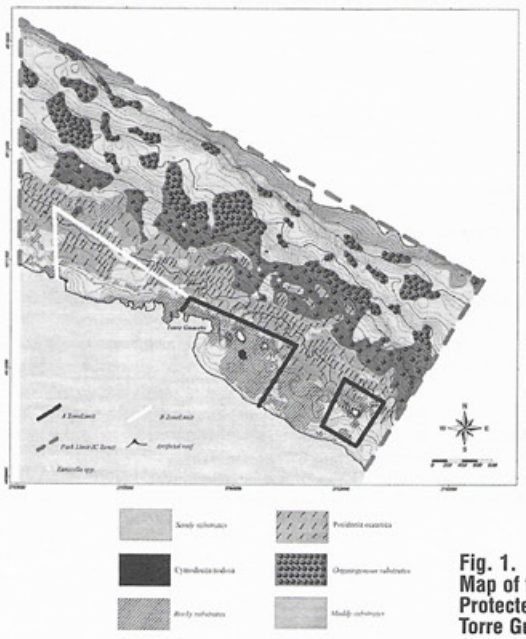


Fig. 1. Map of the Marine Protected Area of Torre Guaceto.

The MPA of Porto Cesareo (40°14'N; 17°54'E) has an extension of 16.654 ha. It is a small village with intense turistic activities. Results show that also in this case sea grasses and coralligenous formations are excluded from the no-take no access zone. Several other self-contradictions emerge. The date mussel *Lithophaga lithophaga* fishery, albeit prohibited, is very active inside the MPA, with the result that the extent of desertified seascape is continuously increasing and one of the most represented community is that of sea urchin barrens. Moreover, a sewage outfall and a fish and mussels aquaculture farm are located within the MPA in proximity of the integral protection zones and a sandy beach with free access is within the no-take no access zone (Fig. 2).

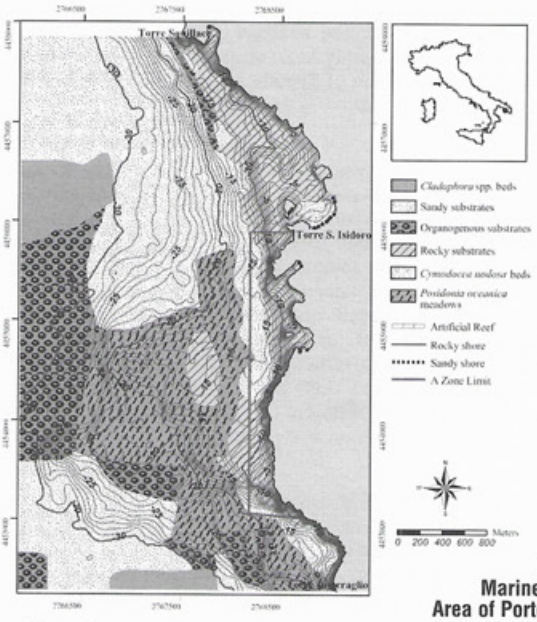


Fig. 2. Map of the Marine Protected Area of Porto Cesareo.

Discussion and Conclusion

In both cases, results emphasize that present zoning is totally arbitrary and collected data provide different scenarios for a correct zoning plan able to include both ecological and socio-economic aspects.

Thus, large-scale mapping even if are costly and time-consuming, allow managers to visualise the spatial distribution of habitats, thus aiding the planning of networks of marine protected areas and allowing the degree of habitat fragmentation (in the case of Porto Cesareo determined by the date mussel fishery) to be monitored. As Gray states (4), a mosaic of marine habitats must be protected if complete protection of biodiversity is to be achieved. Representative samples of species and assemblages distinctive of a particular locality or region should be included within reserve boundaries to grant their long-term persistence.

References

1 - Cabeza, M., Moilanen, A., 2001. Design of reserve networks and the persistence of biodiversity. *Trends in Ecology and Evolution, 16*, 242-248.
2 - Villa F., Tunesi L., Agardy T., 2002. Zoning Marine Protected Areas through Spatial Multiple-Criteria Analysis: the Case of the Asinara Island National Marine Reserve of Italy. *Conservation biology* 16 (2), 515-526.
3 - Sala E., Oropeza O., Paredas G., Parra I., Barrera J.C., Dayton P.K., 2002. A general model for designing networks of marine reserve. *Science*, 298: 1991-1993.
4 - Gray, J.S., 1997. Marine Biodiversity: Patterns, threats and conservation needs. *Biodiversity and Conservation* 6, 153-175.

THE MARINE BIOTA OF SHALLOW-WATER HYDROTHERMAL VENTS AT MILOS, AEGEAN SEA

Anna Maria De Biasi [1] *, Stefano Aliani [2], Silvia Cocito [3], Paul Richard Dando [4], Alan Logan [5], Carla Morri [6], Maurizio Pansini [6], Andrea Peirano [3], Gianfranco Sartoni [7], Carlo Nike Bianchi [6]

[1] Centro Interuniversitario di Biologia Marina, Livorno, Italy - * a.debiasi@cibm.it
[2] CNR, Istituto Scienze marine, Santa Teresa, La Spezia, Italy
[3] ENEA, Marine Environment Research Centre, La Spezia, Italy
[4] School of Ocean Sciences, University of Wales - Bangor, Menai Bridge, Anglesey, UK
[5] Centre for Coastal Studies and Aquaculture, University of New Brunswick, Saint John, Canada
[6] Dip.Te.Ris. Università di Genova, Genova, Italy
[7] Dip. Biologia Vegetale, Università di Firenze, Firenze, Italy

Abstract

Macroalgae, seagrass and epifauna were analysed to generate hypotheses about the mechanisms through which vents affect shallow-water ecosystems. They include: increased nutrient supply or food resources; greater habitat provision for cryptic species; induction of advective mechanisms favouring larval settlement, and an intermediate disturbance regime created by periodic emission of toxic fluids.

Keywords: Hydrothermal vents, macroalgae, epifauna, seagrass, Aegean Sea

Introduction

Shallow-water vents occurring along Mediterranean coasts (especially along the Aeolian and Hellenic arcs), emit heat, gas and metals in coastal marine ecosystems. While similar emissions are know to strongly influence the surroundings in deep-sea vents, little has been documented in their shallow–water counterparts. We summarise the results obtained from recent researches carried out at Milos island, Aegean Sea (1). The analysis of macroalgae, seagrass and epifauna offered a sufficiently large array of benthic community responses to generate a first set of hypotheses about the mechanisms through which vents affect shallow-water ecosystems.

Methods

The study was carried out in June 1996 in Palaeochori Bay. Its sea-bottom was mapped by echosounder, and canopy cover of existing seagrass beds was estimated visually. Six rocky shoals, all within 40 m depth, were recognised: three were close to hydrothermal vents, three were not (2). Qualitative samples of macroalgae and fauna were collected at all the sites, and later identified to species. Epibenthic communities were investigated quantitatively by taking images (4 photo-stations x replicate), each with a different slope, i.e., (sub)horizontal, inclined, (sub)vertical and overhanging using a UW camera with a wide-angle (15 mm) lens. Slides were analysed to calculate percentage cover of different taxa. Epibenthic communities were define by cluster analysis on cover data.

Results

Cymodocea nodosa and *Posidonia oceanica* covered the inner and the outer part of the bay, respectively (3). Both showed a patchy distribution but only *C. nodosa* was found in zones with hydrothermal vent, often living in dense rings as close as 12 m from the emission.

83 algae, [36 Rhodophyceae, 33 Fucophyceae, 13 Chlorophyceae, 1 Tribophyceae (4)], and 212 epifaunal species (5) [24 Porifera (6), 32 Cnidaria (7, 8), 33 Serpuloidea (9), 4 Brachiopoda (10)] were collected. Both lists (especially algae) included a large proportion of species with warm-water affinities. Vent sites were comparatively species-richer than non-vent sites.

58 species (algae, poriferans, bryozoans, cnidarians, polychaetes and ascidians) were recognized in the photosamples (11). Substratum cover was nearly 100 % in almost all the stations. Cluster analysis defined three communities dominated by algae and three by animals. Comparing vent and non-vent sites and the different slopes, the most significant differences were detected for overhangs, where the groups dominated by scleractinians and sponges and by sciaphilic algae, respectively, were more abundant at vents.

Discussion

No vent-obligate macroepibenthic species were found: however, the high number of species with warm-water affinities can be related to seawater temperature anomalies induced by venting (12). While the immediate vicinity of vents was usually deprived of macroepibenthos, diversity was proportionally higher at vent sites (5). Vent proximity also correlated with higher epibenthic cover on overhangs, whose morphology may comport confinement and hence accumulation of vent emissions (11). Venting appeared detrimental to *P. oceanica* while *C. nodosa*, a more tolerant species, took advantage (1).

These results underline a significant influence of shallow-water venting. These effects range from taxonomic selection, some species or higher groups being favoured while others are inhibited, to a general enhancement of species richness. The latter may be caused by (9): increased nutrient supply to algae or food resources to filter-feeding epifauna; greater habitat provision for cryptic species through enhanced deposition of carbonate mounds; induction of advective mechanisms favouring larval settlement, and an intermediate disturbance regime created by the periodic emission of toxic fluids. Further studies are necessary to test these hypotheses and elucidate the vent-induced patterns on shallow-water biota.

References

1 - Dando P. R., Aliani S., Arab H., Bianchi C. N., Brehmer M., Cocito S., Fowler S. W., Gundersen J., Hooper L. E., Kölbl R., Kuever J., Linke P., Makropoulos K. C., Meloni R., Miquel J.-C., Morri C., Müller S., Robinson C., Schlesner H., Sievert S., Stöhr R., Stüben D., Thomm M., Varnavas S. P. and Ziebis W., 2000. Hydrothermal studies in the Aegean Sea. *Phys. Chem. Earth*, 25: 18.

2 - Cocito S., Bianchi C.N., Morri C. and Peirano A., 2000. First survey of sessile communities on subtidal rocks in an area with hydrothermal vents: Milos Island, Aegean Sea. *Hydrobiol.*, 426: 113-121.

3 - Aliani S., Bianchi C.N., Cocito S., Dando P., Meloni R., Morri C., Niemeyer A., Peirano A. and Ziebis W., 1998. A map of seagrass meadow in Palaeochori Bay (Milos Island, Greece) a marine area with hydrothermal activity. *Rapp. Comm. Int. Mer Médit.*, 35: 512513.

4 - Sartoni G. and De Biasi A.M., 1999. A survey of the marine algae of Milos Island, Greece. *Cryptog. Algol.*, 20: 271-283.

5 - Morri C., Bianchi C.N., Cocito S., Peirano A., De Biasi A.M., Aliani S., Pansini M., Boyer M., Ferdeghini F., Pestarino M. and Dando P., 1999. Biodiversity of marine sessile epifauna in an Aegean island subject to hydrothermal activity: Milos, eastern Mediterranean Sea. *Mar. Biol.*, 135: 729739.

6 - Pansini M., Morri C. and Bianchi C. N., 2000. The sponge community of a subtidal area with hydrothermal vents: Milos Island, Aegean Sea. *Est. Coast. Sh. Sci.*, 51: 627635.

7 - Morri C. and Bianchi C. N., 1999. Hydroids (Cnidaria: Hydrozoa) from the Aegean Sea, mostly epiphytic on algae. *Cah. Biol. Mar.*, 40: 283291.

8 - Morri C., Vafidis D., Peirano A., Chintiroglou C. C. and Bianchi C. N., 2000. Anthozoa from a subtidal hydrothermal area of Milos Island (Aegean Sea), with notes on the construction potential of the scleractinian coral *Madracis pharensis*. *It. J. Zool.*, 67: 319325.

9 - Bianchi C.N. and Morri C., 2000. Serpuloidea (Annelida: Polychaeta) from Milos, an island in the Aegean Sea with submarine hydrothermalism. *J. mar. biol. Ass. U.K.*, 80: 259-269.

10 - Logan A., Bianchi C. N., Morri C., Zibrowius H. and Bitar G., 2002. New records of recent brachiopods from the eastern Mediterranean Sea. *Ann. Mus. Civ. St. nat. "G. Doria"*, Genova, 94: 407418.

11 - De Biasi A. M., Bianchi C. N., Aliani S., Morri C., Cocito S., Peirano A., Dando P., in press. Epibenthic communities in a marine shallow area with hydrothermal vents. *Chem. Ecol.*

12 - De Biasi A.M. and Aliani, S., in press. Shallow water hydrothermal vents in the Mediterranean sea: stepping-stones for Lessepsian migration? *Hydrobiol.*

SHORT-TERM CHANGES OF HYDROBIOLOGICAL FEATURES IN THE GULF OF MILAZZO (TYRRHENIAN SICILY)

Decembrini F. *, Azzaro F., Galletta M., Raffa F.
IAMC-CNR, Messina, Italy - * decembrini@ist.me.cnr.it

Abstract
In the framework of a wider National research program dealing with costal waters quality (MIUR-Cluster10-SAM) two seasonal hydrobiological cruises were carried out in the Gulf of Milazzo to study the changes in thermo-haline structures, nutrients concentrations and phytoplankton biomass (expressed as chlorophyll*a*) distribution. Two water masses: Tyrrhenian Surface Water in the uppermost 50m-thick layer and Levantine Intermediate Water below them are present and flow in the same direction (W-E). Chl-*a* distribution showed a clear phytoplanktonic accumulation in a frontal zone located between nearshore and offshore waters during both stratification and mixing periods.

Key-words: hydrography, chlorophyll a , Tyrrhenian Sea

Introduction

In the Mediterranean sea the phytoplankton biological cycle is driven by seasonal conditions: in summer when water stratification exists the phytoplankton community is in a stationary phase after spring growth; in winter when vertical water mixing prevails autotrophic populations are in lag period preceding the late-winter development

The aim of this short note is to describe the hydrological and trophic conditions during fall-to-winter transition when convective mixing destroyes the pycnocline and enriches the surface waters with nutrients.

The Gulf of Milazzo is a natural Bay of about 25 Km^2 of the nothern coast of Sicily, comprised between two Capes of Milazzo (west side; 38°16'N-15°14'E) and Rasocolmo one (eastern side; 38°18'N-15°33'E), and open to the Tyrrhenian sea. The central stretch of coast hosts wide sandy beaches and several seasonally-controlled stream outflows. The city of Milazzo and its harbour are located in the lee of Cape Milazzo and in the neighbours a refinery and a thermal power plant have been settled in 1960s. The continental shelf is narrow and irregular having a width of ~0.2 km off the C° Milazzo and ~ 2 km in the center where at ~1.4 km from the coast reaching 500m depth. Hydrodynamics in the Gulf is complex: a general cyclonic circulation in the uppermost layer of off-shore waters can be identified, while the inner part is characterized by a smaller anticyclonic structure influenced by geomorphology and winds. The most frequent winds are from SE and from NW, this latter can be often very intense in winter and spring.

Sampling

Sampling was performed on board the *M/V L. Sanzo* on December 18th 2002 and on February 26th 2003. The hydrographic surveys (CTD/Rosette) approached the area through eleven fixed stations on three transects. Three samples were taken in the layer hosting the Deep Chlorophyll Maximum (above-DCM, DCM and below-DCM).

Temperature and conductivity, salinity, and dissolved oxygen were recorded using SBE-911+CTDO profiler equipped with Turner Scufa fluorometer (for Chl*a*). CTD and fluorescence data quality was checked by comparison with lab samples.

Inorganic phosphorous and nitrogen (PO_4 and NO_3 [1]; NH_4 [2]) were analyzed using US/VIS spectrophotometer; and Chl*a* concentration was determined by spectrofluorometer [3].

Results and Discussion

In December surface warmer waters (17.56 °C) were separated by a thermocline, in the layer between 50 and 100m, from the deeper waters (14.14 °C), while in February the homogeneity of the thermal field existed (13.74 and 14.53 °C). Surface salinity (37.82 ppt) was homogeneous up to 60m then an halocline down to 70m (37.85-38.65 ppt) was found in late-fall, whereas in February the salinity resulted constantly increasing with the depth (37.60-38.62 ppt) along the whole water column. Though different to each other the thermo-haline structures of the transects in late-fall and winter showed a high spatial homogeneity.

Nutrient concentration in late-fall showed mean values of 0.29±0.19 µM for PO_4, 0.21±0.18 µM for NH_4 and 1.81±2.07 µM for NO_3, whereas higher values were found in February (0.36±0.24 µM for PO_4, 0.70±.065 µM for NH_4 and 3.26±4.36 µM for NO_3) due to winter mixing which enriched euphotic layer.

Chl*a* concentration in the 0-80m layer ranged between 0.12 and 0.44 μgl^{-1} with a mean value of 0.14±0.04 μgl^{-1} in December and 0.25±0.08 μgl^{-1} in February when the values were doubled . In both periods the integrated Chl*a* values (0-80m) exhibited a general coast-to-offshore increase evidencing a weak frontal zone linked to the hydrodinamic coastal circulation (Fig. 1).

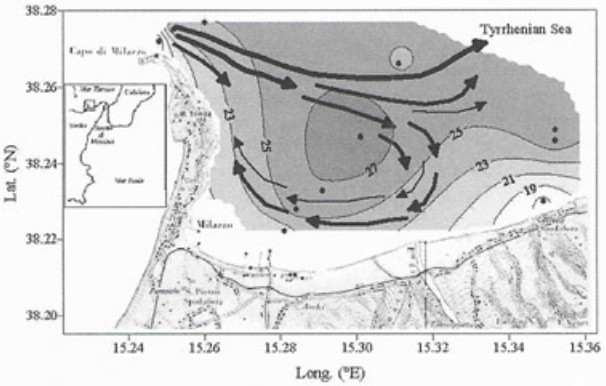


Fig. 1. Gulf of Milazzo : water circulation and integrated Chl*a* (mg m^{-2}) of the 0-80m layer in winter.

Vertical Chl*a* distribution showed a pattern typical of temperate waters with the DCM generally located at 50m of depth in both periods and stations. The DCM depth during the measurements uplifted with respect to that observed in late spring and the one known for Tyrrhenian off-shore waters as well [4]. This trophic condition seems to be linked to both hydrographic conditions and phytoplankton cycle. In late fall the autotrophic community shows lower biomass when a weak water stratification exists; whereas in February with omogeneous water column, Chl*a* presents higher values in relationships to the bimodal plankton pattern. This condition is supported by the vertical distribution of dissolved oxigen maximum, which is located above the DCM in December and below it in winter.

In conclusion short-term hydrobiological changes were evidenced by different thermo-haline structures and nutrients and chlorophyll*a* concentrations. A frontal zone between the costal and the off-shore waters, due mainly to meso-scale dynamical structure, was evidenced in both periods by accumulation of phytoplankton biomass.

References

1 - Aminot A., Chassepied M., 1983. Manuel des analyses chimiques en milieu marin. *Centre National pour l'Exploration des Océans*. 1-395.
2 - Strickland J.F.H., Parson T.R., 1972. A pratical handbook of seawater analisys. *Bull. Fish. Res. Ed. Can.*, 167: 311 p.
3 - Lazzara L., Bianchi F., Falcucci M., Hul, V., Modigh M., Ribera D'Alcalà' M., 1990. Pigmenti clorofilliani. *Nova Thalassia*, 11: 207-223.
4 - Azzaro F., Decembrini F., Raffa F., Greco S. Caratteristiche idrobiologiche del tirreno sud orientale 33° Congresso Biologia Marina Mediterranea - Castelsardo (SS) 3 - 8 Giugno 2002.

SPRING EVOLUTION OF WATER COLUMN FEATURES AND PLANKTONIC COMMUNITIES IN THE GULF OF MILAZZO (SICILY)

Decembrini F. *, Bergamasco A., Raffa F., Sitran R., Gangemi E.
IAMC-CNR, Messina, Italy - * decembrini@ist.me.cnr.it

Abstract

The present work is based on original data collected during spring 2003 in the frame of a national programme (MIUR Cluster10-SAM) dealing with the development of new technologies and approaches to coastal monitoring. Meteoceanographic forcings are crucial factors in driving dynamics and physical features of coastal waters which in turn strongly influence planktonic communities. High-frequency automatic data improve the detail of the oceanographic context, framing on a longer time-scale the snapshots caught during field campaigns. Joint interpretation helps in discriminating which process (stratification, mixing) mostly influenced planktonic compartment in early May.

Key-words: Meteoceanographic forcings, phytoplankton, microzooplankton, Tyrrhenian Sea

Introduction

Scope of this short note is to describe the relations between the physical features of the water column and the planktonic communities in the Gulf of Milazzo (Sicily), open to the southern Tyrrhenian sea. A synthetic characterization of the study area is presented in (1).

A system approach has been adopted by combining data coming from an automatic platform with quasi-fortnightly field data which included vertical profiling by CTDOF/Rosette and watersamplings above-, within- and below-DCM in a selected 120m-deep station. Standard methods were used for chemical and biological analyses (2).

Results and Discussion

The expected increasing trend of air temperature, initially very steep (30 degrees in early May), was abruptly interrupted due to a two-week period of atmospheric instability which forced a decrease below 20 degrees (Fig. 1). Temperatures raised then to unexpectedly high values for late spring.

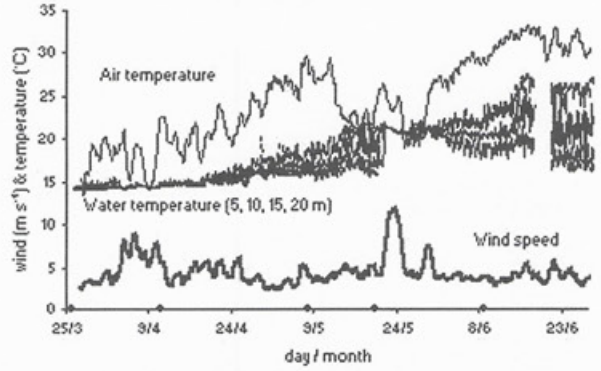


Fig. 1. Platform data: Climatic parameters (24-hours running averages) and hourly watercolumn thermal structure.

Late-winter water column was homogeneous (15 degrees). Differential warming of the uppermost layer began in the second half of April. Seasonal thermocline is already formed in early May (ΔT=5 degrees) when the wind forcing induces a strong mixing which makes homogeneous the uppermost layer (21 degrees). The water column warming continues until the end of spring when the thermocline is about 10 degrees between 5 and 20 m.

Isopycnal trends (Fig. 2) reflect the initial homogeneity of the water column (28.4 σ_t). An evident stratification is then reached, mainly constrained by bottom salinity and uppermost 40m warming. The presence of a pycnocline (50m) is therefore observed in early May. The layer between 28.2 and 28.4 σ_t hosts the DCM which appears in late winter (40m) and reaches 0.5 µg-Chl*a* l^{-1}. In late spring this layer looses buoyancy with the ongoing stratification and carries DCM down to 70m.

Phytoplankton density (Fig. 3) was generally low and uniform (40 to 50 x10^3 cells l^{-1}). A slight decrease in early May (30 x10^3 cells l^{-1}) is then recovered (max 54 x10^3 cells l^{-1}). Flagellates (<20 µm) dominate (80-90%) in the whole period at every depth; the remaining percentage is equally shared by dinoflagellates and diatoms. Only in late winter these latter are relatively more abundant in the intermediate layer and dominate in the lowermost one.

Microzooplankton abundance was generally low with minimum in early April (10 cells l^{-1}) and increased till late spring (40 cells l^{-1}).

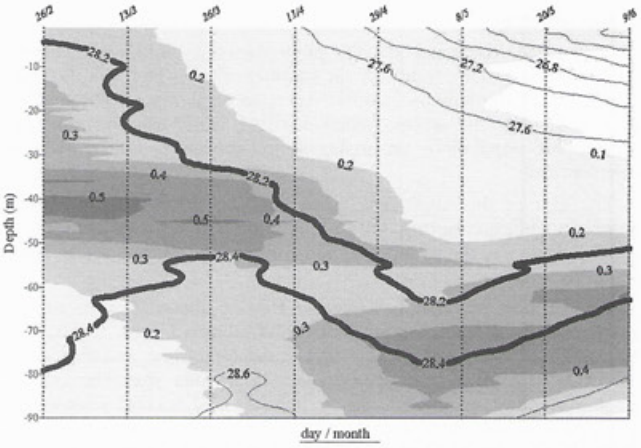


Fig. 2. Field data: Isopleths of density (st) and phytoplankton biomass (mg-Chla l-1) distribution.

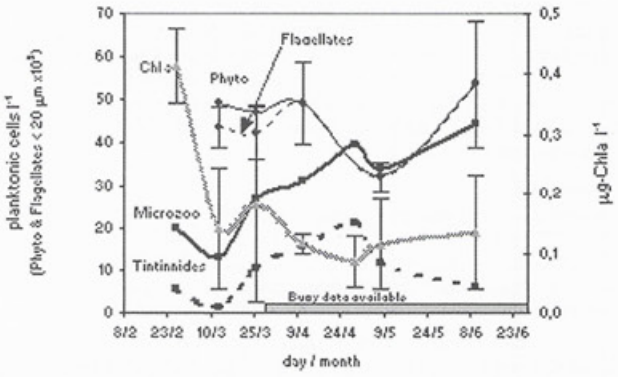


Fig. 3. Planktonic field data: Column-averaged phyto- and microzooplanktonic densities.

Each of tintinnids and metazoan represented about 40%, non-ciliates protozoan were 10% of the total. Though vertical distribution of these groups exhibited no significant differences, tintinnids were little more abundant in the uppermost layer.

The post spring-bloom outcoming scenario shows phytoflagellates in a stationary phase, controlled by microzooplankton which exhibits an increasing trend characterized by a typical delay with respect to the autotrophic component.

The downlift of the pycnocline in early May induced by water warming determined the sinking of planktonic communities and the generalized decrease of their densities. The subsequent recovery of this biotic component is not influenced by wind-induced mixing in upper layers.

References

1 - Decembrini, F., Azzaro, F., Raffa, F., Galletta, M.G., submitted. Short-term changes of hydrobiological features in the Gulf of Milazzo (Tyrrhenian Sicily), *Rapp. Comm. Int. Mer Médit. (this volume).*

2 - Standard methods for the Examination of Water and Wastewater, APHA, 1976, ISBN 0-87553-078-8.

ROLE OF MIXED AND FRAGMENTATED HABITATS IN FISH HABITAT PREFERENCE

S. Deudero * and A. Frau

Laboratorio de Biología Marina and GOI (IMEDEA-CSIC/UIB). Departamento Biologia. Facultat de Ciencias. Edif. Guillem Colom, Universitat de les Illes Balears. Palma Mallorca, Spain - * salud.deudero@uib.es

Abstract

Fish species composition, abundance, diversity and niche breath of mediterranean littoral communities have been assessed by visual census at rocky bottoms versus mixed meadows of *Posidonia oceanica* and boulders. Labridae and Sparidae species show differences in habitat preference, although fish assemblages are very similar in abundance and there are not significant differences in niche breath of both habitats. Physical structure is one of the main factors affecting the general characteristics of the associated fish assemblages -fish abundance, species richness The data highlights the benefit of fragmented habitats in the littoral fish communities.

Key-words: fish, niche, preference, Mediterranean

Rocky habitats constitute an optimal habitat for some fish species and Mediterranean littoral fish communities have been traditionally studied on rocky bottoms (1). However, studies carried out on vegetated ecosystems highlight the rule of the seagrass beds as spawning areas, recruitment and nursery zones, refuge zones for many nocturnal species (2) and feeding areas (3). In fact, *Posidonia oceanica* seagrass beds provide an habitat with a large spatial heterogeneity for the fish communities.

The objective of this study is to compare the rocky habitat with the mixed meadows of rock and *Posidonia.* Previous studies are mainly centred in rocky bottoms (4) or vegetated habitats (5). In the Mediterranean, most of the sublittoral seafloor is covered by rocky areas mixed with seagrass patches. However, there is an evident lack of studies concerning the comparison of both habitats (6). Niche breath in mixed meadows is expected to be larger than in rocky bottoms due to the higher species diversity.

Material and Methods

Underwater visual census were performed at shallow depths (10-20m) over rocky bottoms and mixed meadows (rocky reefs and *Posidonia oceanica*) during the 9th- 20th July 2002, between 9:00 - 14:00 GMT. 9 sampling sites were settled along the perimeter of Dragonera Natural Park (W Mediterranean). 52 replicates were performed: 21 transects for rocky bottoms and 21 transects for mixed habitats.

Mobile fishes were quantified along a transect (50 m long x 5m wide) while cryptic species were counted in 20m x 5m transect. Fish density (n indiv/250m^2) was calculated by taking into account the mid point of each abundance class (7).

Coverage seagrass *Posidonia oceanica*/transect was quantified along a 50 m strip with transects >30% seagrass coverage considered as mixed habitats and transects < 30% classified as rocky bottoms.

Differences among fish abundance at each type of habitat were tested with ANOVA for 3 Sparidae species and 7 Labridae species. Density data (n° of fishes/250m^2) were log (x+1) transformed after Cochran's test.

Habitat preference of each species was calculated with the Affinity Index of Habitat Preference that links the abundance and the occurrence of each specie in relation to the total abundance and the total occurrence:

$$IA=(A_h \cdot O_h)/(A_t \cdot O_t)$$

A_h =relative abundance of the species in the habitat; A_t = relative abundance of species in all habitats; O_h = occurrence of the species in the habitat; O_t = occurrence of the species in all habitats.

Niche breath was calculated by $B=1/\Sigma p_i^2$ as used in fish trophic ecology.

Species richness (S), number of individuals (N), equitativity (J') and the Shannon-Weaver diversity Index (H') were calculated with the *Primer*.

Results and Discussion

A total of 10273 individuals were censused, with 4909 fishes among rocky bottoms and 5364 over mixed habitats. Sparidae, Apogonidae and Labridae are the most relatively abundant families in both habitats, but relative abundance of Serranidae, Sparidae, Trypterigiidae, Muraenidae and Scorpaenidae are higher in rocky habitats than in mixed habitats.

Species richness (S), Equitativity (J') and Shannon-Weaver index (H') were very similar at both habitats with no significant differences among them (ANOVA, p>0.05). The highest variability was exhibited by the mean density of fishes per transect (N) with 45,2% at rocky habitats and 34,29% at mixed meadows.

Values of fish abundance at mixed meadows and rocky bottoms are very similar. Fish assemblages in physically "structured environments" tended to be more similar to each other than to those in unvegetated sand habitats[5].

Habitat preference and ecological niche breath

Habitat distribution patterns at both habitats varied throughout the species. Generally, labrids preferred mixed meadows while sparids were commonly associated to rocky bottoms. *D. annularis* (6,7), *S. rostratus, S. tinca, S. doderleini* and *S. mediterraneus* showed higher affinity for mixed habitats, probably due to the food resources provided by rocky bottoms along the use of *Posidonia* seagrass beds as refuge areas against predation (3) or as nursery areas (4,7). Generally, fish species associated with vegetated habitats are likely to be responding to needs for food and shelter. *D. sargus* (4) and *S. ocellatus* prefer the rocky habitat, and *S. doderleini* and *D. vulgaris* have similar affinity for both types of habitats (Fig. 1).

Niche breath of the mixed habitat (B= 5.6) is slightly higher than the one in rocky bottoms (B=5.1) although not statistically significant (ANOVA, p>0.05).

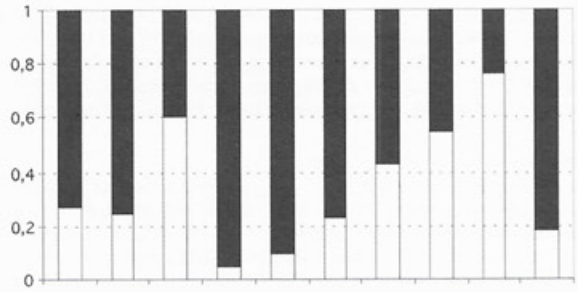


Fig. 1. Affinity index values for the *Symphodus* spp. and *Diplodus* spp. species at the mixed habitat (black bars) and at the rocky habitat (white bars).

References

1 - Bell J.D. and Harmelin-Vivien M., 1982. Fish fauna of French Mediterranean *Posidonia oceanica* seagrass meadows: I. Community structure. *Thetys,* 10: 337-347.

2 - Fasola M., Canova L., Foschi F., Novelli O. and Bressnan M., 1997. Resource use by Mediterranean rocky slope fish assemblages. P.S.Z.N.I: *Mar. Ecol.* ,18: 51-66.

3 - Francour P., 1997. Fish assemblages of *Posidonia oceanica* beds at Port-Cros (France, NW Mediterranean): Assessment of composition and long-term fluctuations by visual census. P.S.Z.N.I: *Mar. Ecol.* 18: 157-173.

4 - Garcia-Rubies A. and Macpherson E., 1995. Substrate use and temporal pattern of recruitment in juvenile fishes of the Mediterranean littoral. *Mar. Biol.,* 124: 35-42.

5 - Guidetti, P. 2000. Differences among fish assemblages associated with nearshore *Posidonia oceanica* seagrass beds, rocky-algal reefs and unvegetated sand habitats in the Adriatic sea. *Est. Coast Shelf Sci.* 50: 515-529.

6 - Guidetti P., Bussotti S. and Boero F., 2001. Fish visual census in shallow meadows of mediterranean small-sized seagrasses *Rapp. Comm. Int. Mer Médit.,* 36.

7 - Harmelin-Vivien M., Harmelin J.G. and Leboulleux V., 1995. Microhabitat requirements for settlement of juvenile sparid fishes on Mediterranean rocky shores. *Hydrobiologia,* 300-301, 309-320.

THE USE OF RECONSTRUCTIVE METHODS IN COMBINATION WITH "BEYOND BACI" DESIGNS: THE CASE STUDY OF CAPO FETO (SW SICILY, ITALY)

Giuseppe Di Carlo * , Fabio Badalamenti, Claudia Passalacqua
IRMA-CNR, sez. di IAMC, Laboratorio di Biologia Marina, Castellammare del Golfo (TP), Italy

Abstract

Changes in leaf production and rhizome elongation rates of *Posidonia oceanica* have been evaluated by means of reconstructive methods to evaluate the response to a dredging carried out in 1993. Asymmetrical sampling design "beyond BACI" was used to detect the impact with a single sampling as dating methods obviated lack of pre-impact data. Leaf production and rhizome elongation rates were reconstructed for 4 years before 4 years after the impact. Rhizome elongation almost doubled after the impact. Control sites did not present any significant variations from before to after the impact. Results suggest a pulse disturbance, since leaf production did not change and internodal length increased in a short-time scale.

Keywords: Posidonia oceanica; reconstruction methods; impact

Introduction

P. oceanica meadows are recognized to be key ecosystems in the marine environment. In the last decade a regression of *P. oceanica* beds has been reported due to anthropogenic causes (1,2). A submerged pipeline was deployed at Capo Feto (SW Sicily, Italy) in 1993. This caused an increase of water turbidity and sedimentation rate. Vertical rhizomes overcome burial process by increasing internodal length, but when the balance between sedimentation and plant growth is lost, the plant suffocates (3). This study utilises a "beyond BACI" sampling design (4) in combination with reconstruction methods (5) to assess the response of the seagrass *P. oceanica* to the impact caused by a coastal dredging.

Material and Methods

144 vertical shoots shoots of *P. oceanica* were randomly sampled in October 2000 at depths of maximum shoot density both at impact (Capo Feto) and control sites (Tonnarella). The length of all internodes was measured using a stereomicroscope (5). The 1:1 relationship between leaf and vertical internode allows the number of vertical internodes between two consecutive minima in length to be used as a surrogate for the number of leaves produced during a time period. Asymmetrical analyses of variance were used to examine temporal differences between the potentially impacted meadow and the average of control meadows (6). Data were examined by Cochran's *C* test for homogeneity of variances. Appropriate transformations, whenever necessary (7). ANOVA was performed using GMAV5 (University of Sydney).

Results

The results show that there is no evident variation in leaf production rate from before to after pipeline deployment both at Capo Feto and Tonnarella (impact/controls). However, annual rhizome elongation rates were found to be significantly different from before to after the impact at Capo Feto (impact), while no difference was recorded at both control sites (Tonnarella) (Fig. 2). Indeed, an increase of internodal length was recorded at the impacted site starting from 1994. Such increase in rhizome elongation seen after the disturbance could reflect an integrated response of the plant at a different magnitude of response to the impact (6).

Discussion

In *Posidonia oceanica* vertical growth has been demonstrated to be sensitive to sediment dynamics (8,9,10). Internodal length is strictly related to burial and erosion processes (10). In this study, an excess in sedimentation rate lead to an increase vertical growth to overcome burial. Reconstructive methods represent a useful procedure to assess seagrass dynamics, proving a tool for the assessment and management of coastal ecosystems (11). The combination of dating methods with "beyond BACI" designs can be considered an excellent approach to evaluate environmental impacts, especially when pre-impact data are lacking.



Fig. 1. Study area.

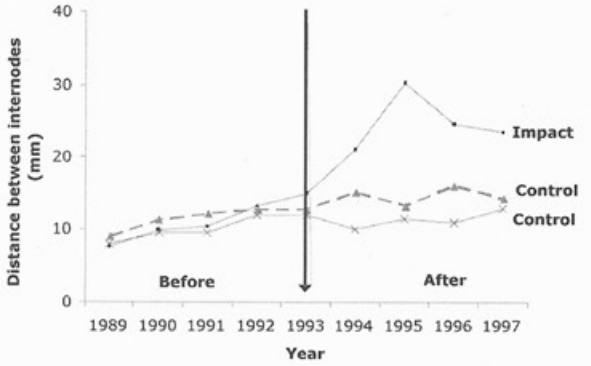


Fig. 2. Rhizome elongation rate variation before and after the putative impact at Capo Feto.

References

1 - Pérès, J.M. 1984. La régression des herbiers à *Posidonia oceanica*. Pp. 39-44. In: Boudouresque C.F., Jeudy de Grissac A., Oliver J. (Eds.) International Workshop on *Posidonia oceanica* beds. GIS Posidonie Publ., Marseille.

2 - Short, F.T., Wyllie-Echeverria, S. 1996. Natural and human-induced disturbance of seagrasses. *Environ. Conserv.* 23(1): 17-27.

3- Hemminga, M., Duarte C. 2000. Seagrass Ecology. Cambridge University Press, Cambridge.

4 - Underwood, A.J., 1992. Beyond BACI: the detection of environmental impacts on populations in the real, but variable, world. *J. Exp. Mar. Biol. Ecol.* 161: 145–178.

5 - Duarte, C.M., Marbà, N., Agawin, N., Cebrian, J., Enriquez, S., Fortes, MD., Gallegos, M.E., Merino, M., Olesen, B., Sand-Jensen, K., Uri, J., VERMAAT J. 1994. Reconstruction of seagrass dynamics: age determination and associated tools for the seagrass ecologist. *Mar. Ecol. Prog. Ser.* 107: 195-209.

6 - Guidetti, P. 2001. Detecting environmetal impacts on the Mediterranean seagrass *Posidonia oceanica* (L.) Delile: the use of reconstructive methods in combination with "beyond BACI" design. *J. Exp. Mar. Biol. Ecol.* 260: 27-39.

7 - Underwood, A.J., 1997. Experiments in Ecology: Their Logical Design and Interpretation Using Analysis of Variance. Cambridge Univ. Press.

8 - Marbà, N., Duarte, C. 1994. Growth Response of the seagrass *Cymodocea nodosa* to experimental burial and erosion. *Mar. Ecol. Prog. Ser.* 107: 307-311.

9 - Marba, N., Duarte, C.M., Cebrian, J., Gallegos, M.E., Olesen, B., Sand-Jensen, K. 1996. Growth and population dynamics of *Posidonia oceanica* on the Spanish Mediterranean coast: elucidating seagrass decline. *Mar. Ecol. Prog. Ser.* 137: 203-213.

10 - Duarte, C.M., Terrados, J., Agawin, N., Fortes, M.D., Bach, S., Kenworthy, W.J., 1997. Response to a mixed Philippine seagrass meadow to experimental burial. *Mar. Ecol. Prog. Ser.* 147: 285–294.

11 - Durako, M.J., Duarte, C.M., 1997. On the use of reconstructive aging techniques for assessing seagrass demography: a critique of the model test of Jensen *et al,*. 1996. *Mar. Ecol. Prog. Ser.* 146: 297–303.

DIVERSITE DE LA MACROFAUNE BENTHIQUE DE LA LAGUNE MELLAH (ALGERIE NORD-EST)

Draredja B. * et Kara M. H.

Laboratoire Bioressources Marines, Université Badji Mokhtar, Annaba, Algérie - * draredjab@yahoo.fr

Résumé

L'inventaire de la macrofaune benthique de la lagune Mellah a révélé la présence de 42 espèces: 13 Mollusques, 14 Polychètes, 12 Crustacés et 5 espèces appartenant à des embranchements faiblement représentés, formant le groupe dénommé "divers". La densité moyenne à l'échelle de la lagune est estimée à 2816,6 ind./m^2.

Mots - clés: Macrobenthos, Lagune, Mellah, MED, Algérie

Introduction

Le Mellah, située à l'extrême Est de l'Algérie (8° 20' E et 36° 54' N), est une lagune saumâtre dont la salinité varie entre 25,4 et 34,8 psu. Elle communique avec la mer par un chenal long et étroit. Depuis l'aménagement de ce dernier en 1988, peu de travaux ont été effectués sur le compartiment macrozoobenthique de la lagune (1, 2). Le but de cette note est de dresser un inventaire des espèces qui la colonisent et de déterminer leur importance relative.

Matériel et méthodes

Ce travail est réalisé de décembre 1997 à décembre 1998. Des échantillons de sédiment sont prélevés mensuellement à l'aide d'une benne de type "Van Veen", dans cinq stations réparties selon un plan longitudinal du Nord au Sud de la lagune. Après le tamisage du sédiment sur une maille de 1mm, les individus récoltés sont stockés dans du formol à 10%. Ils sont triés par groupe zoologique, identifiés et dénombrés.

Résultats et discussion

L'inventaire de la macrofaune benthique de la lagune révèle la présence de 44 espèces (Tab. 1). Cette diversité est nettement supérieure à celle trouvée par d'autres auteurs comme (3) (37 espèces), (4) (21 espèces), (1) (29 espèces), mais inférieure à celle signalée par (5) (56 espèces).

Tab. 1. Dominance moyenne (Dm) des espèces macrozoobenthiques recensées dans la lagune Mellah.

Espèces	Dm	Espèces	Dm
Mollusques		*Lumbriconereis gracilis*	1,4
Brachydontes marioni	19,65	*Micronereis vasciegata*	0,33
Loripes lacteus	21,80	*Platynereis dumerilii*	1,21
Abra ovata	4,45	*Glycera convulata*	0,54
Cardium glaucum	1,94	*Phyllodoce pusilla*	0,16
Venerupis decussata	2,32	**Crustacés**	
Cerithium vulgatum	1,84	*Corophium insidiosum*	2,79
Hydrobia ventrosa	1,18	*Microdeutopus gryllotalpa*	2,51
Rissoa sp	1,86	*Amphithoë ferox*	0,48
Nassa pygmaea	0,39	*Gammarus aequicauda*	0,18
Haminea navicula	0,13	*Gammarus sp*	0,03
Scaphopode ind	0,98	*Maera grossimana*	0,01
Bulla utricata	0,14	*Cyathura carinata*	8,84
Cyclonassa nerita	0,5	*Idotea baltica*	0,04
Polychètes		*Anthura gracilis*	0,69
Aricia foetida	4,33	*Penaeus kerathurus*	0,03
Nainereis laevigata	3,14	*Carcinus estuari*	0,003
Heteromastus filifomis	7,12	*Cypridina mediterranea*	0,78
Capitella capitata	0,81	**Divers**	
Serpula vermicularis	1,9	*Ophiura texturata*	0,48
Pectinaria koreni	0,44	*Amphiura chiajei*	0,79
Salmacina dysteri	0,43	Planaire ind.	0,003
Harmathoë spinifera	0,54	Spongiaire ind.	0,45
Nereis caudata	1,62	Sipunculidae ind.	0,75

Parmi les groupes zoologiques existants, les mollusques dominent nettement (Fig. 1). Au niveau spécifique, les deux bivalves *Loripes lacteus* et *Brachydontes marioni* sont dominants et représentent 41,4 % de l'ensemble de la macrofaune (Fig. 2).

La densité moyenne du macrobenthos dans la lagune s'élève à 2821,74 ind/m^2. La partie Nord, sous influence marine, est plus riche en espèces et en individus par rapport au Sud soumis à l'influence continentale. Des densités moyennes saisonnières comprises entre 11865 ind/m^2 en automne et 953 ind/m^2 en été sont signalées par (6).

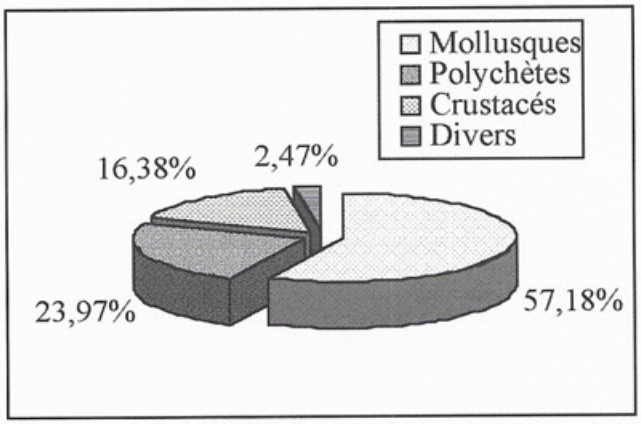


Fig. 1. Fréquence des différents groupes macrozoobenthiques récoltés dans la lagune Mellah.

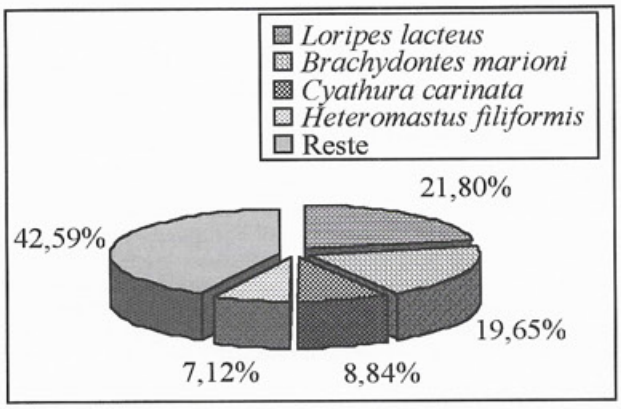


Fig. 2. Fréquence des principales espèces macrozoobenthiques récoltées dans la lagune Mellah.

Références

1 - Grimes S., 1994. Contribution à la connaissance des populations de *Cardium glaucum* (Bruguière, 1789), *Loripes lacteus* (Linnaeus, 1758) et *Brachydontes marioni* (Locard, 1889) du lac Mellah (El-Kala, Algérie): Écologie et dynamique. Thèse magister en Océanographie biologique, ISMAL (Alger), 211 p.

2 - Refes W., 1994. Contribution à la connaissance de la population de *Ruditapes decussatus* (Linnaeus, 1758) du lac Mellah (El-Kala, Algérie): Écologie, reproduction, dynamique de la population et exploitation. Thèse magister en Océanographie biologique, ISMAL (Alger), 197 p.

3 - Semroud R., 1983. Contribution à l'étude écologique des milieux saumâtres méditerranéens: le lac Mellah (El-Kala, Algérie). Thèse 3ème cycle, USTHB (Alger), 137 p.

4 - Guelorget O., Frisoni G. F., Ximenes M. C. et Perthuisot J. P., 1989. Expressions biologiques du confinement dans une lagune méditerranéenne: le lac Mellah (Algérie). *Rev. Hydrobiol. Trop. 22 (2)*: 87-99.

5 - Draredja B., 1992. Conditions hydrosédimentaires et structure de la macrofaune benthique en période printanière d'un écosystème lagunaire méditerranéen: lac Mellah. Thèse de magister en océanographie biologique, ISMAL (Alger): 147 p.

6 - Semroud R., 1985. Contribution à l'étude des milieux saumâtres méditerranéens: Le lac Mellah (El-Kala, Algérie): Densité et biomasse moyennes des principales espèces benthiques. *Rapp. Comm. Int. Mer Médit., 29, 4:* 167-168.

DYNAMIQUE DES PROTOZOAIRES CILIÉS DANS DEUX BASSINS CONTRASTÉS DE LA SALINE DE SFAX (TUNISIE)

Jannet Elloumi [1] *, Habib Ayadi [1], Jean-François Carrias [2], Télesphore Sime-Ngando [2], Abderrahmen Bouaïn [1], Mekki Boukhris [1]

[1] Laboratoire de Planctonologie, UR 00/UR/0907, Ecobiologie et Ecophysiologie animales. Département des sciences de la vie, Faculté des Sciences de Sfax, Tunisie - * jannetelloumi@yahoo.fr, jannetelloumi@voila.fr, Habib.Ayadi@fss.rnu.tn

[2] Laboratoire de Biologie comparée des protistes, UMR, CNRS 6023, Univ. Blaise Pascal, Clermont-Ferrand, France j-francois.carrias@Ibp.univ-bpclermont.fr, telesphore.sime-ngando@ibp.univ-bpclermont.fr

Résumé

Les protozoaires ciliés planctoniques de la saline de Sfax ont été analysés dans deux bassins de salinité contrastée (A1=45‰, M2=180‰), entre le mois de janvier et le mois de septembre 2003. Les peuplements se caractérisent par la dominance des Oligtrichida (55%) et des Prostomatida (37%) dans A1, alors que ce sont les Heterotrichida qui dominent (69%) dans M2. Le nombre de taxons rencontrés est nettement plus élevé dans A1 (n=29) que dans M2 (n=5). Nos résultats soulignent l'importance de la salinité comme paramètre déterminant et sélectif des populations des ciliés dans la saline de Sfax.

Mots clés : Saline, salinité, ciliés

Introduction

La saline de Sfax est un milieu paralique artificielle, au sein duquel plusieurs facteurs sont susceptibles d'agir; la morphologie des bassins, l'hydrologie et la salinité jouent un rôle majeur (1,2). Le climat aride accentue l'installation de conditions de sur-salure dans les deux bassins dont M2 est un véritable milieu extrême. Le phytoplancton et le zooplancton de la saline ont été étudiés au cours des années 1999-2000 (3). Notre travail est original dans le sens qu'on a pris en considération les protozoaires ciliés planctoniques qui peuvent représenter une importance capitale dans la biomasse zooplanctonique marine. Si leur rôle dans le transfert de la matière et d'énergie a été largement démontré (4,5), leur importance dans les marais salants reste très mal connue.

Matériels et méthodes

La saline de Sfax (10° 44'E; 34° 49'N) présente une hydrologie artificielle fixée par les saulniers qui ajustent le transfert de l'eau d'un partènement à l'autre de telle façon qu'un champ de salinité stable couvre l'ensemble des surfaces évaporatoires. Deux bassins de salinité très différente ont été choisis pour les échantillonnages. Le bassin A1 de salinité moyenne 46‰ (40‰-46‰) fait partie des «avants pièces» de la saline, bassins recevant directement l'eau de mer. Le deuxième bassin étudié est le bassin M2 de salinité moyenne 190‰ (180‰-220‰) situé dans les bassins formant les «partènements intérieurs». Les échantillons ont été collectés à l'exutoire de chaque bassin toutes les trois semaines, entre les mois de janvier et octobre 2003 (10 échantillons par bassin). Les organismes sont fixés au lugol et le dénombrement est réalisé selon la méthode d'Uthermöhl.

Résultats et discussions

Dans le bassin A1, les ciliés oligotrichida (*Strombidium* sp, *Strombidinopsis* sp...) représentent 55% de l'abondance totale des ciliés, ensuite viennent les prostomatida (*Urotrichia* sp., 37%) les autres ciliés (*Euplote* sp, *Colpoda* sp., 6%). En M2, on remarque une forte dominance des ciliés heterotrichida qui forment 69% de l'abondance totale (Fig. 1).

La densité des ciliés en A1 varie de 900 à 34,8 10^3 cellules/l (12,91 10^3± 12,69 10^3cellules/l). On remarque la présence de deux pics de développement (Fig. 2), le premier au mois de mai dû à l'oligotrichida

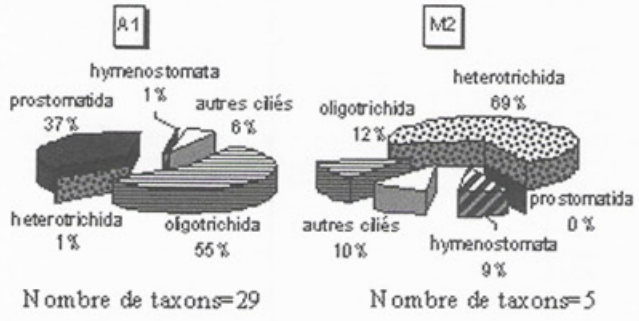


Fig. 1. Abondance relative des ciliés dans les bassins A1 et M2 de la saline de Sfax.

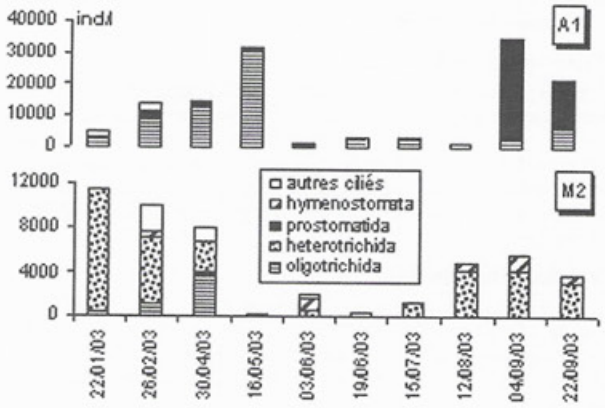


Fig. 2. Répartition spatio-temporelle des ciliés dans les bassins A1 et M2 de la saline de Sfax.

Strombidium sp. qui représente alors 67% des ciliés totaux, un deuxième au mois d'octobre dû au développement d'*Urotricha* sp. (90.8% des ciliés totaux). En M2, les valeurs fluctuent de 300 à 11,6 10^3 ind/l (4,79 10^3±3,92 10^3 cellules/l). La densité maximale correspond au développement très important de *Fabrea salina* qui forme alors 96.55% des ciliés totaux. Généralement, les taxons à tendance marine tel que les oligotriches (*Stombibium* sp, *Strobilidium* et *Tintinnopsis*) et les prostomatidés (*Urotrichia* sp.) dominent au niveau de A1. Ces mêmes genres sont aussi communément rencontrés en milieu marin (6) et lacustre (7). En M2, c'est surtout *Fabrea salina* qui est présente. Ainsi, l'abondance et la richesse spécifique des ciliés diminuent avec l'augmentation de la salinité, qui représente donc un facteur sélectif pour les ciliés planctoniques, *Fabrea salina* étant l'un des principales espèces adaptées au milieu extrême sursalé tel qu'elle est observée au niveau du bassin M2.

Références

1 - Hedgpeth J.W., 1959. Some preliminary considerations of the biology of inland mineral waters. *Archivio Oceanogr. Limnol.*, 11 : 111-141.

2 - Davis J.S., 1978. Biological communities of nutrient enriched Salina. *Aquatic. Bot.*, 4 : 23-42.

3 - Ayadi H., Toumi N ., Abid O., Medhioub K., Hammami M., Sime-Ngando T., Amblard C et Sargos D., 2002. Etude qualitative et quantitative des peuplements phytoplanctoniques et zooplanctoniques dans les bassins de la saline de Sfax. *Rev. Sci. Eau.*,15/1 : 123-135.

4 - Wiadnyane N.N and Rassoulzadegan F., 1989. On the role of microorganisms in the precipitation of Ca Co3. *J. Sedim. Petrol.*, 4 : 113-126.

5 - Dolan JR., 1991. Microphageous ciliate in mesohaline Chespeake bay waters : estimates of growth rates and consumption by copepods. *Mar. Biol.*, 111 : 303-309.

6 - Jame M.R and Hall J.A., 1995. Plankton ciliated protozoa: their distribution and relationship to environmental variables in a marine coastal ecosystem. *J. plankton Res.*17: 659-683.

7 - Carrias J. F., 1996. La boucle microbienne en milieu lacustre : Structure et fonctionnement des communautés pico planctoniques et de protistes flagellés et ciliés. Thèse de doctorat de l'université Blaise Pascal de Clermont II. 223 p.

PHYTOPLANKTON VARIATIONS IN A MEDITERRANEAN CHANNEL DURING A DIURNAL TIDE.

Facca Chiara [1] * and De Casabianca Marie-Luce [2]

[1] Department of Environmental Sciences, Venice, Italy - * facca@unive.it
[2] CNRS-Cefe, UPR 9056, S.M.E.L., Sète, France

Abstract

The present study discusses phytoplankton abundance and diversity diel variations in the channel, which connects the Thau lagoon (France) to the Mediterranean Sea. Abundance in surface and bottom samples, collected every three hours in May the 15th 2002 and in October the 22nd 2002, with good windless weather conditions, displayed similar trends. Peaks occurred during the ebb tide, except for the surface samples, collected in October, when the abundance remained almost constant. Pearson correlation revealed that tidal height variations affected mostly phytoplankton diversity, enriching the number of species during ebb.

Key-words: phytoplankton, tide, lagoon

Introduction

Phytoplanktonic populations have a short life cycle and their presence/absence can be affected by an high number of variables (temperature, salinity, light intensity, nutrient availability…). To investigate the weak tide current effects of on phytoplankton abundance and diversity, a Mediterranean channel (Thau lagoon), with slight tidal height variations (±15 cm, on average), was chosen. The Thau lagoon has a wind-induced hydrodynamic pattern, negligible freshwater inputs and the sea-lagoon exchanges occur through the Sète channel [1], where sampling station is located. This area is, moreover, affected by high nutrient inputs, above all nitrogen, due to the farmed shellfish excretions and biodeposition.

Methods

Water samples were collected by means of a bucket and a Kemmer bottle at the surface and at the bottom, respectively. Sampling campaigns were carried out in May the 15th 2002 and in October the 22nd 2002 (two windless days), every three hours from 08:00 a.m. to 08:00 p.m. to comprise a diurnal tide. Moreover, samples were collected around 10:00 p.m. to describe the dark condition. Phytoplanktonic specific composition and abundance were determined at light inverted microscope (Zeiss, Germany) according to Utermöhl's method [2]. Shannon diversity index and Pieolu evenness were calculated.

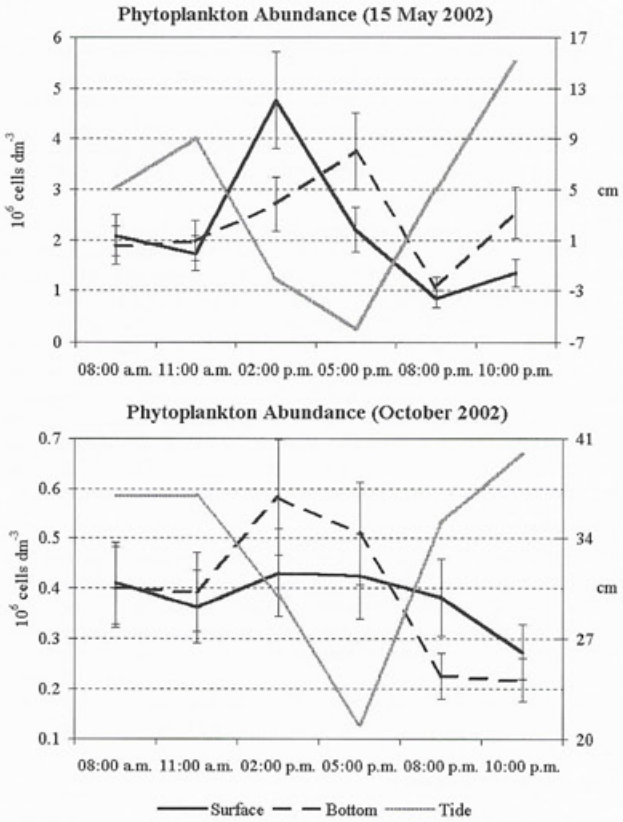
Results

Marked abundance fluctuations were observed in May the 15th (Fig. 1). Surface and bottom samples displayed a similar mean value, 2.16 ± 1.37 and 2.32 ± 0.91 x 10^6 cells dm^{-3}, respectively, but the maximum and the minimum strongly differed. Surface community was 0.84 x 10^6 cells dm^{-3} at 08:00 p.m. and 4.76 x 10^6 cells dm^{-3} at 02:00 p.m. (Fig. 1). Bottom community presented low abundance but, also, low variations (between 1.06, at 08:00 p.m., and 3.76 x 10^6 cells dm^{-3}, at 05:00 p.m.). Some taxa were commonly widespread during all day and the most abundant was nanoflagellates (spherical flagellates, which size is less than 5 µm). During the ebb some species (i.e. *Nitzschia frustulum* Grunow and *Fragilaria* sp.) appeared, favouring the increase of diversity.

In October the 22nd surface abundance remained almost constant, varying between 0.27 x 10^6 cells dm^{-3}, at 10:00 p.m., and 0.43 x 10^6 cells dm^{-3}, at 02:00 p.m. In bottom samples abundance was higher than in surface from 08:00 a.m. to 05:00 p.m. (Fig. 1). It reached 0.58 x 10^6 cells dm^{-3} in the early afternoon and, then, it dropped to 0.22 x 10^6 cells dm^{-3}, in the evening. Nanoflagellates were still the most abundant taxa. During the ebb tide Dinophyceae abundance increased and *Pseudonitzschia heimii* Manguin represented till the 10% of total phytoplankton community.

Pearson correlation highlighted that, in May, diversity and evenness were significantly ($p<0.05$) affected by tidal height variations. In October, on the contrary, Shannon index was indirectly correlated with water temperature. No significant correlation was observed between abundance and the considered physical parameters.

Bacillariophyceae, both pelagic and benthic species, were, in general, more abundant during ebb than during flood tide. Pennate diatoms, often common in benthic habitat, were more frequent in bottom than in surface samples and they clearly characterised the ebb, highlighting the strong influence of lagoon waters on channel. Seawater effects on phytoplankton species were, instead, less evident.



References

1 - De Casabianca M.L., and Kepel R.CH., 1999. Impact of dominant winds on hydrological variables in a Mediterranean lagoon (Thau lagoon, France). *Oebalia*, 25: 3-16.

2 - Utermöhl H., 1958. Zur Vervollkomnung der quantitativen Phytoplankton-Methodik. *Mitt. int. Verein. Limnol.*, 9: 1-38.

SPATIAL DISTRIBUTION OF BENTHIC DIATOMS IN THE SURFACE SEDIMENT OF VENICE LAGOON, ITALY

Facca Chiara * and Sfriso Adriano
Department of Environmental SciencesVenice, Italy - * facca@unive.it

Abstract
Surface sediment samples (ca. 2-3 mm) were collected in 65 stations in summer 2002, to investigate spatial distribution of the epipelic diatoms. Total abundance varied between 0.26 and 3.60 x 10^6 cells cm^{-3}. The highest values were recorded in protected areas, far from the deepest canals. A spot distribution, with marked small-scale fluctuations, was often observed. The community was mainly constituted by raphid genera, such as *Navicula* spp. and *Nitzschia* spp., but also centric diatoms were important in some sites. Shannon diversity increased progressively from the mainland to the sea.

Key-words: diatoms, epipelon, sediment, lagoon

Introduction

The ecological role of benthic diatoms, as primary producers and sediment stabilizers, in shallow water, is widely recognized [1]. Moreover, recently, a lot of studies propose to use trophic indices based on benthic diatom communities to assess freshwater quality (i.e. [2]). The present study aims to describe the spatial distribution of diatoms in the lagoon and their ability to scale trophic conditions, also, in brackish waters.

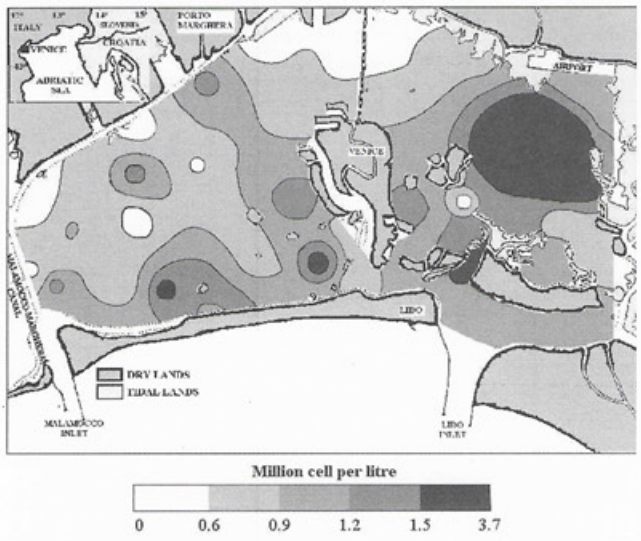
The study area is the central part of Venice lagoon, subject to a high water renewal and strongly affected by many anthropic activities. In this area the mean water depth, except for the canals, does not exceed 1 m. At present macroalgal biomass is almost absent [3], but some zones close to the port entrances are colonised by seagrasses. By considering the whole central lagoon the dominant primary producers are microorganisms, which live in water column or on bottom habitats. In this paper we present the results of a spatial investigation of benthic diatom distribution in the 2-3 mm sediment top layer of the whole central lagoon. Epipelic diatom seasonal distribution has already been investigated in some sites of Venice lagoon, showing abnormal variations, often independent of temperature changes [4].

Methods

Sampling sites were located in the area comprised between the Malamocco port entrance, in the south, and the Burano-Torcello wetlands, in the north. Sediment samples (thick ca. 5 cm) were collected by means of a Plexiglas corer in always-submerged zones (1 m deep), out of canals. Undisturbed surface minicores (2-3 mm thick) were stored with hydrogen peroxide for 24 hrs and, then, diluted with synthetic seawater [4]. Diatoms were counted and identified by the light inverted microscope according to Utermöhl's method [5].

Results and Discussion

Diatom abundance, in general, was spread along an increasing gradient from the mainland to the sea. Several spots, contrasting with surrounding distribution, were, however, observed (Fig. 1). The highest values (up to 3.59 x 10^6 cells cm^{-3}) were recorded in protected areas, north of Venice. The abundance was below the average value (1.02 ± 0.54 x 10^6 cells cm^{-3}) along the main canals and in the areas of intense bivalve catching, where minimum cell concentrations occurred (0.26 x 10^6 cells cm^{-3}). On the whole 84 taxa were identified. Rhapid genera were the most abundant as both cell and specie number, whereas arhapid diatoms were almost negligible. Centric diatoms, in particular *Thalassiosira* sp., were widespread near the mainland, south of the translagoon bridge. *Amphora exigua* Gregory, *Amphora veneta* Kützing, *Cocconeis molesta* Kützing, *Navicula lanceolata* Kützing, *Nitzschia lanceolata* Smith and *Nitzschia microcephala* Grunow were the background of benthic community in the whole study area. Other species, such as *Cocconeis scutellum* Ehrenberg, varied zone by zone.



Shannon diversity index was higher along the Lido island than near the mainland. Similarly, communities with a high number of species were grouped near the port entrances. The diversity and the specie number seemed to fit the trophic conditions of the lagoon better than the abundance. In fact, nutrient concentrations are higher close to the mainland, affected by industrial, urban and agricultural sewage inflow [6]. Diatom abundance was probably affected by other factors, such as physical alterations of bottom habitats due to the frequent sediment re-suspension/settlement phenomena. The area, where diatoms were less abundant, was, in fact, affected by oil tanker transit and by intense clam fishing.

References

1 - MacIntyre H.L., Geider R.J., and Miller D.C., 1996. Microphytobenthos: the ecological role of the "secret garden" of unvegetated, shallow-water marine habitats. I. Distribution, abundance and primary production. *Estuaries*, 19: 186-201.
2 - Prygiel J., Whitton B.A., and Bukowska J. (eds.), 1999. Use of Algae for Monitoring Rivers III. Agence d'Eau Artois-Picardie, Douai, France, 271 p.
3 - Sfriso A., Facca C., and Ghetti P.F., 2003. Temporal and spatial changes of macroalgae and phytoplankton in a Mediterranean coastal area: the Venice lagoon as a case study. *Mar. Environ. Res.*, 56: 617-636.
4 - Facca C., Sfriso A., and Socal G., 2002. Temporal and spatial distribution of diatoms in the surface sediments of the Venice lagoon. *Bot. Mar.*, 45: 170-183.
5 - Utermöhl H., 1958. Zur Vervollkomnung der quantitativen Phytoplankton-Methodik. *Mitt. int. Verein. Limnol.*, 9: 1-38.
6 - Sfriso A., Facca C., Ceoldo S., Silvestri S., and Ghetti P.F., 2003b. Role of macroalgal biomass and clam fishing on spatial and temporal changes in N and P sedimentary pools in the central part of the Venice lagoon. *Oceanol. Acta*, 26: 3-13.

NOTES ON THE BIOLOGY OF *PERCNON GIBBESI* (BRACHYURA, GRAPSIDAE) IN THE CENTRAL MEDITERRANEAN SEA

Fanelli E. [1], Azzurro E. [2] *

[1] Istitut de Ciencies del Mar, 003 Barcelona, Spain - efanelli@cmima.csic.es
[2] Istituto di Scienze del Mare, Università di Ancona, Italy

Abstract

The flat rock crab *Percnon gibbesi*, found for the first time in 1999 in Linosa (Pelagie Islands-Italy), was expanded in southern and western Mediterranean. This study focused on some aspects of its biology in order to investigate the causes of its rapid spreading. Crabs examined were collected during August 2003 in 4 different sites in the Central Mediterranean (Linosa, Lampedusa, Palermo and Marzanemi, Sicily-Italy). Carapace length sex and ovigerous condition were determined. Some differences were evidenced between the samples collected on natural and artificial rocks.

Key words: biology, reproduction, Percnon gibbesi, Central Mediterranean

Introduction

Percon gibbesi (H. Milne Edwards, 1853) is an alien species, recorded for the first time in the central Mediterranean sea in 1999 (1). Since now several records of this species were marked in different areas of the Mediterranean sea (2,3,4) together with several oral communication (www.ciesm.org/atlas/), demonstrating the rapid spreading of this species. Some preliminary studies were focused on reproduction (5) and feeding (6), but despite its large abundance in the southern coasts of Italy (Sicily and Pelagie islands) many aspects of its biology and ecology are still unknown. The aim of this study is to contribute to the knowledge of some biological aspects of this exotic species.

Material and Methods

A total of 229 specimens of *Percnon gibbesi* were collected in the southern coast of Italy (see Fig. 1) in August 2003, from 0 to 3 m of depth.

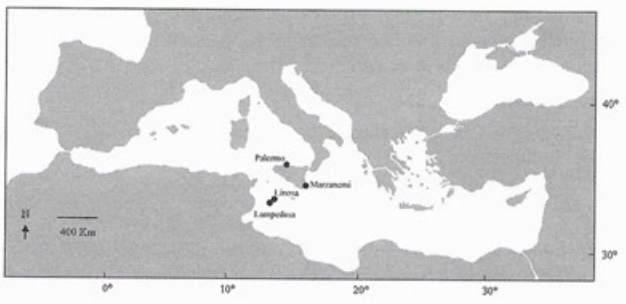


Fig. 1. Sampling sites.

All the samples were measured in mm (carapace length CL with the accuracy of 0.1 mm). Normality of the length data was determined using the Kolmogorov–Smirnov test prior to comparing the differences between samples collected on natural (specimens collected in Linosa) and artificial rocks (specimens from Lampedusa, Palermo and Marzanemi). To estimate fecundity, eggs from 20 recently spawned females were manually removed from the pleopods and then the procedure suggested by Abello (7) was followed. Sex-ratios by 1 mm size classes were determined and tested by a chi-square analysis.

Results and Discussion

The length frequency distribution of the whole sample, grouped in 1 mm, showed that CL ranges between 11 mm and 38 mm and the distribution is plurimodal. Three modes are recognisable peaking at CL ranges of 11-18 mm, 19-28 mm, and 29-38 mm. Linosa population was mainly formed by smaller animals (CL: 11-28 mm), while Lampedusa, Palermo and Marzanemi populations were chiefly composed by medium and large size specimens (CL: 14-38 mm). This can be probably due to the wider crevices offered by the artificial reefs to larger individuals, comparing to natural rocks, that give a more suitable protection to the smaller specimens. The normalized distributions of natural rocks and artificial rocks samples (natural rocks K-S d=0,22278, p<0,10 ; Lilliefors p<0,01; artificial rocks: K-S d=0,18037, p> 0,20; Lilliefors p<0,05) resulted different.

Of a total of 229 individuals, 123 (53.7%) were males and 106 (46.3%) females with a sex-ratio of 1:0.86. Males are bigger than females and the maximum size recorded in this study overreaches the values referred by Manning and Holthuis (8) (a male measuring 38,2 mm CL and 39,9 mm CW). The smallest females carrying eggs had a 14 mm CL, FMS for August resulted 13,4 mm CL. In the sampling period 92% of studied females carried eggs in different development stages. The brood size of these females ranged from 38 (the smallest female carrying eggs) to 11.881 eggs.

Some hypothesis may be formulated in order to explain the rapid spreading:

1) P. gibbesi could have occupied an empty niche;

2) Its apparent long reproductive period, as reported by Puccio *et al.* (3), together with a low FMS as reported in this study;

3) Its feeding habits, mainly focused on algae and coralline algae (4), abundant and no competitive resources in its living habitat.

Further biological and ecological studies are necessary to understand the role of this species in the coastal ecosystem and the potential implications in the Mediterranean trophic webs.

References

1 - Relini M., L. Orsi, V. Puccio and E. Azzurro, 2000. The exotic crab *Percnon gibbesi* (H. Milne Edwards, 1853) (Decapoda, Grapsidae) in the Central Mediterranean. *Scientia Marina*, 64(3): 337-340.

2 - Garcia L. and B. Reviriego, 2000. Presència del cranc subtropical *Percnon gibbesi* (H. Milne Edwards, 1853) (Crustacea, Decapoda, Grapsidae) a les Illes Balears. Primera cita a la Mediterrània occidental. *Bolleti de la Societat d'Història natural de les Balears*, 43: 81-89.

3 - Mueller C. First record of *Percnon gibbesi* (Crustacea: Decapoda: Grapsidae) for the Balearic Islands, 2001. *Senckenb. Marit.* 31(1): 83-89.

4 - Pipitone C., Badalamenti F., Sparrow A., 2001. Contribution to the knowledge of *Percnon gibbesi* (Decapoda, Grapsidae), an exotic species spreading rapidly in Sicilian waters. *Crustaceana* 74(10): 1009-1017.

5 - Puccio V., Relini M., Azzurro E. 2002. Osservazioni sulla riproduzione di *Percnon gibbesi* (H. Milne Edwards, 1853) a Linosa. Symposium SIBM, Castelsardo, Italy: 3-8 June 2002.

6 - Puccio V., Relini M., Azzurro E., Relini L.O., 2002. Feeding habits of *Percnon gibbesi* (H. Milne Edwards, 1853) in the Sicily strait. VIII Colloquium on Crustacea Decapoda. Corfù, Greece: 2-6 September 2002.

7 - Abellò P. 1989. Reproducyion and moulting in *Liocarcinus depurator* (Linnaeus, 1758) (Brachyura: Portunidae) in the Northwestern Mediterranean sea. *Scientia Marina*, 53(1): 127-134.

8 - Manning R.B., Holthuis L.B., 1981. West African Brachyuran Crabs (Crustacea: Decapoda). *Smithsonian Contribution to Zoology*, 306, 379 p.

THE DATE-SHELL *LITHOPHAGA LITHOPHAGA* L. COLONIZATION OF IMMERSED ROCKS AT THE EASTERN PART OF THE ADRIATIC SEA

Ivana Grubelic *, Ante Simunovic, Marija Despalatovic
Institute of Oceanography and Fisheries, Split, Croatia - * grubelic@izor.hr

Abstract
The aim of this paper is to show the mode and the time during which the date-shell penetrates an intact rock immersed into the sea, as well as its development and the structure of its population in various periods.

Key words: Lithophaga lithophaga, colonization, immersed rocks

Introduction

There are bibliographic data about the distribution of the date-shell (1), its reproductive cycle (2, 3), biology and ecology in the eastern part of the Adriatic (4), the method of burrowing the rock (5, 6). Because of its specific life in the rock and its inaccessibility, the date-shell is still partly unknown. Our results contribute to the new knowledge about the date-shell and help decide on the profitability of its farming in immersed rocks.

Materials and Methods

In order to identify the time and method of date-shell penetration into the rock habitat, and to monitor the development of its population in various periods, the rocky breakwaters of the marinas around Split were chosen, since the exact time of their immersion into the sea has been known. The research was conducted in ACY marina in 1986 (built in 1984), in marina Split (built in 1952 and 1986) in 1987, and in marina Zenta (built in 1979) in 1989. The research was repeated in the same sites in 2003. Sample collecting was done by scuba divers, using the method of direct collecting from the area of 1/4 m^2.

Results and Discussion

The results of the research show (Tab. 1) that after two years a sponge *Cliona sp.* was in the rock (ACY), and after ten years shellfish *Rocellaria dubia* was present (Zenta). Besides *Cliona sp.* and *R. dubia*, the population of *Lithophaga lithophaga* (Tab. 2) was well developed in the rock that has been in the sea for 35 years (Split). The biometric characteristic of the date-shell population is shown in Table 2. Dominate specimens were of 40-49 mm (28,6%), 60-69 mm (25,0%) and 50-59 mm (23,2%). The largest date-shell was 82,0 mm long, 23,0 mm wide and 25,31 g of weight. According to old data, it grew in the rock for about 25 years.

Table 1. The presence of *C. celata, R. dubia and L. lithophaga* in the rocks that were immersed at different times.

	C.celata	*R.dubia*	*L.lithophaga*
Split: 1986-1987	-	-	-
Split: 1986-2003	+	+	-
ACY: 1984-1986	+	-	-
ACY: 1984-2003	+	+	-
Zenta: 1979-1989	+	+	-
Zenta: 1979-2003	+	+	+
Split: 1952-1987	+	+	+
Split: 1952-2003	+	+	+

The research was repeated in September 2003, and the obtained results (Tab 1) are: *Cliona sp.* and *R. dubia* have developed in the rock that has been in the sea for 19 years (ACY). Both species completely penetrated the rock up to about 4 cm. However, the date-shell has not yet developed. Besides *Cliona sp.* and *R. dubia,* the population of date-shell was found in the rocks that has been in the sea for 24 years (Zenta) and for 51 years (Split). The biometric characteristics of the date-shell populations are shown in Table 2. Dominate specimens in Zenta (1979-2003) were of 60-69 mm (31,0%) and 50-59 mm (22,4%). The largest date-shell was 87,0 mm long, 23,9 mm wide and 21,1 g of weight. According to old data, it grew in the rock for about 14 years. Dominate specimens in Split (1952-2003) were of 40-49 mm (30,6%), 50-59 mm (27,8%) and 30-39 mm (22,2%). In this population were 6 empty shells (16,7%). The largest date-shell was 75,5 mm long, 19,7 mm wide and 17,5 g of weight. According to old data, it grew in the rock for about 41 years.

Table 2. Biometrics characteristics of the population of *L. lithophaga* in the rocks of different immersion time (1/4 m^{-2}).

	N	Min	Max	X	SD
Zenta: 1979-2003	58	26,1	87,0	57,8	14,4
Split: 1952-1987	56	32,0	82,0	53,1	12,3
Split: 1952-2003	36	23,8	75,5	49,7	11,9

It can be concluded that the populations of the date-shell, that lived in the rocks immersed into the sea 24 and 35 years ago, have the characteristics of a healthy population, while the population of the date-shell in the rock immersed 51 years ago, showed the signs of decay and absence of renewal.

References

1 - Nordsieck F., 1969. Die europaischen Mearesmuscheln. Gustav Fisher Verlag, Stuttgart, pp. 37-38.
2 - Valli G., Nodari P., and Sponza R., 1986. Allevamento sperimentale di *Lithophaga lithophaga* (L.) (Bivalvia, Mytilacea) e studio del ciclo riproduttivo nel golfo di Trieste. *Nova Thalassia,* 8: 1-13.
3 - Simunovic A., Grubelic I., Tudor M., and Hrs-Brenko M., 1990. Sexual cycle and biometry of date-shell *Lithophaga lithophaga* L. (Mytilidae). *Acta Adriat.,* 31 (1/2): 139-151.
4 - Simunovic A., and Grubelic I., 1992. Biological and ecological studies of the dateshell (*Lithophaga lithophaga* L.) from the eastern Adriatic Sea. *Period. biol.,* 94 (3): 187-192.
5 - Agius I., 1976. The rock boring date mussel *Lithophaga lithophaga. Maltese Nat.,* 2 (3): 65-68.
6 - Bolognani-Fantin A. M., 1979. The pallial gland of *Lithophaga lithophaga*: a histochemical and biochemical approach of the rock borring problem. *Malacologia,* 18: 587-589.

CARACTÉRISATION BIOCHIMIQUE D'UN CRUSTACÉ PHYLLOPODE *ARTEMIA SALINA* DE LA SALINE DE SFAX

Wassim Guermazi *, Habib Ayadi, Abderrahmen Bouaïn

Laboratoire de Planctonologie, Unité de recherche 00/UR/0907, Ecobiologie et Ecophsiologie animales,
Département des sciences de la vie, Faculté des sciences de Sfax, Tunisie - Habib.Ayadi@fss.rnu.tn, * Wassim016@yahoo.fr

Résumé

Artemia salina de la saline de Sfax a été analysé dans plusieurs bassins de différents salinités (M1, M2, M3 et B1) et particulièrement au niveau du bassin M2 (S = 180‰) entre le mois de mars et juin (1, 2, 3). Nous avons constaté des teneurs en protéine assez élevées chez la femelle (en moyenne 215 µg / ind et des variations temporelles atteignant des maximum en période printanière, période à laquelle *Artemia* croit considérablement. Lorsque les conditions environnementales deviennent plus difficiles, ces teneurs baissent et *Artemia* arrête de croître et consacre son énergie à la production de cystes.

Mots clés : Saline, Artemia , Protéine

Introduction

Artemia salina est un petit crustacé vivant dans les lacs salés, les lagunes et les salines. Elle est pourvue de nombreux appendices, ne possède pas de carapace chitineuse. Comme filtreur, elle se nourrit de micro-algues, saisies à l'aide de ses pattes filtrantes. Ce crustacé eurihalin est fréquemment rencontré dans les habitats salés et les marais salants car il a la particularité de pouvoir vivre dans des eaux de salinité allant de 5 à plus de 300‰. *Artemia* se reproduit de deux manières, par ovoviviparité (production de larves vivantes) ou par oviparité (production d'embryons en diapause, ou cystes).

Généralement, les protéines occupent le pourcentage le plus important dans la composition de plusieurs crustacés (40-55% du poids sec) particulièrement chez le phyllopode *Artemia salina* (4). C'est un type d'alimentation de premier ordre chez de nombreuses poissons. Ainsi, l'utilisation d'*Artemia* à des fin aquacoles n'a cessé de s'amplifier depuis la découverte de ses hautes valeurs nutritives. Nous sommes intéressé à *Artemia salina*, particulièrement la souche de Sfax, afin d'évaluer son potentiel énergétique pour des applications en aquaculture.

Matériel et méthodes

La méthode de Folin Lowry modifiée est celle la plus couramment utilisée. Des individus à différentes étapes de croissance (unités fonctionnelles), cystes, nauplii et adultes mâles et femelles sont triés sous une loupe binoculaire, puis broyés à l'ultraturaxe dans le réactif C ; on ajoute le réactif de Folin, une coloration bleue se révèle. La lecture de la densité optique est faite à 700 nm. En se référant à la gamme étalon des solutions de BSA à différentes concentrations, on peut déterminer les teneurs en protéines au niveau de chaque stade de développement.

Résultats

La teneur de protéine au niveau des cystes oscille entre 48µg/ ind et 169µg/ind respectivement au mois de juin et mois d'avril (en moyenne 101.11µg / ind, ±61.84). Cette quantité de protéine est faible comparée à celle des autres unités fonctionnelles *d'Artémia.* (Fig. 1). Ainsi, au niveau des nauplii, on note une légère diminution des teneurs en protéines, le maximum est de 90.67 µg/ind au mois de mai. Les teneurs en protéines des nauplii et des cystes sont presque comparables mais nettement inférieures à celles des adultes. Les femelles adultes présentent une valeur maximale de 342 µg/ind et un minimum de 85.67 µg/ind coïncidant souvent avec une floraison algale. Les teneurs en protéines au niveau des mâles évoluent de la même manière que celles des femelles avec des teneurs qui oscillent entre 106.67 µg/ind et 248 µg/ind respectivement au mois de juin et mois de mars (en moyenne 163.50 µg/ind, ±60.07).

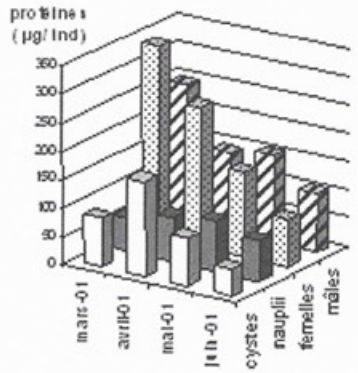


Fig. 1. Variation temporelle de la teneur protéique chez *Artemia* au niveau du basin M2 (absorbance à 700 nm).

Discussion

Les teneurs en protéines augmentent de manière quasi-linéaire du cyste à la femelle adulte (Fig. 2), ceci se traduit par une élévation de la valeur calorifique qui est principalement due aux variations de la composition qualitative et quantitative de ces substances organiques. Les femelles montrent les plus fortes teneurs en protéines; les mâles présentent des quantités plus faibles. Ceci pourrait être expliqué par le fait que les adultes de plus grande taille contiennent plus de protéines nécessaires à la reproduction et au maintien de l'individu. La biomasse de protéine diminue au mois de mai et juin; ceci pourrait être dû aux conditions climatiques particulières. En effet, l'énergie dépensée par *Artemia* adulte au cours de ces deux mois est utilisée pour construire de nouvelles structures protéiques. A cet égard *Artemia* arrête sa croissance lorsque les conditions climatiques deviennent diffciles pour se reproduire.

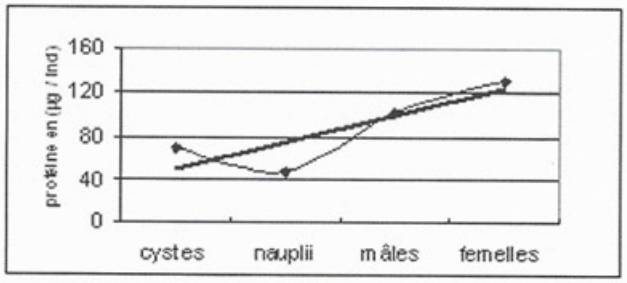


Fig. 2. Evolution de la teneur en protéine en fonction du stade de développement *d'Artemia*.

Références

1 - Toumi N., 1998. Contribution à l'étude géochimique et biologique des marais salants de la saline de Sfax. DEA, Ecologie générale. f.S.S.université de Sud.

2 - Toumi N., H. Ayadi, 1998/ Etude des cycles saisonniers du zooplancton de la saline de Sfax. *Bull. Inst. Nat. Des sciences et technologie de la mer*, N° spécial (4) : 60-63.

3 - Toumi N., H. Ayadi, 2001. *Artemia* in saltworks of Sfax (Tunisia) distribution and application in aquaculture. Med coast 01, E. Ozhan (Ed.) pp 1007-1016. ISBN 975-1748 (2.cilt).

4 - Sorgeloos *et al.*, 1986. Manuel for the culture and the use of brine shrimp *Artemia* in aquaculture. *Artemia* reference center. State University of Ghent Belgium. 319 p.

PHYTOPLANKTON OF THE GULF OF SUEZ AND THE EFFECT OF BALLAST WATER

Halim Y. * and A.A. Ismael

Department of Oceanography, Faculty of Science, Alexandria, Egypt - * youssefhalim@hotmail.com

Abstract

The phytoplankton population in the Suez Gulf consists of 171 species and varieties belonging to 8 groups. The Gulf is an oligotrophic basin, affected by two man-made factors: turbidity caused by powerful ship propellers and the release of waste and ballast water from ships, respectively a negative and a positive factor. The latter factor creates micro-environments where brackish water species thrive. This effect was clear even at stations located far away from the coast and from any land-based sources.

Key words: Phytoplankton, ballast water, Suez Gulf

The Gulf of Suez extends 300 km to the northwest of the Red Sea proper and is connected to the Mediterranean by the Suez Canal. Up to 76 standard ships cross the canal per day (1). Very little is known about the phytoplankton of this Gulf (2, 3). Quantitative and qualitative samples were collected from April 1999 to May 2001 from thirteen stations, which differ regarding their location relative to the navigating Channel, to their proximity to the coast and regarding their total depth.

The Gulf phytoplankton consisted of 171 species and varieties belonging to 8 groups (Dinophyceae, 88 sp., Bacillariophyceae 69 sp., Chlorophyceae 5 sp., Cyanophyceae 4 sp. and Prymnesiophyceae 2 sp., Cryptophyceae, Euglenophyceae and Chrysophyceae with a single species each). The phytoplankton populations in both northern (St 1 to 3) and intermediate zones (St 4 to 8) present similarities, but the southern zone (St 9 to 13) is different. The dinoflagellates are more diversified in this latter zone, contributing 65 % to the total. Eleven dinoflagellates were restricted to this zone throughout the period of study, especially at the offshore stations. They are true indicators of surface Red Sea influx: *Amphisolenia bidentata*, *Citharistes regius*, *C. deflexum*, *C. reflexum*, *Dinophysis monacantha*, *Gyrodinium nasutum*, *Noctiluca scintillans*, *Parahistoneis* sp., *Phalacroma ovum*, *Pyrocystis fusiforme* and *Pyrodinium bahamensis* var *compressum*. *Pyrodinium bahamensis* var *compressum* recorded only from the southern zone, is known however to have reached the Mediterranean at Port Said (4). Several species, which are characteristic of the open Red Sea and the Indian Ocean became adapted to the Gulf waters and extend to the northernmost Gulf (St 1): *C. breve*, *C. humile* and *Protoperidinium sinaicum*.

Ceratium egyptiacum, described from the Bitter Lakes (5) in the Suez Canal, remains endemic to the Gulf of Suez, the canal and the East Mediterranean up to Lebanon (6) and to Turkish waters (7). It is not known from elsewhere, either in the Red Sea or the Mediterranean (8,9).

As the Gulf of Suez is an oligotrophic basin, the standing crop was very low (84 to 9900 cell l^{-1}). It is less affected by natural conditions than by two man-made factors: turbidity caused by ship propellers and waste water release from ships. The first factor is negative as turbidity inhibits photosynthesis while the second enhances production. An unexpected observation is the occurrence on many occasions of fresh water and brackish water species in this high salinity Gulf (average 42 psu): *Cyclotella meneghiniana*, *Euglena* sp., *Merismopedia* sp., *Nitzschia closterium*, *Oscillatoria* sp., *Pandorina* sp., *Pediastrum* sp., *Spirulina* sp., *Staurastrum* sp. and *Synedra ulna*. Brackish species occur at stations scattered along the north-south axis, ranging in standing crop from 18 to 6250 cell l^{-1}. Their appearance is not related to season or location, but to the release of ship ballast and waste water causing local enrichment in nutrient salts. Ballast water therefore creates micro-environments of low salinity in the Gulf, where alien species thrive. The relation is positive between the average standing crop of brackish water species and the average vessels in ballast (Fig. 1).

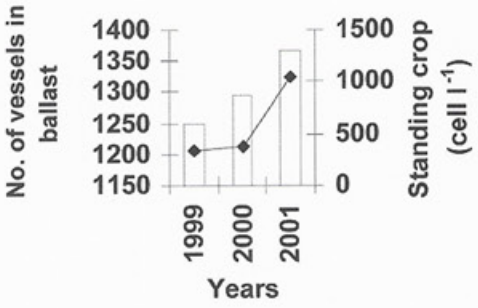


Fig. 1. Average vessels in ballast and average standing crop of brackish water species in the Suez Gulf.

References

1 - Suez Canal Authority. 2001. Yearly reports, Egypt, 87 p.

2 - Cleve. P.T.1903. Report on plankton collected by Mr. Thorild Wulff during a voyage to and from Bombay. *Ark. Zool. Stockholm*, 1: 329-381.

3 - Ostenfeld, C.H. and J.Schmidt. 1901. Plankton fra det Röde Hav Aden bugten. Vidensk. *Medd. Naturh. Foren.*, Kjobenhaven: 141-182.

4 - Halim, Y. 1970. Microplankton des eaux egyptiennes. III-Especes indopacifiques ou erythreennes a l'extreme nord du Canal de Suez. Journées Etudes Planctonol. *Rapp.P-V. Reun. int. Explor. Scient. Mer Médit.* : 57-59.

5 - Halim, Y. 1963. Microplancton des eaux égyptiénnes. Le genre *Ceratium* Schrank (Dinoflagellés). *Rapp.P-V. Reun. int. Explor. Scient. Mer Médit.* : 17(2):495-502.

6 - Lakkis, S. 1998. Dinoflagellate assemblages from the Lebanese seawater (Eastern Mediterranean). Abstract, the Sixth International Conference on Modern and Fossil Dinoflagellates, Trondheim, Norway: 89.

7 - Koray, T., Gokpinar, S., Yurga, L., Turkoglu, M. and S. Polat. 1999. Microplankton species of Turkish Seas. http:// bornova.ege.edu.tr

8 - Dowidar, N.M. 1971. Distribution and ecology of *Ceratium egyptiacum* Halim and its validity as an indicator of current regime in the Suez Canal. *Int. Revue ges. Hydrobiol.*, 56: 751-760.

9 - Dowidar, N.M. 1972. Morphological variations in *C. egyptiacum* in different natural habitats. *Marine Biology*, 16: 138-149.

IMPACT DE LA RESTAURATION ENVIRONNEMENTALE SUR L'ICHTYOFAUNE DU LAC SUD DE TUNIS

Méjri Hamadi * et Ben Souissi Jamila

Institut National Agronomique de Tunisie, Tunis-Mahrajène, Tunisie - * hamadi.mejri@lycos.com, bensouissi.jamila@inat.agrinet.tn

Résumé

L'inventaire de l'ichtyofaune, réalisé suite au projet de réhabilitation écologique du lac sud de Tunis, a permis de recenser 59 espèces essentiellement thalassiques contre 14 caractéristiques de la biocœnose Lagunaire Eurytherme et Euryhaline (L.E.E) rencontrées lors de l'effondrement biologique du milieu. L'augmentation de la biodiversité est attribuée à une meilleure qualité des eaux de la lagune. Les poissons actuels du lac sont essentiellement migrateurs, certains d'entre eux sont qualifiés d'exceptionnels [1].

Mots-clés : Lagune de Tunis- Restauration environnementale- Ichtyofaune

Introduction

Le lac sud de Tunis, situé au nord-est de la Tunisie (Fig. 1), a toujours subi l'action anthropique sans cesse grandissante de la ville de Tunis et de ses faubourgs et a constitué jusqu'à 1998 le réceptacle des eaux de ruissellement et des décharges domestiques et industrielles. Cet état de pollution, aggravé par une géomorphologie particulière, était à l'origine de l'effondrement biologique qui s'est traduit par l'instabilité spatio-temporelle des paramètres abiotiques et trophiques, l'eutrophisation extrême et la contamination élevée des sédiments par les métaux lourds toxiques et la chute drastique de la biodiversité dans la lagune. Avant les aménagements, les peuplements de la lagune étaient représentés par la biocœnose L.E.E avec dominance d'espèces fortement polluo-tolérantes [2]. Pour remédier à cette situation, il a été décidé de procéder à la restauration environnementale de la lagune et de ses berges. Le projet vise :

- la dépollution du plan d'eau par le détournement des eaux usées et l'évacuation des sédiments contaminés;
- la restructuration géomorphologique du lac par un dragage jusqu'à -2 mètres de profondeur, le remodelage de la ligne des berges et le remblaiement des zones de stagnation;
- l'amélioration de l'hydrodynamisme par l'approfondissement et l'élargissement de la communication avec la mer [2].

Dans le cadre d'une étude pluridisciplinaire visant l'évaluation des impacts du projet de réhabilitation écologique du lac, le présent travail concerne l'évolution de la faune ichtyologique dès la fin des aménagements (automne 2001).



Fig. 1. Situation géographique et géomorphologique actuelle du lac Sud de Tunis.

Méthodologie

Les poissons examinés aussi bien adultes que juvéniles proviennent de la pêche professionnelle utilisant essentiellement les filets maillants et les capétchades et des captures spécifiques réalisées à l'aide d'épuisette, de carrelet et de la plongée.

Résultats et discussion

Les travaux antérieurs [3] font état de 14 espèces seulement, appartenant toutes à la classe des Ostéichtyens et réparties en 6 ordres, 8 familles et 12 genres. La majorité des espèces appartient à la Biocœnose L.E.E et est dominée par *Anguilla anguilla* et *Aphanius fasciatus*.

La reconquête du milieu, désertifié au cours des travaux de dragage et isolé de la mer par les écluses, a débuté avec l'installation quasi-instantanée d'espèces macrobenthiques. La dynamique de repeuplement du lac a mis en évidence la colonisation de l'écosystème par des espèces exotiques venues de Méditerranée orientale et du golfe de Tunis et la réinstallation d'espèces vivant dans les canaux et le lac avant le projet [4].

L'examen de 1031 poissons a permis d'évaluer l'impact de l'amélioration de la qualité des eaux sur les peuplements ichtyologiques du lac sud. Ainsi, nous avons pu inventorier 59 espèces dont 55 Ostéichtyens.

Quatre Chondrichtyens, un Myliobatidae, un Rajidae, un Rhinobatidae et un Torpedinidae, sont signalés pour la première fois dans cet écosystème lacustre. L'actuel lac sud de Tunis est envahi par une faune d'Elasmobranches de type subtropical et s'apparente donc aux milieux lagunaires saumâtres hyperhalins à l'instar de la lagune des Bibans [5].

Les poissons osseux inventoriés appartiennent à 12 ordres, 28 familles et 42 genres. L'ordre des Perciformes est le plus représenté avec 14 familles, 26 genres et 38 espèces. Les familles les plus représentées dans le lac sont celles des Sparidae, Labridae et Mugilidae. L'ichtyofaune actuelle du lac est dominée par les espèces exclusivement marines, celles-ci sont passées de 0 à 52%. Les poissons caractéristiques de la biocœnose L.E.E et les espèces marines pouvant pénétrer occasionnellement dans les milieux saumâtres sont plus rares et représentent chacune 24% contre, respectivement 58 et 42% avant la réhabilitation écologique du milieu.

L'étude biométrique et méristique met en évidence la dominance des alevins et juvéniles. L'abondance des immatures montre que le lac offre des conditions trophiques favorables à leur croissance et à leur reproduction. De même, l'étude du régime alimentaire de *Gobius niger*, *Scorpaena porcus* et *Zeus faber* a permis de conclure à la sédentarité de ces espèces. Les poissons étudiés montrent une stratégie adaptative du régime alimentaire selon les proies disponibles.

Conclusion

Bien que ponctuelle, notre étude a contribué à l'évaluation du projet de réhabilitation écologique du lac sud de Tunis. Le vide biologique correspondant à la fin des travaux a permis le passage brutal d'une biocœnose L.E.E typique à une biocœnose originale du type estuarien. Si les peuplements ichtyologiques actuels semblent dans leur majorité s'être progressivement installés avec succès peut-on dire pour autant que ces communautés ont aujourd'hui atteint leur point d'équilibre ? Il ne semble pas que cela soit encore le cas.

Références

1- Quignard J.P. et Zaouali J., 1981. Les lagunes periméditerranéennes. Bibliographie ichtyologique annotée. 2ème partie : Les étangs français de Canet à Thau. *Bull. Off. Natn. Pêch.* Tunisie, 5(1): 41-96.

2- Ben Souissi J., 2002. Impact de la pollution sur les communautés macrobenthiques du lac sud de Tunis avant sa restauration environnementale. Thèse. Doctorat Fac. Sci. de Tunis: 278 p.

3- Groupement Concept-Fresenius-Consult, 1997. Etude d'observation de la qualité des eaux du complexe Lac sud. Port de Tunis. Canal de navigation. Rapp. d'avancement trimestriel n°4, (Tome 1), SEPTS : 134–147.

4- Ben Souissi J., Rezig M. et Zaouali J., 2003. Appearance of invasive species in the southern lake of Tunis. Proceedings of Sixth International Conference on the Mediterranean Coastal Environment. Vol. 2: 911-922.

5- Capapé C., Zaouali J., Radujkovic B. and Quignard J.P., 2001. Observations on the Elasmobranches fishes from the lagoon of Bibans (Southern Tunisia, Central Mediterranean). *Rapp. Comm. int. Mer Médit.*, 36: 366.

A NEW HOST-PARASITE ASSOCIATION FROM THE LEVANTINE BASIN BATHYAL ZONE

Tammy Horton [1], Arik Diamant [2] and Bella Galil [3] *

[1] Southampton Oceanography Centre, Southampton, UK - txh@soc.soton.ac.uk
[2] National Center for Mariculture, Israel Oceanographic and Limnological Research, Elat, Israel - diamant@agri.huji.ac.il
[3] National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel - * bella@ocean.org.il

Abstract

A new species of a buccal-inhabiting isopod parasite was identified in the shortnose greeneye, *Chlorophthalmus agassizi*, collected on the upper slope off the southern coast of Israel, Levantine Basin. Infection rate, at 33%, is relatively high considering it is based on free-living populations in the open sea.

Key words: Fish ectoparasite, Cymothoidae, Ceratothoa, Chlorophthalmus agassizi

Cymothoids are ectoparasites of marine, fresh, and brackish water teleost fish. They are known to parasitise many families and numerous species of fish, including many of commercial importance, especially in tropical/subtropical regions (1).

In May 2003, a survey of the demersal fauna of the upper slope (300-400 m depth) off the southern coast of Israel (32°N 34°2E), revealed the presence of buccal inhabiting isopod parasites in the shortnose greeneye, *Chlorophthalmus agassizi* Bonaparte, 1840. Further research has confirmed that these isopods constitute a new species of cymothoid, which is currently being described, and that *Chlorophthalmus agassizi* is a new host record for cymothoid isopods. Marine cymothoids are almost exclusively inhabitants of shallow waters, few being known from bathyal depths (1) and the discovery of a cymothoid species confined to deeper waters is unusual. The host species *Chlorophthalmus agassizi* is a circumglobal bathydemersal fish frequently found in large schools on the continental shelf and upper slope, on mud and clay bottoms, including the Mediterranean coast of Israel (2, 3). This species has little or no commercial value, but is an important forage fish for larger predators.

The new cymothoid species can be distinguished from other species in the genus by a combination of characters but most closely resembles *Ceratothoa steindachneri*. The differentiating characters of the new *Ceratothoa* species, and other accounts of infection from museum collections will be presented.

Though cymothoid infestation levels are known to vary for a given host species and locality, and occurrence of infested fishes is extremely patchy (1, 5), the prevalence of infection we observed, as high as 33% in one of the trawls (N=163), is relatively high considering it is based on free-living populations in the open sea. Higher rates of infestation have been recorded in wild fish populations from enclosed bays and lagoons (4), or those raised in aquaculture (6-8).

References

1 - Brusca R.C., 1981. A monograph on the Isopoda Cymothoidae (Crustacea) of the Eastern Pacific. *Zool. J. Linn. Soc.*, 73: 117-199.
2 - Merret N.R., 1990. Chlorophthalmidae. Pp. 351-360. *In*: Quero J.C., Hureau J.C., Karrer C., Post A. and Saldanha, L., (eds.), Check-list of the fishes of the eastern Tropical Atlantic (CLOFETA). JNICT, Lisbon; SEI, Paris; and UNESCO, Paris. Vol. 1.
3 - Galil B.S., and Goren M., 1994. The deep sea Levantine fauna – new records and rare occurrences. *Sencken. Marit.*, 25(1/3): 41-52.
4 - Bragoni G., Romestand B., and Trilles J.P., 1984. Parasitoses à cymothoadien chez le loup *Dicentrarchus labrax* (Linnaeus, 1758) en élevage I. Écologie parasitaire dans le cas de l'étang de Diana (Haute-Corse) (Isopoda Cymothoidae). *Crustaceana*, 47: 44-51.
5 - Horton T., and Okamura B., 2002. The distribution of *Ceratothoa steindachneri* (Crustacea: Isopoda: Cymothoidae) parasitic in *Echiichthys vipera* in the north-east Atlantic. *J. Mar. Biol. Assoc. UK*, 82: 415-417.
6. Horton T., and Okamura B., 2001. Cymothoid isopod parasites in aquaculture: a review and case study of a Turkish sea bass (*Dicentrarchus labrax*) and sea bream
(*Sparus auratus*) farm. *Diseases of Aquatic Organisms*, 46: 181-188.
7 - Sievers G., Lobos C., Inostroza R., and Ernst S., 1996. The effect of the isopod parasite *Ceratothoa gaudichaudii* on the body weight of farmed *Salmo salar* in southern Chile. *Aquaculture*, 143: 1-6.
8 - Šarušic G, 1999. Preliminary report of infestation by isopod *Ceratothoa oestroides* (Risso, 1826) in marine cultured fish. *Bull. Eur. Assoc. Fish. Pathol.*, 19: 110-112.

BENTHIC FORAMINIFERA DYNAMICS IN RESPONSE TO NATURAL AND MAN-MADE EUTROPHICATION IN THE OLIGOTROPHIC SOUTHEAST MEDITERRANEAN SHELF

Hyams O. [1, 2 *], Almogi-Labin A. [3], Benjamini C. [1] and Herut B. [2]

[1] Department of Geology and Environmental Sciences, Ben Gurion University of the Negev, - Israel - * orith@ocean.org.il
[2] Israel Oceanographic & Limnological Research, National Institute of Oceanography, Haifa, Israel
[3] Geological Survey of Israel, Jerusalem, Israel

Abstract

Total standing stocks (TSS), simple diversity and in-sediment distribution depth of living benthic foraminifera vary remarkably along the eastern Mediterranean inner shelf, tracking the trajectory of eutrophication, from naturally oligotrophic to man-made hyper-eutrophic ecosystem. While the oligotrophic environments show high seasonality, TSS and biodiversity, the anthropogenically eutrophic environments show small seasonal variations and low to moderate TSS and simple diversity values.

Key words: Southeastern Mediterranean, benthic foraminifera, eutrophication

Introduction

The continental shelf of the southeastern Mediterranean is dominated by recycled Nile delta sediment input from the south, falling off northwards. This reduced sediment flux is coupled to low natural nutrient input, making the Levant shelf a most oligotrophic shallow water environment (1, 2). During the last decades, however, it is subjected to natural as well as man-made eutrophication influences tracking the full range of trophic levels. This makes it a unique area to study the impact of eutrophication processes on living benthic foraminifera. This group is most abundant and diverse in the Israeli shallow shelf (3), and is known to respond to environmental factors, e.g. food supply and oxygen levels.

The present study aims to record the response of benthic foraminifera to changes in seasonality and trophic levels in the inner shelf of the southeastern Mediterranean. This will be done using benthic foraminifera as sensitive tracers of the natural and man-made interference. For this, a comparison is performed between 4 sites along the Israeli coast varying between oligotrophic and hyper-eutrophic conditions. The southernmost station is probably within the permanently nutrient enriched Nile cell (post the high Aswan dam, 1965) while the stations to the north represent both natural and local point source pollution.

Material and Methods

Three permanent stations were sampled during winter and spring 2003 in the southern part of the Israeli coast: AS1, off Ashqelon at 33m; PL3 and PL29, off Palmahim, at 38 and 36m, respectively. A fourth station S1 at 40m, off Bet-Yannai, was studied during 1996-1998, and was used for comparison. These sites are situated from south to north along the known gradient of sediment and nutrient supply reflecting increasing distance from the Nile sources with the exception of the Palmahim PL3 site located amid this transect. PL3 is situated 200m north to a sewage sludge outlet ("Shafdan" domestic sewage treatment plant) being the most hyper-eutrophic station, with the highest supply of organic matter. PL29 is located 4.5km north to the sludge outlet and is a relatively clean station. AS1, located ~27km southern to Palmahim stations, represents the site most proximal to the recycled nilotic nutrients' source while S1 located 50km northern to Palmahim represents the natural highly oligotrophic environment (4).

Water column properties as temperature, salinity, turbidity, pH and dissolved oxygen were determined *in-situ* using YSI 6000. Water for nutrients and chlorophyll-a (Chl-a) was sampled from the sea surface and above the sea floor using Niskin bottles. At each sampling site sub-cores were taken from a box corer for foraminiferal reconnaissance and chemical analyses. The sub-cores were sliced immediately on board into 0.5 or 1cm thick layers and stored in Rose Bengal-ethanol solution. The oxygen content in the sediment was measured immediately on board with oxygen-needle-electrodes (micromanipulator). The Chl-a content, of the top sediment 0.5cm, was determined using spectrophotometer after lyophilization and acetone extraction. In the lab, Rose-Bengal stained benthic foraminifera from the 63-2000μm size-fraction were picked and counted. The data on the benthic foraminifera refers to the top 5cm of the sediment.

Results and Discussion

Density, diversity and in-sediment distribution varies considerably between the three studied sites. In general the TSS varies between 100 and 1300 specimens/10cc and simple diversity varies between 22 and 76 species/site. The in-sediment living depth varies between top 2 to top 10cm while the average living depth (ALD, cf. 5) is changing between 0.4 and 2cm.

The benthic foraminiferal census data shows two ecologically distinct groups. The first group includes sites PL29 and S1 which reflect the healthy natural oligotrophic southeastern Mediterranean inner shelf conditions. The other group includes sites AS1 and PL3 that primarily reflect mesotrophic and hyper-eutrophic conditions attributed to man-made interventions.

Oligotrophic southeastern Mediterranean - The first group is characterized by large seasonal variation in TSS, high diversity, ventilated sediments down to 2.0 cm and relatively low content of Chl-a. The average TSS in PL29 is 890±260 (Std. Error of the Mean) with high TSS of 800-1000 specimens/10cc during spring in both sites. Species richness is high, with up to 76 species/site in PL29 (on average 67±9). Living foraminifera are found down to 10cm in PL29 with ALD of 2.7cm. Chl-a of 0.1μg/g occurred during winter, increasing to 1.7μg/g during early spring.

Anthropogenically eutrophic southeastern Mediterranean - Sites PL3 and AS1 are characterized by small seasonal variations and low to moderate TSS and simple diversity values. The TSS in the hyper-eutrophic PL3 is low with 134±21 specimens/10cc. The simple diversity is 25±1 species/site, and the in-sediment habitat depth is restricted to the top 2cm, as also reflected by the 0.4cm ALD. In AS1 the TSS and simple diversity is somewhat higher with 257±42 specimens/10cc, and 53±3 species/site. The in-sediment depth range is 2-5cm as is also reflected by the shallow ALD of 0.5cm.

Periodic anoxia alternating with periods of oxygen penetration down to 0.9cm occurred in PL3. Chl-a in the top sediment varies seasonally between 0.2μg/g dry wt. during winter overturn and 10.6μg/g during early spring with the initiation of water column stratification. In site AS1 the sediments are ventilated down to 0.5-2cm and Chl-a varies between 0.7μg/g during winter and 3.2μg/g during early spring.

The increasing nutrient load due to man-made intervention, of sewage disposal (PL3) or of the permanently nutrient enriched Nile water (AS1), shows a dramatic impact on the ecologically sensitive benthic foraminiferal group in the otherwise oligotrophic southeastern Mediterranean shelf. It considerably reduces the seasonal variability, causing moderate to sharp decline in species richness whereas in natural undisturbed regions it is much higher. It also causes a marked decrease in TSS as compared with healthy regions. It reduces sharply the living zone of the benthic foraminifera, often to the topmost sediment layer, occasionally causing the temporary disappearance of the group.

References

1 - Yacobi Y.Z., Zohary T., Kress N., Hecht A., Robarts R.D., Waiser M., Wood A.M., and Li W.K.W., 1995. Chlorophyll distribution throughout the southeastern Mediterranean in relation to the physical structure of the water mass. *J. Mar. Systems*, 6: 179-190.

2 - Herut B., Almogi-Labin A., Jannink N.T., and Gertman I., 2000. The seasonal dynamics of nutrient and chlorophyll a concentrations on the SE Mediterranean shelf-slope. *Oceanol. Acta*, 23: 771-782.

3 - Hyams O., 2000. Benthic foraminifera from the Mediterranean inner shelf, Israel. M.Sc. thesis (In Hebrew, English abstract), Ben-Gurion University of the Negev, 228 p.

4 - Jannink N.T., 2001. Seasonality, biodiversity and microhabitats in benthic foraminiferal communities. *Geologica Ultraiectina*, 203, 192 pp.

5 - Jorissen F.J., de Stigter H.C., and Widmark J.G.V., 1995. A conceptual model explaining benthic foraminiferal microhabitats. *Mar. Micropaleont.*, 26: 3-15.

MICROPHYTOPLANKTON IN TWO EASTERN ADRIATIC ESTUARIES

Nenad Jasprica * and Marina Carić

Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik, Croatia - * jasprica@labdu.izor.hr

Abstract

Microphytoplankton (MICRO) composition and abundance, including environmental factor measurements, were investigated in two southeastern Adriatic estuaries. The MICRO communities in estuaries are of marine origin. Diatoms and dinoflagellates were the most important MICRO constituents. The main feature of MICRO assemblages is the simultaneous dominance of more than one species. The reason for this can be found in the very frequent and rapid changes of environmental conditions in these dynamic ecosystems.

Keywords: microphytoplankton, estuaries, southeastern Adriatic

Field-oriented research, including microphytoplankton (MICRO, cells >20 µm) composition and abundance, and environmental factor measurements, were carried out at fixed stations in the two estuaries in 1999 and 2000. Water samples were collected at the Vlaška station (43° 03' N, 17° 29' E, 10 m max. depth) in the Neretva River estuary (NRE), and at the Ombla-2 station (42° 41' N, 18° 07' E, 15 m max. depth) in the Ombla River estuary (ORE).

The estuaries of the Neretva River and the Ombla River are situated in the Middle Adriatic and the South Adriatic, respectively. Both of them are highly stratified and low tidal (25 cm average daily amplitude) estuaries. The Neretva River and the Ombla River are 22.3 and 4 km long, respectively. The annual average flow of the Neretva River and the Ombla River is 414 $m^3 s^{-1}$ and 26 $m^3 s^{-1}$, respectively.

Water samples were taken using 5 L Niskin bottles from the surface to bottom at each meter depth in the NRE. In the ORE, samples were taken at depths of 0.5, 2, 4, 6, 10, and 15 meters. Samples were collected at monthly intervals. Physical-chemical parameters and MICRO cells were determined using standard oceanographic methods.

The aim of the present study was to investigate the physical-chemical conditions in the water column and to determine the dominant MICRO taxa in these estuaries.

Water column stratification was found throughout the year in both estuaries. A sharp halocline was situated frequently at 2-4 m depths. The whole column water was well aerated in the ORE, since hypoxia or anoxia was noticed below eight meters in the NRE. Euphotic layer in both estuaries decreased in the summer-autumn period. The concentration of all measured nutrients in the NRE were from 1.9 (NO_3) to 10.1 (PO_4) times higher than in the ORE. MICRO abundance oscillated in the NRE and ORE in four and three orders of magnitude, respectively (Fig. 1).

Diatoms and dinoflagellates were the most important MICRO constituents in both estuaries. Diatoms dominated the MICRO abundance throughout the year in the NRE (49-99%), but dinoflagellates caused outbursts of growth in September 1999. On the other hand, dinoflagellates were dominant (31-88%) group in the ORE, except in November 1999, March and November 2000, when diatoms were prevailed.

Two or three peaks of MICRO were observed throughout the year (Fig. 1). The first peak in the NRE (in April 1999) was reflected in the intensive development of diatoms (78% of MICRO, *Thalassiosira* sp., *Cerataulina pelagica*, *Chaetoceros compressus*, *Ch. curvisetus*, *Hemiaulus hauckii* and *Leptocylindrus danicus*). During the second peak (August-September 1999), *Nitzschia longissima* and *Scrippsiella trochoidea* were the most abundant species (>10^6 cells L^{-1}). *Cyclotella* sp. and *Ceratium fusus* showed a 94% contribution to the MICRO abundance at the third peak in April 2000.

In the ORE, the spring peak (in April 2000) was mostly made up (85% of MICRO abundance) of *Calyptrosphaera oblonga* and *Scrippsiella trochoidea*. During the second peak (June-August 2000), the greatest number of species with an abundance greater than 10^3 cells L^{-1} were identified. They are as follows: *Eutreptia lanowii*, *Scrippsiella trochoidea* (>10^4 cells L^{-1}), *Chaetoceros* spp., *Nitzschia longissima*, *Gonyaulax* sp., *Prorocentrum triestinum*, *Gyrodinium fusiforme* and *Protoperidinium tubum*.

The MICRO communities in estuaries are of marine origin. The surface layer showed some fresh and brackish water taxa (*Asterionella formosa*, *Fragillaria crotonensis* and others), but they were present at background levels. The main feature of MICRO assemblages is the simultaneous dominance of more than one species. The reason for this can be found in the very frequent and rapid changes of environmental conditions in these dynamic ecosystems. In the ORE, neritic species are more frequent due to the direct inflow of deep southern Adriatic waters. Our studies stress the important role of nutrients in the MICRO structure. However, not only the quantity, but also the quality of nutrients may influence MICRO composition. Different MICRO species can exploit nutrient sources with varying capabilities and different nitrogen sources may selectively stimulate the development algal species (1).

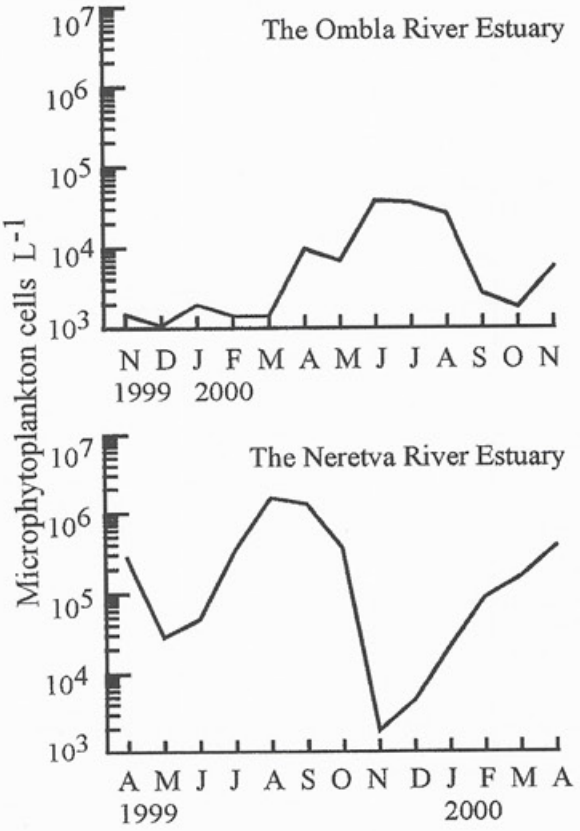


Fig. 1. Microphytoplankton abundance in the estuaries (values are expressed as water column mean).

References

1 - Berman T. and Chava, S., 1999. Algal growth on organic compounds as nitrogen sources. *J. Plankton Res.*, 21: 1423-1437.

THE PARTICULATE ß-DIMETHYLSULPHONIOPROPIONATE (DMSP) LEVELS IN RELATION TO PHYTOPLANKTON SPECIES DURING A SPRING BLOOM IN TOULON BAY (FRANCE)

Natacha Jean [1], Jean-Louis Jamet [2] *, Gérard Boge [2] and Dominique Jamet [2]

[1] CNAM / Intechmer E.A 3202 "Environnements Marins Naturels et Contrôlés", Cherbourg France

[2] Université de Toulon et du Var, Equipe de Biologie des Milieux Aquatiques, EBMA, Laboratoire des Processus de Transferts et d'Echanges En Environnement, EA, La garde, France - * jamet@univ-tln.fr, boge@univ-tln.fr, d.jamet@univ-tln.fr

Abstract

This work investigated the origin of particulate DMSP in a Mediterranean ecosystem perturbed by anthropogenic inputs (Toulon bay, France). We studied the contribution of phytoplankton species to DMSP levels. Dinoflagellates were always predominant in comparison to Bacillariophyceae and peaked in March-April. The intracellular concentrations of DMSP revealed that Dinoflagellates contained about five times more DMSP than Bacillariophyceae. *Alexandrium minutum* produced up to 56% of the DMSP pool. We suggest that the production of the nitrogenous toxin by *Alexandrium minutum* may explains its high levels of DMSP synthesis.

Keywords : DMSP; Alexandrium minutum; eutrophication; coastal ecosystem; mediterranean sea

Dimethylsulphide (DMS) is the most abundant form of volatile sulphur in the ocean and is produced by the enzymatic cleavage of ß-dimethylsulphoniopropionate (DMSP), which is abundant in phytoplankton (1). It is accepted that DMSP is an osmolyte and a cryoprotectant for marine algae (2).

We have studied particulate DMSP in Toulon Bay for the size class 5-90 µm to show the contribution of phytoplankton species to DMSP levels in this perturbed and eutrophic littoral marine ecosystem. Protein concentrations were used to determine the biomass. To compare the phytoplankton activity with DMSP synthesis, the DMSP/protein ratio was calculated.

The temporal evolution showed three peaks (March, June and September, Fig. 1). The March peak corresponded to the highest total level of DMSP synthesis (0.58 nanomoles DMSP.µg-1). The 5–90 µm size class was principally composed of algal cells belonging to the Dinoflagellates or to the Bacillariophyceae. Dinoflagellate biomass and abundance peaked in March-April, whereas Bacillariophyceae biomass and abundance peaked in October-November. No relationship ($p > 0.1$, Spearman test) was found between Bacillariophyceae biomass and the DMSP concentration, whereas a significant correlation was observed between Dinoflagellate biomass and DMSP concentration ($r = 0.699$; $p = 0.011$). We have separated Bacillariophyceae and Dinoflagellates out of seawater to determine their respective contributions to DMSP production. Comparison of the intracellular concentrations of DMSP in the two samples revealed that Dinoflagellates contained about five times more DMSP than Bacillariophyceae (Table 1). These results highlight the importance of Dinoflagellates and the minor contribution of Bacillariophyceae in DMSP production. We had also identify the species implicated in DMSP synthesis. The peaks of biomass were consistent with peak of DMSP above all for *Alexandrium minutum* (Fig. 1). Five monospecific samples were prepared and analysed for DMSP contents. The intracellular content per unit of biovolume was highest in *A. minutum* (Table 1).

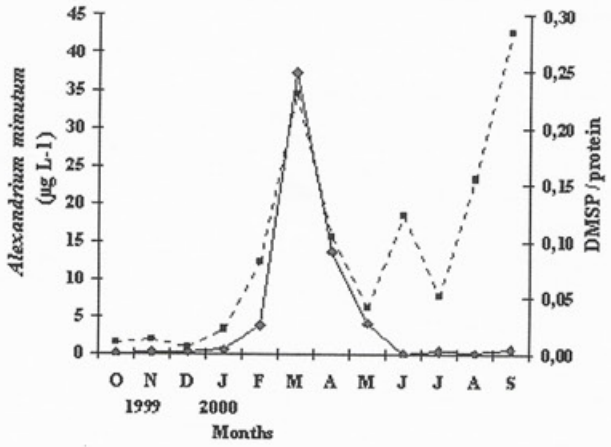


Fig. 1. Relationships between the DMSP / protein ratio (black square) and the *Alexandrium minutum* biomass (grey diamond).

Our results suggest that the semi-enclosed configuration of Toulon Bay and its exposure to high levels of human activity could lead to stronger productivity involving high concentrations of DMSP. This hypothesis is in accordance with (3). In addition, it is generally accepted that Prymnesiophytes and Dinoflagellates produce more DMSP than Bacillariophyceae. (4) measured similar values in Dinoflagellates (355 to 972 mM). *A. minutum* produce toxins such as PSP (paralytic shellfish poison) and DSP (diarrheic shellfish poison) (5) and grows better in nitrogen-rich ecosystems. This specific nitrogen requirement could be due to the production of nitrogenous precursor of the PSP, called saxitoxin (STX) (6). In the osmoregulation in algal cells, two compounds could be produced (DMSP or Glycine betaine, GBT). The production of GBT require high nitrogen levels. In Toulon Bay, high DMSP levels have been found in *A. minutum* suggesting the preferential synthesis of DMSP rather than GBT. This suggests that the nitrogen requirement of *A. minutum* was not totally fulfilled in spite of the high nitrate levels.

Table 1. Intracellular concentrations of DMSP in phytoplanktonic algae.

Dinoflagellates	**124 +/- 5.7 mM**
Bacillariophyceae	**25.1 +/- 1.1 mM**
Alexandrium minutum	**3387.6 +/- 121.9 mM**

References

1 - Ackman R.G., Tocher C.S., and Mac Lachlan J., 1966. Occurrence of dimethyl-ß-propiothetin in marine phytoplankton. *J. Fish. Res. Bd. Canada,* 23: 357-364.

2 - Karsten U., Wiencke C., and Kirst G.O., 1992. Dimethylsulfoniopropionate (DMSP) accumulation in green macroalgae from polar to temperate regions: interactive effects of light *versus* salinity and light versus temperature. *Polar Biol.*, 12: 603-607.

3 - Niki T., Kunugi M., Kohata K., Otsuki A., 1997. Annual monitoring of DMS-producing bacteria in Tokyo Bay, Japan, in relation to DMSP. *Mar. Ecol. Progr. Ser.*, 156: 17-24.

4 - Belviso S., Christaki U., Vidussi F., Marty J.-C., Vila M., and Delgado M., 2000. Diel variations of the DMSP-to-chlorophyll ratio in Northwestern Mediterranean surface waters. *J. Mar. Syst.*, 25: 119-128.

5 - Lassus P., Arzul G., Erard E., Gentien P., and Marcaillou C., 1995. Phytoplankton time – series data of the French phytoplankton monitoring network: toxic and dominant species. *In*: Belin C., Bellaeff B., Raffin B., Ibanez F., and M. Rabla M. (eds.), Harmful Marine Algal Blooms, Technique et Documentation, Lavoisier, Intercept Ltd.

6 - Premazzi G., and Volterra L., 1993. Microphyte toxins. Joint Research Center Edition, CE, Ispra, 336 p.

ÉTUDE DE L'INTERACTION TORTUE MARINE *CARETTA CARETTA* – CHALUT BENTHIQUE DANS LE GOLFE DE GABÈS (TUNISIE)

Imed Jribi [1], Mohamed Nejmeddine Bradai [2] et Abderrahmen Bouain [1]
Faculté des Sciences de Sfax, Tunisie - * Jribi.Imed@edunet.tn
Institut National des Sciences et Technologies de la Mer (INSTM), Sfax, Tunisie

Résumé
Les tortues marines et en particulier la caouanne *Caretta caretta* entrent en interaction avec la plupart des engins de pêche dans les eaux tunisiennes. L'étude de l'interaction tortue marine – chalut benthique dans le golfe de Gabès montre un taux de capture important évalué à 0,82192±0,24878/sortie en mer. Le nombre total de captures accidentelles a été évalué à 5458±1652/an, la mortalité reste relativement assez faible (182±55/an).

Mots clés : Caretta caretta, Golfe de Gabès, Chalut benthique, Capture accidentelle, Mortalité

Introduction

Dans ce travail, nous contribuons à l'évaluation de l'effet de la pêche au chalut benthique sur *Caretta caretta* dans le golfe de Gabès, une zone présumée comme aire d'alimentation et d'hivernage (1, 3, 4 et 5) en Méditerranée. La pêche au chalut benthique y est très développée et entraîne des captures accidentelles importantes (2). Le but essentiel de ce travail est l'estimation des taux de captures accidentelles, de la capture totale et de la mortalité.

Matériel et méthodes

La région du golfe de Gabès, au sud-est du pays, représente environ 750km, soit 58% des côtes tunisiennes. C'est la zone de pêche maritime numéro 1 de la Tunisie avec 65% de la flottille chalutière, soit 270 unités, rattachée aux différents ports de cette région. Au cours de ce travail effectué en 2001 et 2002, nous avons travaillé à bord de 4 chalutiers rattachés au port de Sfax. Nous avons effectué 73 sorties en mer totalisant 497 jours de mer au cours desquels nous avons réalisé 5256 traits de chalut. Nous avons enregistré par ailleurs la position géographique et l'heure des captures, la longueur courbe de la carapace et l'état physique de l'animal à la capture.

Résultats et discussion

Toutes les tortues marines, capturées accidentellement au cours de ce travail, étaient des caouannes *Caretta caretta*. Les tableaux 1 et 2 illustrent respectivement l'effort de pêche déployé et les taux de captures estimés.

En tenant compte du taux de capture calculé et du nombre de sorties réalisées par l'ensemble de la flottille chalutière active dans la région du golfe de Gabès en 2001 et 2002 (6640,5/an), nous estimons le nombre de captures à 5458±1652/an. Ce chiffre, très élevé, serait le plus important en Méditerranée pour la pêche au chalut benthique.

Tableau 1. Effort de pêche déployé en 2001-2002.

Effort de pêche observé			
Période	Sorties	jours	traits
Hiver (déc-fév)	16	121	1256
Printemps (mar-mai)	22	143	1478
Eté (jui-mi-jui)	7	45	476
Automne (sep-nov)	28	188	2046
Total	73	497	5256

Tableau 2. Estimation des taux de capture par chalutage benthique dans la région du golfe de Gabès.

Taux de capture				
Période	tortues	tortues/sortie	tortues/jour	tortues/trait
Hiver	15	0,93750± 0,52076	0,12397± 0,07116	0,01194± 0,00601
Printemps	22	1,00000± 0,51582	0,15385± 0,06824	0,01488± 0,00645
Eté	9	1,28571± 1,33304	0,20000± 0,14741	0,01891± 0,01225
Automne	14	0,5000± 0,23642	0,07447± 0,04043	0,00684± 0,00357
Total	60	0,82192± 0,24878	0,12072± 0,03321	0,01142± 0,00292

L'observation des positions géographiques des points de captures (Fig. 1) montre que la tortue marine peut être capturée à n'importe quel point où les chalutiers sont actifs. Toutefois les zones situées à l'ouest et au nord-est de l'île Djerba peuvent être présumées comme zones de concentration de la tortue marine. Les captures se répartissent sur toute l'année mais diminuent légèrement en automne. Elles concernent surtout les subadultes dont la longueur courbe de la carapace se situe entre 50 et 70cm. Les tortues sont capturées pendant la période froide surtout le jour alors qu'elles sont capturées surtout la nuit pendant la période chaude. Les taux de capture sont plus élevés dans les faibles profondeurs (<50m), zones normalement interdites pour la pêche au chalut benthique.

Les tortues capturées étaient en majeure partie (95%) en bon état physique. Une seule était dans un état comateux (1,67%) et deux étaient mortes (3,33%) à l'ouverture du filet sur le pont. Ceci nous permet d'estimer la mortalité des tortues marines dans la région du golfe de Gabès à 182±55/an.

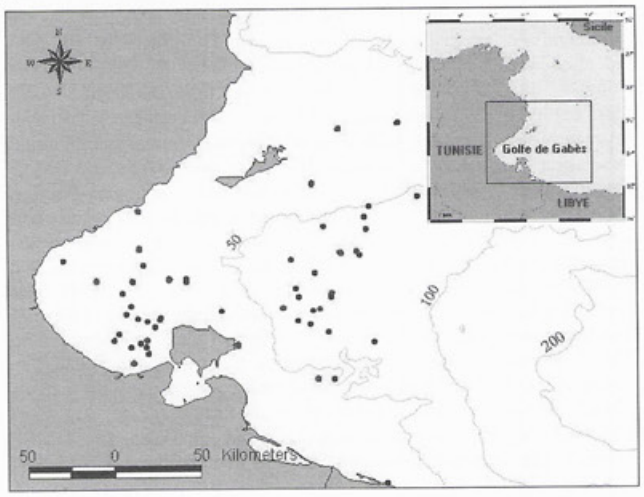


Fig.1. Zone de concentration des captures accidentelles dans le golfe de Gabès.

Conclusion

Malgré l'importance des captures, la mortalité est relativement faible suite probablement à la courte durée des traits de chalut. Ces captures accidentelles paraissent de loin plus importantes que celles enregistrées il y a une dizaine d'années (2 et 5) témoignant des efforts de conservation déployés dans la région.

Références

1 - Aragano R., Basso R., Cocco M., Gerosa G., 1992. Nuovi dati sugli spostamenti di Tartaruga marina comune (*Caretta caretta*) in Mediterraneo. *Boll. Mus. Ist. Univ. Genova*, 56 - 57: 137 - 164.
2 - Bradai M.N., 1992. Les captures accidentelles de *Caretta caretta* au chalut benthique dans le golfe de Gabès. *Rapp. Comm. int. Mer Medit.*, 33 (1) : 285.
3 - Gerosa G., Casale P., 1999. Interaction of marine turtles with fisheries in the Mediterranean. *UNEP (RAC/SPA)* : 59 p.
4 - Laurent L., Nouira S., Jeudy De Grissac A., Bradai M.N., 1990. Les tortues marines de Tunisie : *Premières données. Bull. Soc. Herp. Fr.* 53 : 1-17.
5 - Laurent L., Lescure J., 1994. L'hivernage des tortues caouannes *Caretta caretta* dans le Sud tunisien. *Revue d'Ecologie (Terre vie)* 49 : 63 - 86.

COMPOSITION OF THE EPIBIOTIC ASSEMBLAGE ASSOCIATED WITH *CARETTA CARETTA* (LINNAEUS, 1758)

Kitsos M.-S. [1] *, Christodoulou M. [1], Arvanitidis Ch. [2], Mavidis M. [1], Kirmitzoglou I. [1], Koukouras A. [1]

[1] Department of Zoology, School of Biology, Aristoteleio University of Thessaloniki, Greece - * akoukour@bio.auth.gr

[2] Institute of Marine Biology of Crete, Iraklio, Crete, Greece

Abstract

Thirty-seven loggerhead turtles washed ashore in northern Greece were sampled. A total of 63 macrobenthic species and 17 species of algae were identified from the material of which 47 macrobenthic species and 13 species of algae are reported for the first time as epibionts of the loggerhead turtle.

Key words: Caretta caretta, epibionts

Introduction

The existing information on the composition of the assemblage associated with *Caretta caretta,* is little known and limited to a rather small number of papers (1-6). The aim of this study is to give new information on the composition of the assemblage associated with the loggerhead turtle.

Materials and Methods

Thirty-seven, loggerhead turtles washed ashore from April 2000 to January 2003 in the northern Aegean Sea were sampled. All epibionts were carefully removed from various parts of the turtle's body and their position recorded. In the laboratory all specimens were identified and counted.

Results and Discussion

The analysis of the collected material revealed the presence, of 63 macrobenthic species (4.824 individuals) as well as the presence of 17 species of algae.

Annelida was the most dominant taxonomic group with 31 species (Fig. 1). Only two previous studies have reported species of Annelida as epibionts of *Caretta caretta* (2, 3). Among Annelida, Polychaeta are represented by the highest percentage (34%; 27 species). Twenty-five of these species are reported for the first time as epibionts of *Caretta caretta*. Oligochaeta and Hirudinea were represented by 3 and 1 species respectively. This is the first time Oligochaeta are reported as epibionts of *Caretta caretta*.

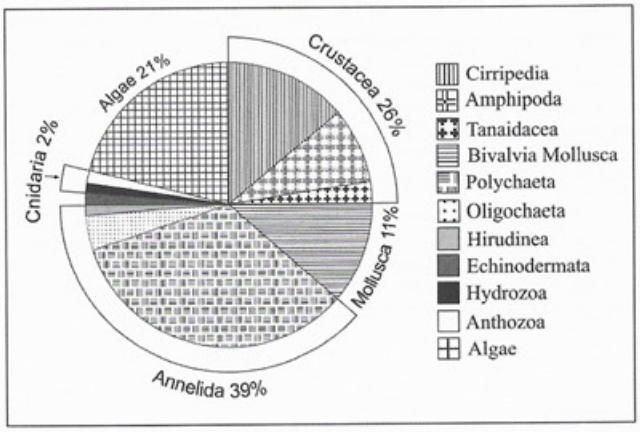


Fig. 1. Participation percentages of the various taxonomic groups in the assemblage associated with *Caretta caretta*.

Crustacea are second in species number (20 species). However, in previous studies this group was reported as the most dominant (2, 3). Among Crustacea, Cirripedia Thoracica had the highest percentage (14%; 11 species). Amphipoda and Tanaidacea were represented by 7 and 2 species respectively. The amphipod *Caprella andrae* Mayer, 1890 was the most abundant species. The tanaidacean *Leptochelia savignyi* (Krøyer, 1842) is reported for the first time as an epibiont of *C. caretta*.

The most abundant species of algae was *Cladophora prolifera* (Roth) Kützing. Of the 17 species found, 13 are reported for the first time as epibionts of *C. caretta*.

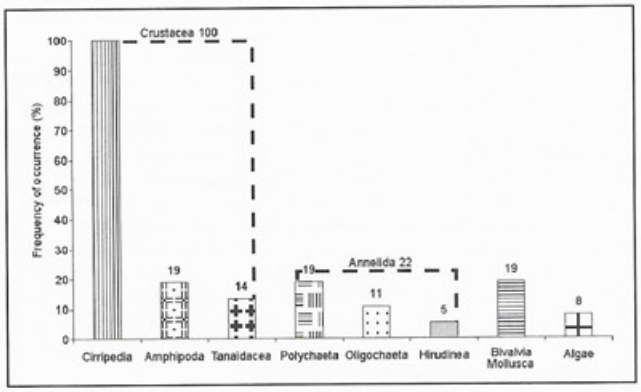


Fig. 2. Frequency of occurrence of the main taxonomic groups of the epibionts of *Caretta caretta*.

Concerning Bivalvia Mollusca (9 species), with the exception of *Ostrea edulis* (Linnaeus, 1758), all other species found, are reported for the first time as epibionts of *C. caretta*.

Crustacea had the highest frequency of occurrence (100%) (Fig. 2) due to the very high value (100%) of the thoracican cirriped *Chelonibia testudinaria* (Linnaeus, 1758). This species has been reported as the most frequent epibiont of the loggerhead turtle (2, 3, 5, 9). The group of Annelida were second, with Polychaeta having the highest percentage. Bivalvia Mollusca had the same frequency percentage with Polychaeta while algae had a low frequency percentage.

Most of the species found, were attached on the peripheral plates of the upper part of the turtle's carapace, while all algae were mainly found in the anterior and posterior part of the upper surface of the carapace.

Concerning the biogeography of all the epibiont species found, 60% are cosmopolitan 31% are Atlanto-Mediterranean and only 9% are endemics. The high percentage of cosmopolitan species should be attributed to the migratory habits of *Caretta caretta*.

References

1 - Frazier, J., D. Margaritoulis, K. Muldoon, C.W. Potter, J. Rosewater, C. Ruckdeschel, S. Salas, 1985. Epizoan communities on marine turtles. I. Bivalve and gastropod mollusks. *Pubbl. Staz. zool. Napoli, (I., Marine ecology),* 6(2): 127-140.

2 - Caine, E.A., 1986. Carapace epibionts of nesting loggerhead sea turtles: Atlantic coast of U.S.A. *Journ. exp. mar. Biol. Ecol.,* 95: 15-26.

3 - Frick, M.G., K.L. Williams, M. Robinson, 1998. Epibionts associated with nesting loggerhead sea turtles (*Caretta caretta*) in Georgia, U.S.A. *Herpetol. Rev.,* 29(4): 211-214.

4 - Abel Sentúes, G., J. Espinoza-Avalos, J.C. Zurita, 1999. Epizoic algae of nesting sea turtles Caretta caretta (L.) and Chelonia mydas (L.) from the Mexican Caribbean. *Bull. Mar. Sci.,* 64(1): 185-188.

5 - Gramentz, D., 1988. Prevalent epibiont sites on Caretta caretta in the Mediterranean Sea. *Naturalista sicil.*, IV, XII (1-2): 33-46.

6 - Kitsos, M.- S., M. Christodoulou, S. Kalpakis, M. Noidou, A. Koukouras, 2003. Cirripedia Thoracica associated with Caretta caretta (Linnaeus, 1758) in the Northern Aegean Sea. *Crustaceana,* 76(4): 403-409.

REPRODUCTIVE BIOLOGY OF A THREATENED REEF-BUILDING VERMETID (MOLLUSCA, GASTROPODA) OFF THE COAST OF ISRAEL

A. Klerman, M. Fine [2] and B. S. Galil [*]

[1] National Institute of Oceanography, Israel Oceanographic and Limnological Research, Haifa, Israel
[2] University of Haifa-Oranim, Israel and Centre for Marine Studies, University of Queensland, Australia

Abstract

The *Dendropoma* reefs off the coast of Israel have been decimated over the past 30 years. As part of a research to elucidate the causes of decline, we studied the reproductive biology of *D. petraeum*. Spermatogenesis was detected as early as December, and reproductive activity ceased in July. Females brooded 1-30 egg capsules in their mantle cavity. The pace of reproductive activity differed between the fore- and back reef populations, and between the two sites studied. The females' reproductive period is shorter and the number of egg capsules is smaller than in the *Dendropoma* populations off Spain.

Key words: Vermetid reef, endangered, reproduction biology

Vermetids are sessile gastropods distributed in tropical and subtropical seas. Of the nine species of vermetids known from the Mediterranean, two are reef-building, *Vermetus triqueter* Bivona-Bernardi, 1832, and *Dendropoma petraeum* (Monterosato, 1892) (1). *Dendropoma petraeum*, protected by a thick shell and a close fitting operculum, inhabits the surf-beaten raised edges of the reefs. Living *D. petraeum* reefs have been described from rocky shores in the southern Mediterranean from Gibraltar Straits and southeastern Spain to the Levantine Basin (2-4). The importance of the reefs lies in being the core intertidal rocky habitat, in their rarity, and in physically protecting the shoreline from erosion. *Dendropoma petraeum* have been recently recognized as a threatened species in need of protection (5) as the reefs' location, at the meso- and infralittoral, places them at risk from coastal development and pollution.

Off the coast of Israel vermetid reefs were studied in the 1960s (2), and 1970s (6). We have recently revisited those locations to study their current status and reproductive capacity. Digital photography was used to analyze the state of the reefs. We found that only the reefs between Dor and Shikmona have retained relatively dense living populations, while most other sites are in progressive stages of demise. The once extensive reefs off Acre were destroyed by urban development, the reefs of Akhziv- Shavei Zion – Rosh-Hanikra, even at a distance of 1000 m from the shoreline, have been overgrown by algae flourishing on sewage and organic wastes from nearshore outfalls. At Mikhmoret, where platform rims were composed of 30% living vermetids 30 years ago (7), they were found in the present study to retain barely 1% living individuals. However, we found deeper-living *Dendropoma* clusters (30-150 cm below MSL) even where the rim populations were nearly extinct, like at Mikhmoret.

To gauge the reproductive state of the surviving populations we studied the (a) reproductive cycle, (b) the number and size of egg capsules produced, and (c) the number and range of embryonic stages per capsule at two locations, Atlit (32°41N 34°55E) and Shikmona (32°49N 34°57E), 30 kms apart.

Specimens were collected monthly from December 2002 to August 2003 from several sites at each location and transported alive to the laboratory. Some specimens were preserved in Bouin for histological studies, others were studied *in vivo* and some were preserved in 10% buffered formalin. A total of 124 specimens were dissected, and 625 capsules were measured and their contents carefully examined. The number of capsules observed in the brooding females examined ranged from 1 to 30, with only 13 of the 122 females having more than 10 capsules at one time. The number of eggs/embryos per capsule ranged from an average of 1.4 to 4.7, and the size of the egg capsules varied from 0.54 to 1.32 mm in length, (mean= 0.97 ±0.14); N= 709. The populations examined exhibited a discrete reproductive cycle lasting from December to June. Active spermatogenesis was observed as early as December, whereas active oogenesis was not observed till March. Of the 284 capsules collected in March and April over half contained unsegmented eggs and trochophore larvae, whereas by mid-June over 90% of the 341 capsules examined contained prehatching embryos. A complete cessation of reproductive activity was observed in the summer months. We noted that the reproductive cycle of the population sampled at Atlit lagged slightly behind Shikmona's, and that at the latter site, capsules from females collected in April on the fore reef contained more early stages (eggs and trochophore larvae), than capsules from females collected on the back reef (52% vs. 44%).

Comparison with the reproductive biology of *D. petraeum* off south-eastern coast of Spain (3) reveals remarkable differences between the populations: the reproductive period is shorter in Israel with cessation of reproductive activity in July, whereas off Spain some brooding females were found in August and September; the number of simultaneously-brooded capsules per female was much smaller in Israel (mean 5 vs. 25; max. 30 vs. 86); but most capsules contained 2 or more eggs/embryos, and 28 of 625 capsules examined contained more than 5 eggs/embryos, whereas off Spain each capsule usually enclosed a single egg or embryo.

Since dispersal of the larvae is mostly limited to the parental reef, it is entirely possible that the differences observed in their reproductive biology may hint at differing life history characteristics of the two populations separated by the length of the Mediterranean Sea that may have implications for their conservation. Or it may be that the deterioration of the SE Levantine reefs is reflected in their the lower fecundity and shorter reproductive period. It would be most interesting to examine genetic variability in specimens from a number of reef sites across the Mediterranean Sea.

References

1 - Sabelli B., Giannuzzi-Savelli R., and Bedulli D., 1990. Catalogo annotato dei molluschi marini del Mediterraneo. Vol. 1. Libreria Naturalistica Bolognese, Bolgona. 348 p.

2 - Safriel U., 1966. Recent Vermetid formation on the Mediterranean shores of Israel. *Pro. Malac. Soc.*, London, 37: 27-34.

3 - Calvo M., Templado J., and Penchaszadeh P.E., 1998. Reproductive biology of the gregarious Mediterranean vermetid gastropod *Dendropoma petraeum*. *J. Mar. Biol. Ass. U.K.*, 78: 525-549.

4 - Antonioli F., Chemello R., Improta S., and Riggio S., 1999. *Dendropoma* lower intertidal reef formation and their paleoclimatological significance, NW Sicily. *Mar. Geol.*, 161: 155-170.

5 - Scotti G., and Chemello R., 2000. I molluschi marini mediterranei degni di protezione: stato delle conoscenze e forme de tutela. *Boll. Malac.*, 36(1-2): 61-70.

6 - Ben-Elihau M. N., 1975. Polychaete cryptofauna from rims of similar vermetid reefs on the Mediterranean coast of Israel and the Gulf of Elat: Sabellidae (Polychaeta Sedentaria). *Isr. J. Zool.*, 24: 54-70.

7 - Lipkin Y., and Safriel U., 1971. Intertidal zonation on rocky shores at Mikhmoret (Mediterranean, Israel). *J. Ecol.*, 59: 1-30.

DEVELOPMENT OF A COUPLED, 3D HYDRODYNAMICAL-ECOLOGICAL-TERRESTRIAL MODELLING SYSTEM: RESULTS FROM AN APPLICATION TO A SMALL, SEMI-ENCLOSED MEDITERRANEAN GULF

V. Kolovoyiannis, A. Tamvaki, G. Tsirtsis *

Department of Marine Sciences, University of the Aegean, University Hill, Mytilini, Greece - * gtsir@aegean.gr

Abstract

The development and application of a coupled modeling system, along with the first results, are described in this work. The model consists of three interacting components, a hydrodynamic, an ecological and a terrestrial sub-model. High resolution experiments were conducted, using a shallow, semi-enclosed gulf as an implementation area, in order to test the model's behaviour. Driven by realistic forcing, the model reproduced the general circulation patterns accurately, whereas the simulated ecological variables showed reasonably good fit when validated against independent field data. With further development and extensive testing, this model system can become a valuable tool assisting in integrated coastal zone management.

Key-words: coupled model, coastal ecosystem dynamics

Introduction

Within the framework of integrated coastal zone management, a coupled modeling system has been developed. This study has three objectives: the development of a coupling methodology in order to link together a general circulation model with a biochemical model and a terrestrial model, the testing of the simulation capabilities of this modeling system especially in reproducing and quantifying basic ecological processes (flow of matter at the lower trophic levels, nitrogen cycling, microbial loop) and finally, the presentation of the results of the first simulation experiments.

Methodology

Model Description

The model system is made up of three interacting components: (a) a hydrodynamic submodel, a 3 dimensional version of the Princeton Ocean Model (POM) [1], that provides the physical transport fields, (b) a water-column ecological submodel, consisting of seven state variables: nitrate, ammonium, phosphate and dissolved organic nitrogen concentrations, phytoplankton, zooplankton and bacterial biomasses and (c) a terrestrial submodel, that estimates the point and non-point nutrient fluxes to the marine ecosystem due to agricultural run-off.

The source code of the well-known, terrain-following, general circulation model POM was used as a basis for the development of the code of the ecological submodel. The ecological model [2, 3], focuses on the mass – energy flow through the microbial food web and therefore is suitable for studying eutrophication processes. The two models, that run simulaneously, are coupled using the same spatial discretization and the same time step (POM's internal mode time step). The coupled model solves the following general equation:

$$\frac{\partial C}{\partial t} = \underbrace{-u\frac{\partial C}{\partial x} - v\frac{\partial C}{\partial y} - (w + w_s)\frac{\partial C}{\partial z}}_{\text{Advection - Sinking}} + \underbrace{A_h\left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2}\right) + A_z\frac{\partial^2 C}{\partial z^2}}_{\text{Turbulent Diffusion}} + \left.\frac{dC}{dt}\right|_{ECO}$$

that describes the rate of change of the concentration of a non-conservative, ecological variable C in the 3-dimensional space and time. POM calculates the advection – turbulent diffusion part, (calculation of u,v,w velocities and horizontal A_h – vertical A_z diffusivities). The term $\left.\frac{dC}{dt}\right|_{ECO}$ represents the system of finite differential equations of the ecological submodel that simulates the rate of change of C due to biochemical processes [3]. Other characteristics of the ecological submodel are: the user-specified integration scheme (3 schemes are available – Euler, Runge-Kutta 2nd and 4th order), the use of a time step cutting technique in order to avoid unrealistic simulation results (e.g. negative concentrations of biochemical variables) [4], dynamic calculation of the settling velocity w_s of phytoplankton.

In order to estimate the nutrient runoff from non point sources a terrestrial submodel was constructed. The watershed of the test area was divided into unit source areas using a grid of 1x1 km. The surface nutrient runoff was subsequently calculated by applying the SCS Curve number equation [5]. The dissolved fractions of the nutrients nitrate, ammonium, organic nitrogen, phosphates were computed daily with the use of SCS by evaluating the rainfall height, evaportranspiration and drainage losses and by taking into consideration the land use, slope, crop management and soil water content [6]. The predicted amount of the dissolved nutrient runoff was assumed to end up in the marine environment through the main streams of the region.

Description of application

The test area, the gulf of Gera, is a shallow, semi-enclosed gulf in the North-eastern Aegean, Greece, surrounded by an intensively cultivated watershed. High resolution experiments were conducted – a 100x100 m grid with 11 sigma layers was used – attempting to simulate the variation in space and time of the physical, chemical and biological prognostic state variables, under typical winter and summer conditions and during the transitional time period between mixing and stratification and vice versa. The model is driven by realistic forcing: wind stresses, variable surface and open boundary conditions, tidal elevation, solar radiation and nutrient fluxes from agricultural runoff.

Results and Discussion

The general circulation patterns are reproduced quite well, while the simulated biochemical variables showed reasonably good fit when validated, with statistical methods, against independent field data, collected on a monthly basis. The simulation results emphasize the importance of the hydrodynamic-physical processes and mass exchanges between the gulf and the oligotrophic pelagic waters of the Aegean in determining the trophic level of the gulf ecosystem. During the winter period, environmental conditions impose a poor renewal regime, with residence times of up to 2-3 months. Nutrient inputs from terrestrial sources lead to an increase by about 50% of the water column nutrient stock, and, if the physical conditions (light, temperature) are optimum, this can give rise to phytoplanktonic blooms. During summer conditions, the renewal of the gulf waters is more intense and biochemical variables are kept at low levels. This coupled model can be used as an efficient tool in developing an integrated methodology for the sustainable development of the coastal zone.

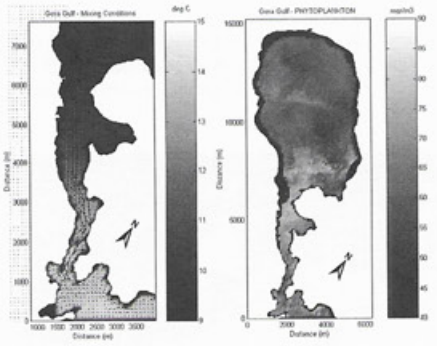


Fig. 1. Distribution of simulated quantities at 5m depth during typical mixing conditions (March): (a) velocity and temperature field and (b) phytoplanktonic carbon.

References

1 - Blumberg A.F., Mellor G.L., 1987. A description of a three-dimensional coastal ocean circulation model. In: N.Heaps (ed.), Three-dimensional Coastal Ocean Models, Vol. 4, American Geophysical Union.

2 - Fasham M.J.R., Ducklow H.W., McKelvie S.M., 1990. A nitrogen-based model of plankton dynamics in the oceanic mixed layer. *J. of Marine Research,* 48: 591-639.

3 - Arhonditsis G., Tsirtsis G., Karydis M., 2002. The effects of episodic rainfall events to the dynamics of coastal marine ecosystems: applications to a semi-enclosed gulf in the Mediterranean Sea. *J. of Marine Systems,* 35: 183-205.

4 - Zavatarelli M., Baretta J.W., Baretta-Bekker J.G., Pinardi N., 2000. The dynamics of the Adriatic Sea ecosystem. An idealized model study. *Deep-Sea Research I,* 47: 937-970.

5 - US Department of Agriculture – Soil Conservation Service, 1972. National Engineering Handbook, Hydrology Section 4. USDA, Washington (Chapters 4-10).

6 - Hawkins R. H. 1978. Runoff curve numbers with varying site moisture. *Journal of the Irrigation and Drainage Division* 104(IR4): 389-398.

INCREASING DOMINANCE OF THE CALYCOPHORAN SIPHONOPHORE *MUGGIAEA ATLANTICA* IN DIFFERENT AREAS OF NORTH-WESTERN MEDITERRANEAN AND ADRIATIC SEA. A POSSIBLE RELATIONSHIP WITH HYDROCLIMATIC CHANGES

Licandro P. [1] *, Albertelli G. [1], Batistic M. [2], Carré C. [3], Daly Yahia M.N. [4], Daly Yahia-Kéfi O. [5], Ibanez F. [3], Petrillo M. [1], Sertorio T. [1], Souissi S. [6]

[1] University of Genoa, Dip.Te.Ris, Genoa, Italy - * priscilla@dipteris.unige.it
[2] Institute of Oceanography and Fisheries, Laboratory of Plankton Ecology, Dubrovnik, Croatia
[3] Laboratoire d'océanographie de Villefranche (LOV), Station Zoologique, Villefranche-sur-mer, France
[4] University of Bizerte, Laboratory of Environment Bio-monitoring, Hydrology and Planctology Research Group, Zarzouna, Tunisia
[5] Institut National Agronomique de Tunisie, Unité Ecosystèmes et Ressources Aquatiques, H.P.R.G., Tunis, Tunisia
[6] Ecosystem Complexity Research Group, Station Marine, Université des Sciences et Technologies de Lille, CNRS-UMR 8013 ELICO, Wimereux, France

Abstract

The analysis of a zooplanktonic long-term series (1974-99) in the Ligurian Sea outlined the progressive dominance of the siphonophore *Muggiaea atlantica* on the congeneric *M. kochi*. *M. atlantica*, is one of the main gelatinous carnivorous along the Ligurian coast, established with a high abundance in southern Adriatic in 1996 after a first record in February 1995. Nevertheless there is no clear evidence of a progressive expansion of this species within the Mediterranean basin considering that regular monitoring during 1993-95 in the Bay of Tunis indicated *M. atlantica* as a rare species. The relationship between increasing abundance of *M. atlantica* and hydrological changes driven by climatic forcing in the Ligurian and Southern Adriatic Sea could be hypothesised but further investigations including more extended monitoring zones are still needed.

Keywords: Muggiaea atlantica, Muggiaea kochi, Mediterranean, time series, water temperature

Calycophoran siphonophores are between the main planktonic carnivorous, being able to reach and maintain very high concentrations also several weeks after a phytoplankton bloom. The analysis of a zooplankton long-term series (twenty years) obtained by monitoring a coastal fixed station in the Ligurian Sea (Villefranche, Fig.1), pointed out a progressive change in the population of these gelatinous carnivorous. Weekly sampling at the point B (depth of 80-150 m) in the Bay of Villefranche-sur-mer between 1974 and 1999 (with an interruption between 1978 and 1983), allowed the observation starting from the 80s of a progressive decrease of *Muggiaea kochi* and *Abylopsis tetragona* and a contemporary increase of *Lensia subtilis* and *Muggiaea atlantica*, the latter reaching up to 4080 anterior nectophores 100 m^{-3} during the season of calycophoran's major abundance (i.e. generally late march-July).

The dominance of *M. atlantica* in the coastal Ligurian Sea during spring-early summer was confirmed by the zooplankton's fortnightly records available between 1985-1995 (no data in 1989-1990) at station C (depth of 80 m) in the Gulf of Tigullio, 40 Km east of Genoa [1]. The similarity between siphonophores populations in the two sites is not surprising as the water mass circulation in both stations B and C is principally driven by the Ligurian Current, usually directed westward.

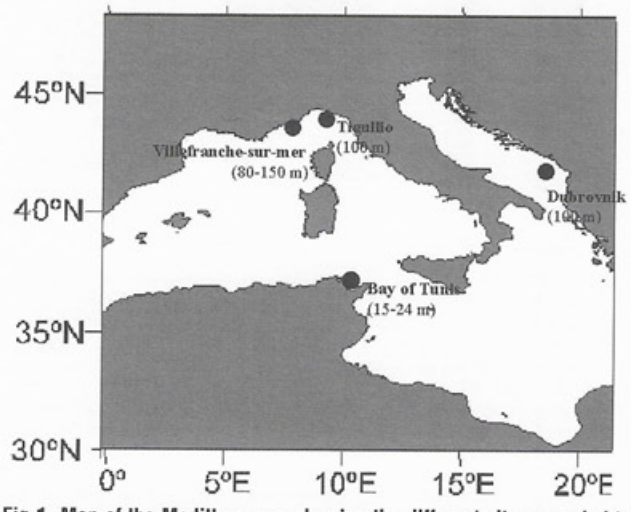


Fig.1. Map of the Meditteranean showing the different sites sampled to study calycophoran siphonophores. The monitoring stations are : Villefranche bay (43°41'N, 07°19'E) ; gulf of Tigullio (44°17'N ; 09°16'E), Dubrovnik (42°38'N ; 18°02'E) and the central stations of the Bay of Tunis (from 36°46 to 36°48'N and from 10°21 and 10°24'E). The geographical positions of these sites and the average depths (between parentheses) are shown.

A shift of dominant species within the calycophoran siphonophores was also observed in Southern Adriatic, at a coastal station near Dubrovnik (depth of 100 m) directly exposed to incoming open sea current. A high frequency sampling (each 1-3 weeks) from January to December 1996 indicated that, although it was recorded for the first time in February 1995 [2], one year later the allochthonous species *M. atlantica* was becoming dominant, representing more than 50% of total calycophorans nectophores in spring and late summer (up to 350 ant. nectophores 100 m^{-3}).

The increasing importance of *M. atlantica* in both Ligurian and Adriatic Seas coincided with hydrological changes observed in the studied areas. 32 years of records (1967-1999) at Point B in Villefranche-sur-mer, indicated a decrease of water temperature from 1975 to the end of the 80s presumably related to air-sea interaction processes. As well as, water masses in Southern Adriatic from 1987 to 1997 were significantly influenced by modifications in the Ionian Sea related to the Eastern Mediterranean Transient. The latter was a transient macroscale-climatic induced phenomenon for which the replacement of the Adriatic Deep Water (ADW) by the Cretan Sea Overflow Water (CSOW) caused an upward displacement of colder waters and of the associated oxygen minimum and nutrient maximum layers [3].

One can thus hypothesises that, being *M. atlantica* more adapted to colder waters that the congeneric species *M. kochi* [4], the first took advantage on the second with a progressive dominance due to its greater reproductive efficiency.

Implementation of the above mentioned time series and continous monitoring in other areas of Mediterranean Sea will be fundamental in order to verify this hypothesis, going further the observed changes occurred within the calycophoran siphonophores communities. Monthly sampling in the central part of the Bay of Tunis during December 1993- November 1995 for example, showed that in this coastal area of South Western Mediterranean influenced by Atlantic waters *M. atlantica* was scarce and only occasionally recorded, *Lensia substilis, Lensia multicristata* and *Muggiaea kochi* being dominant. This situation could have been changed afterwards or remained stable meanwhile, suggesting that the dynamics controlling planktonic populations in this area are different.

Acknowledgements. This work is a contribution to IFB Programme 'Biodiversité et Changement Global'.

References

1 - Licandro P., Ibanez F., 2000. Changes of zooplankton communities in the Gulf of Tigullio (Ligurian Sea, Western Mediterranean) from 1985 to 1995. Influence of hydroclimatic factors. *J. Plank. Res.*, 22 (12): 2225-2253.

2 - Gamulin T., Kršinc F., 1999. Capycophores (Siphonophora, Calycophorae) of the Adriatic and Mediterranean Seas. *Nat. Croat. Suppl.*, 9(2) : 1-198.

3 - Civitarese G., Gacic M., 2001. Had the Eastern Mediterranean Transient an Impact on the New Production in the Southern Adriatic? *Geophysical Res. Lett.*, 28(8): 1627-1630.

4 - Purcell J.E., 1992. Feeding and growth of the siphonophore *Muggiaea atlantica* (Cunningham, 1893). *J. Exp. Mar. Biol. Ecol.*, 62: 39-54.

PRELIMINARY EVIDENCE OF ENDOCRINE DISRUPTION IN THE RED MULLET, *MULLUS BARBATUS*, FROM THE NW MEDITERRANEAN

Rebeca Martín, Ramón Lavado, Rémi Thibaut, and Cinta Porte *
Environmental Chemistry Dept. IIQAB-CSICBarcelona, Spain - * cpvqam@cid.csic.es

Abstract
Red mullets (*Mullus barbatus*) from the NW Mediterranean were collected to assess potential alterations of the endocrine system as a consequence of pollution exposure. Ovarian P-450 aromatase and liver UDP-glucuronyl transferases, two enzymes that might modulate synthesis and inactivation of endogenous steroids, were determined in field collected specimens. During the spring sampling (before reproduction), low P450 aromatase activity was recorded in females from the most impacted sites (Cortiou and Fos). After reproduction, enhanced glucuronidation of testosterone and estradiol by liver microsomal fractions was detected in specimens from those sites. The study describes for the first time some evidence of endocrine disruption in red mullets from the NW Mediterranean.

Keywords: P450 aromatase, UGTs, red mullet

The Western Mediterranean is the recipient of extensive urban and industrial waste-water discharges from bordering countries, and at the same time is an attractive recreational region; it is thus in need of tools for environmental risk assessment. Some recent studies have determined biochemical and cellular responses to pollutants in coastal fish (1-4) in an attempt to assess the toxicity of chemicals that are currently released into the marine environment. Recently, some evidences of endocrine alterations and intersexuality in pelagic fish predators have been reported (5-6), but the interference of pollutants with the endocrine system of coastal fish is largely unknown.

In this study, we have focussed on the red mullet *Mullus barbatus*, because it is a benthic and territorial fish of commercial interest in the region, which has been used in several studies of coastal pollution monitoring. Specimens were collected in spring and autum 2001 from 4-7 sites along the NW Mediterranean. The impact of coastal pollution was assessed by the combined determination of a battery of biochemical markers, namely 7-ethoxyresorufin *O*-deethylase (EROD), UDP-glucuronyl transferases, catalase, and acetylcholinesterase. Those markers indicated strong differences among sampling sites (Fig. 1), the highest degree of stress detected in red mullets from Cortiou (urban and industrial area) and Fos (oil exposure), but also in specimens from the Ebro Delta (pesticide exposure). Levels of alkylphenols, mainly nonylphenol (NP) and octylphenol (OP) were determined in fish bile as a measure of recent exposure to this type of compounds. High levels of alkylphenols were detected in fish from Cortiou, under the influence of Marseille (0.25 µg OP/g, 28 µg NP/g), that appeared as highly polluted in comparison with nearby areas (0.03-0.08 µg OP/g, 0.2-1.6 µg NP/g). Alkylphenols, and particularly octyl- and nonylphenol, have been shown to elicit estrogenic responses both *in-vivo* and *in-vitro*. Therefore, efforts were addressed to assess potential effects on the endocrine system of exposed fish from those impacted areas (Cortiou and Fos) by comparison with two "cleaner" stations (Portofino and Arenzano in the Italian coast). To this end, ovarian cytochrome P450 aromatase, and rates of conjugation of testosterone and estradiol by liver microsomal fractions were selected as potential markers, and they were determined along a pollution gradient before and after the reproductive period.

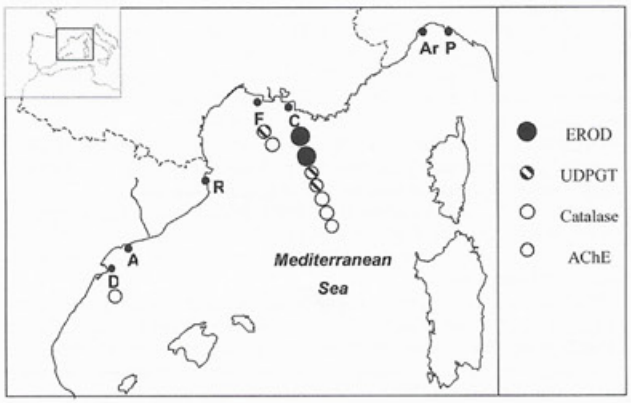


Fig. 1. Map of the NW Mediterranean showing the sites where red mullets were sampled in spring/autumn 2001, together with different biomarkers of exposure, namelly liver microsomal 7-ethoxyresorufin *O*-dethylase (EROD) activity, liver microsomal UDP-glucuronyltransferase using p-nitrophenol as substrate (UDPGT), liver cytosolic catalase activity, and muscle acetylcholinesterase (AChE). The spots in the map indicate those stations that had significantly higher activities when compared to reference sites. Letters of stations belong to P-Portofino, Ar-Arenzano, C-Cortiou, F-Fos-sur-Mer, R-Roses, A-Altafulla, D-Ebro Delta.

During the spring sampling (before reproduction), females from Cortiou and Fos had lower ovarian P450 aromatase activity (16-18 pmol/h/mg protein) than those from the Italian sites (35-36 pmol/h/mg protein). These results suggest the existence of compounds that may interfere (inhibit) this enzymatic activity, and that may lead to a delay in maturation. Histological sections of the gonads confirmed this delay in maturation in both males and females from Cortiou, in comparison with the other stations. After reproduction, ovarian P450 aromatase sharply decreased (up to 10-fold), and although females from Cortiou still had the lowest activity, differences between stations were not statistically significant. At that time, gonads of both males and females were at early stages of development, and no alterations nor differences among sampling sites were recorded.

When the activity of UDP-glucuronyl transferase towards testosterone and estradiol was monitored in liver microsomal fractions, we found that the organisms from the most polluted areas had higher activities of hormone glucuronidation. Toxicant induction of hepatic biotransformation enzymes is a mechanism by which endogenous steroid hormone metabolism and elimination may be altered, thus leading to enhanced testosterone and estradiol clearance, and disruption of the steroid metabolism within the organism. Additionally, glucuronidation of hormones in piscine species appears to be important, both in chemcial signalling and in cessation of their activity via excretion.

Overall, the set of biomarkers used indicated different levels of stress in red mullets along the NW Mediterranean, together with some evidences of endocrine disruption in specimens from highly impacted areas.

References

1 - Roméo M., Mathieu A., Gnassia-Barelli M., Romana A., Lafaurie M., 1994. Heavy metal content and biotrasformation enzymes in two fish species from the NW Mediterranean. *Mar. Ecol. Prog. Ser.* 107: 15–22.
2 - Burgeot T., Bocquéné G., Porte C., Dimeet J., Santella R.M., Garcia de la Parra L.M., Píhol-Leszkowicz A., Raoux C., Galgani F., 1996. Bioindicators of pollutant exposure in the North Western Mediterranean Sea. *Mar. Ecol. Prog. Ser.* 131: 125-141.
3 - Porte C., Escartín E., García de la Parra L.M., Biosca X., Albaigés J., 2002. Assessment of coastal pollution by combined determination of chemical and biochemical markers in *Mullus barbatus*. *Mar. Ecol. Prog. Ser.* 235: 205-216.
4 - Regoli F., Pellegrini D., Winston G.W., Gorbi S., Giuliani S., Virno-Lamberti C., Bompadre S., 2002. Application of biomarkers for assessing the biological impact of dredged materials in the Mediterranean: the relationship between antioxidant responses and susceptibility to oxidative stress in the red mullet (*Mullus barbatus*). *Mar. Pollut. Bull.* 44: 912–922.
5 - Fossi M.C., Casini S., Marsili L., Neri G., Mori G., Ancora S., Moscatelli A., Ausili A., Notarbartolo-di-Sciara G., 2002. Biomarkers for endocrine disruptors in three species of Mediterranean large pelagic fish. *Mar. Environ. Res.* 54: 667-671.
6 - De Metrio G., Corriero A., Desantis D., Zubani D., Cirillo F., Deflorio M., Bridges C.R., Eicker J., de la Serna J.M., Megalofonou P., Kime D.E., 2003. Evidence of a high percentage of intersex in the Mediterranean swordfish (*Xiphias gladius* L.). *Mar. Pollut. Bull.* 46: 358-361.

MICRORÉPARTITION DES HOLOTHURIES ASPIDOCHIROTES AU SEIN DE L'HERBIER DE POSIDONIES DE LA PRESQU'ÎLE DE SIDI-FREDJ – ALGÉRIE

Karim Mezali

Faculté des Sciences et Sciences de l'ingénieur, Mostaganem, Algérie - mezalikarim@yahoo.fr

Résumé

Cette étude s'intéresse à quatre holothurides: *Holothuria tubulosa, H. polii, H. forskali* et *H. sanctori*. La micro-répartition de ces espèces reflète une préférence de *H. tubulosa* pour l'herbier. Par contre, *H. polii* préfère les inter-mattes. Quant à *H. forskali* et *H. sanctori* elles se dissimulent dans les tombants de mattes et les mélanges de blocs.

Mots-clés: Echinodermata, Density, Algerian bassin

Introduction

Les holothuries sont des représentants majeurs du compartiment benthique de l'écosystème à *Posidonia oceanica* [1, 2]. Elles jouent un rôle important dans le "detritus food web" [3] et participent activement au recyclage de la matière organique [4]. La littérature comporte des estimations ponctuelles de densité [5, 6, 7, 8]. Cependant, les facteurs qui régissent leur distribution sont peu connus [9].

Matériel et méthodes

Des dénombrements mensuels (mars 1995-février 1996) sont réalisés par plongée dans une station étirée sur 500 m^2 et présentant une profondeur moyenne de -5 m (Fig. 1). Le choix de cette méthode non destructive se justifie par le fait que les holothuries possèdent potentiellement la possibilité d'effectuer des déplacements dans une direction donnée [10].

Nous avons stratifié l'échantillonnage en quatre biotopes: herbier, tombant de matte, inter-matte et mélange de blocs. La méthode des quadrats est utilisée pour évaluer la densité moyenne de chaque espèce d'holothurie. La densité de l'herbier de Posidonies (nombre moyen des faisceaux/m^2) a été déterminée *in situ*.

Résultats

Densité

Les résultats de la densité sont reportés dans le Tableau 1.

Tab. 1. Densité moyenne des holothuries ainsi que celle de l'herbier du site d'étude.

	Effectif	Densité moyenne/ m^2	Ecart type
Holothuria tubulosa	226	0.942	0.113
Holothuria polii	96	0.400	0.068
Holothuria forskali	54	0.225	0.036
Holothuria sanctori	60	0.250	0.051
Posidonia oceanica	-	**467.28**	**93.91**

Micro-répartition

Holothuria tubulosa est présente dans des proportions presque égales dans l'herbier, inter-mattes et mélanges de blocs. *H. polii* préfère les inter-mattes et l'herbier. *H. forskali* et *H. sanctori* se concentrent dans les tombants de mattes et mélanges de blocs (Tab. 2).

Discussion

H. tubulosa est résultée dominante. La microrépartition des holothurides varie en fonction de la nature du substrat. En effet, *H. polii* au niveau des inter-mattes de Posidonie se couvre avec une fine couche de sable pour se camoufler. L'habitat cryptique de *H. forskali* et *H. sanctori* limite leur distribution au niveau des substrats rocheux [1].

La densité élevée de *H. tubulosa* notée au niveau de l'herbier dense de type II (467.28 faisceaux/m^2) (Tab. 1) est liée à sa richesse en matière organique [11, 12]. En effet, il a été démontré, que la longueur des feuilles de Posidonies est responsable de la décantation et de l'accumulation d'une grande quantité de matériel biodétritique [13].

Tab. 2. Variations des densités moyennes en fonction des biotopes fréquentés par les holothuries. [...]= Ecart type de la moyenne.

	H. tubulosa		*H. polii*		*H. forskali*		*H. sanctori*	
Biotope	Effectif total	Densité moy. (Ind./m^2)	Effectif total	Densité moy. (ind./m^2)	Effectif total	Densité moy. (ind./m^2)	Effectif total	Densité moy. (Ind./m^2)
Inter-matte	30	1.58 [0.60]	18	0.95 [0.35]	1	0.05 [0.05]	3	0.16 [0.12]
Herbier	39	2.05 [0.56]	15	0.79 [0.24]	4	0.21 [0.12]	5	0.26 [0.10]
Tombant de matte	18	0.95 [0.33]	3	0.16 [0.12]	19	1.00 [0.23]	23	1.21 [0.42]
Mélange de blocs	42	2.21 [0.0.34]	9	0.47 [0.19]	8	0.42 [0.14]	15	0.79 [0.33]

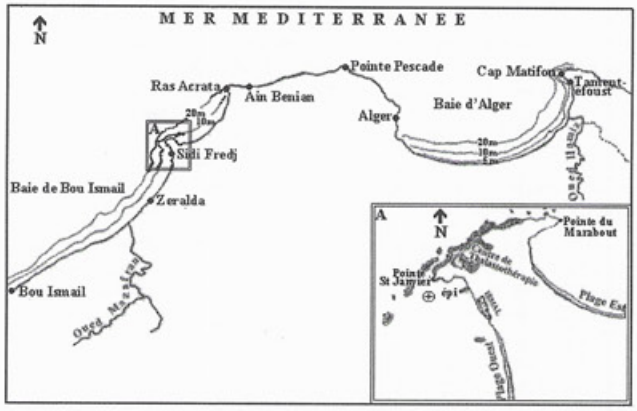


Fig. 1. La presqu'ile de Sidi Fredj. A : détail de la presqu'ile. + = zone d'échantillonage.

Références

1 - Harmelin J. G., Bouchon C., Duval C., and Hong J. S., 1980. Les échinodermes des substrats durs de l'Ile de Port - Cros. *Trav. Sci. Parc Nation. Port - Cros.* France, 6: 25-38.

2 - Coulon P., and Jangoux M., 1993. Feeding rate and sediment reworking by the holothuroid *Holothuria tubulosa* in a Mediterranean seagrass bed off Ischia Island, Italy. *Mar. Ecol. Prog. Ser.,* Vol. 92: 201-204.

3 - Zupo V., and Fresi E., 1984. A study on the food web of *Posidonia oceanica* ecosystem: analysis of the gut contents of echinoderms. *In:* Boudouresque C.F., Jeudy de Grissac A., and Olivier J. (ed.), Fr., 1: 373-379.

4 - Massin C., 1982b. Effects of feeding on the environment: Holothuroidea. Pp. 193-197. *In:* Jangoux M., and Lawrence J. M. (ed.), Echinoderm nutrition, Balkema A.A. Publ., Rotterdam.

5 - Parenzan P., 1963. Distribuzione quantitativa della *Psammechinus microtuberculatus* nel Mar Grande di Taranto. *Rapp. P. V. Commiss. Internation. Explor. Sci. Médit.*, Monaco, 17 (2): 277-282.

6 - Massin C., and Jangoux M., 1976. Observations écologiques sur *Holothuria tubulosa, H. polii* et *H. forskali* et comportement alimentaire de *Holothuria tubulosa. Cah. Biol. Mar., Fr.,* 17: 45-59.

7 - Gustato G., and Villari A., 1979a. On the ecology and species frequency of the genus *Holothuria* in the Gulf of Naples. Pp. 1-387. *In:* Echinoderms: Present and past, Balkema A.A. Publ., Rotterdam.

8 - Azzolina J. F., and Harmelin J. G., 1989. Répartition et fluctuations de densité de trois espèces d'holothuries (Echinodermata). Pp. 219-230. *In:* Boudouresques C.F., Meinesz A., Fresi E. and Gravez V. (ed.), GIS Posidonie Publ., Marseille.

9 - Wada K., 1992. Temporal change in density and size structure of the sea cucumber *Polycheira rufescens* inhabiting the intertidal boulder beach at Hatakejima Island, Japan. *Bull. Seto. Mar. Biol. Lab.,* 35 (6): 363-370.

10 - Francour P., 1990. Dynamique de l'écosystème à *Posidonia oceanica* dans le parc national de Port - Cros: Analyse des compartiments matte, litière, faune vagile, échinodermes et poissons: Thèse de Doctorat, Univ. P. M. Curie, Paris, 373 p.

11 - Choe S., 1963. Biology of the Japanese common sea cucumber *Stichopsus japonicus.* Prusian National University. Pusan 266 p.

12 - Yingst J. Y., 1974. The utilization of organic detritus and associated microorganisms *by Parastichopus parvimensis,* a benthic deposit-feeding holothurian. Ph. D. thesis, University of South California, Los Angeles: 154 p.

13 - Blanc J. J., 1958. Etude géologique et sédimentologique. *Ann. Inst. Océanol.*, Fr., 32: 123 - 153.

FEEDING BEHAVIOUR OF *HOLOTHURIA TUBULOSA* AND *HOLOTHURIA POLII* OF TAMENTEFOUST AREA - ALGERIA

Karim Mezali

Faculté des Sciences et Sciences de l'ingénieur, Mostaganem, Algérie - mezalikarim@yahoo.fr

Abstract

The feeding behaviour of *Holothuria tubulosa* and *H. polii* was carried out in one shallow water area characterised by *Posidonia* meadow. The morphometric characteristics of the ingested particles and their organic matter and water contents were compared to the bottom sediment. The results illustrate the alimentary specificity of each species, which ingest average and fine sediment fraction. The two species are able to discriminate between particles rich and poor in nutritive elements.

Keys-words: Echinodermata, organic matter, sediments

Introduction

Holothurians are major component of *Posidonia* meadow [1]. They play an important rule in recycling of the organic matter and the oxygenation of the bottom [2]. They feed by scraping particulate deposits and selecting organically rich materials using their tentacles. Holothurians ingest the sediment for its nutritive particles [3], bacteria [4], meiofauna [5] and marine phanerogams leaves [6, 7].

Material and methods

The sampling was done during April-May 2001 in one station of -3m depth (Fig. 1). Two batches composed of ten individuals of each species were taken. The water rates of the bottom and pooled guts sediments (first batch) are obtained by weighting before and after desiccation (24h at 105 °C) and the organic matter (OM) is calculated after passing the sediment in oven (2h at 550 °C) using the formulas: % Water= (1 - DW/ WW) x 100; % OM= (1- AW/ DW) x 100 (WW= Wet Weight; DW= Dry Weight; AW= Ash Weight) [8]. The bottom and the pooled guts sediments [9] (second batch) are dried (24h at 105°C), weighted and sieved mechanically (AFNOR sieves). The contents of each sieve are weighted and percentage of the fractions [10] is calculated.

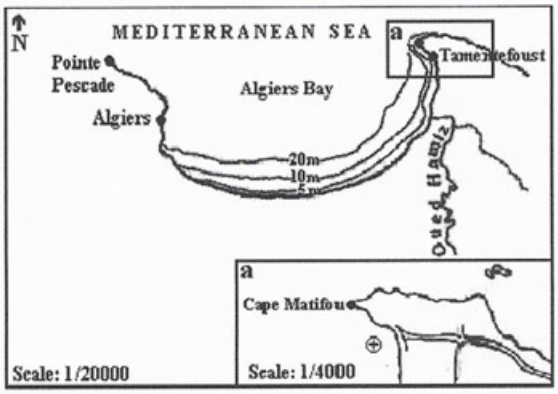


Fig. 1. Situation of the Tamentefoust station. A = detail. + = sampling area.

Results and discussion

Organic matter and water

The high rate of OM obtained in the gut sediment ($p > 0.01$) (Fig. 2) show that the two species have a tendency to select OM from the bottom. The water overvaluation in the gut sediment is in close relationship with the increase of the OM (Fig. 2). Indeed, more the OM is high; more it requires water to ingest it. The difference in OM noted in the gut of the two species could be related to their biota. *H. tubulosa* exist between *Posidonia* leaves, which are responsible for the accumulation of the detritus [11]. *H. polii* prefers the sandy bottom influenced by hydrodynamism that disperses food.

Granulometry

The bottom sediment is characterized by high rate of fine fraction (55,13%) (Tab. 1). The predominance of this fraction is related to OM concentration [12]. It seems that *H. polii*, has a tendency to select this fraction. Generally, *H. tubulosa* and *H. polii* prefers the average fraction (40.36-60.26%) (Tab. 1). The difference noted in selection of the particles could be related to its charge in OM and to the difference existing in the texture of the tentacles [13]. Indeed, according to [6], *H. tubulosa* is able to know particles covered by OM.

Table 1. Gut and bottom fractions percentages. *: Classification according to [12].

Granulometric fraction*	*H. (H.) tubulosa*	*H. (L.) polii*	Bottom sediment
< 40 µm	4.22	5.72	3.20
Very fine fraction (40-60 µm)	1.75	9.10	3.70
Fine fraction (60-200 µm)	17.32	31.92	55.13
Average fraction (200-600 µm)	60.26	40.36	35.12
Coarse fraction (600-2000 µm)	15.86	15.73	2.55

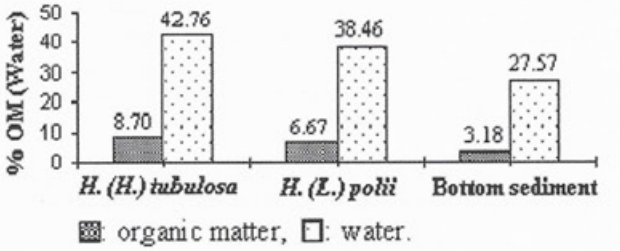


Fig. 2. Gut and bottom organisc matter and water percentage.

References

1 - Azzolina J.F., and Harmelin J.G., 1989. Répartition et fluctuations de densité de trois espèces d'holothuries (Echinodermata). Pp. 219-230. *In:* Boudouresques C.F., Meinesz A., Fresi E. and Gravez V. (ed.), GIS Posidonie Publ., Marseille.

2 - Charbonnel E., Gravez V., Abellard O., Boudouresque C.F., and Remonnay L., 1995. Surveillance de l'herbier de Posidonies du golf de Giens. Pp. 1-106. GIS Posidonie Publ., Marseille.

3 - Coulon P., and Jangoux M., 1993. Feeding rate and sediment reworking by *Holothuria tubulosa* in a Mediterranean seagrass bed off Ischia Island, Italy. *Mar. Ecol. Prog. Ser.*, 92: 201-204.

4 - Yingst J.Y., 1976. The utilisation of organic matter in shallow marine sediments by epibenthic deposit feeding holothurian. *J. exp. Mar. Biol. Ecol.*, 23: 55-69.

5 - Berthon J.F., 1987. Relations trophiques entre quelques espèces d'échinodermes et le phytobenthos dans la baie de Port-Cros. DEA, Univ. Pierre et Marie Curie, Fr., 72 p.

6 - Massin C., and Jangoux M., 1976. Observations écologiques sur *Holothuria tubulosa*, *H. polii* et *H. forskali* et comportement alimentaire de *H. tubulosa*. *Cah. Biol. Mar.*, 17: 45-59.

7 - Verlaque M., 1981. Preliminary data on some *Posidonia* feeders. *Rapp. Comm. Int. Mer Médit.*, 27 (2): 201-202.

8 - Massin M., 1980. The sediment ingested by *Holothuria tubulosa*. Pp. 205-208. *In:* Jangoux M. and Lawrence J.M. (ed.), Echinoderms: Present and Past. Belkema A.A., Publ., Rotterdam.

9 - Roberts D., 1979. Deposit feeding mechanisms and resource partitioning in tropical holothurians. *J. Exp. Mar. Biol. Ecol.*, 37: 43-56.

10 - Berthois L., 1975. Etudes sédimentologiques des roches meubles. 278 p. *In:* Doin (ed.), Paris.

11 - Boudouresque C.F., and Jeudy De Grissac A., 1983. L'herbier à *Posidonia oceanica* en Méditerranée: les interactions entre la plante et le sediment. *J. Rech. Océanogr.*, 8: 99-122.

12 - Berthois L., Crosnier A., and Le Calvez Y., 1968. Contribution à l'étude sédimentologique du plateau continental dans la baie de Biafra. *Cah. ORSTOM*, VI: 1-34.

13 - Roberts D., and Bryce C., 1982. Further observations on tentacular feeding mechanisms in holothurians. *J. Exp. Mar. Biol. Ecol.*, 59: 151-163.

ZOSTERA MARINA IN VENICE LAGOON: A GENETIC STUDY

Micheli C.[1] *, Paganin P. [1], Maffucci M. [1], Nascetti G. [2], Rismondo A. [3], Curiel D. [3]
ENEA CR Casaccia C.P., Roma A.D., Italy - * micheli@casaccia.enea.it
[2] Università di Viterbo "La Tuscia", Viterbo, Italy
[3] SELC Scarl, Venezia, Italy

Abstract
With the aim of investigating the genetic variability of *Zostera marina* in Venice lagoon, two populations in Malamocco basin (San Pietro in Volta and Alberoni) were studied by the PCR (Polymerase Chain Reaction) technique. The results were correlated with environmental parameters and phenological and physiological features of the plants (leaves biometry, biomass and primary production) taken into consideration. Genomic fingerprintings obtained by RAPD (Random Amplified Polymorphic DNA) and confirmed by statistical analyses (NT-SYS), showed high genetic variability within and between two populations only 5 Km apart, confirming the role of *Z. marina* as a cosmopolitan species and its phenotypic plasticity.

Key-words: Zostera marina, RAPD, Venice lagoon

Since environmental stress represents an important factor which can induce changes in the physiology of the species (1), the genetic variability of *Zostera marina* from two different zones of the Venice lagoon was analysed, so that by comparing the results of molecular and environmental tests, a clearer assessment of the state of health of the two meadows could be made.

Samples of *Z. marina* were taken from two sites in the Malamocco basin (San Pietro in Volta and Alberoni) corresponding to an area of 162 km^2. At the San Pietro in Volta site, *Z. marina* meadows are very estensive, mostly mixed with *Cymodocea nodosa*, whilst in proximity to Alberoni the populations are pure and less extensive.

The growth cycle of *Z. marina* favours the period April-June with regard to leaf production, even thougt it is a macrophyte devoid of conspicuous seasons (in contrast to *C. nodosa*) and therefore active all through the year.

Both sites present fairly good transparency values, which permit observation of the seabed (about 1,5 m) in nearly all conditions. The San Pietro in Volta site is characterized by more lasting transparency and sediment of a coarser consistency (2,3).

After collection, individual plants were washed in distillated water and stored in liquid nitrogen (-180 °C). The DNA of *Z. marina* was obtained using previous methodology (4). For the plants of *Z. marina* sampled in Alberoni only, DNA of the flowers, also, was recorded. PCR was applied (6) and the amplification products, obtained by a thermal cycler (Perkin Elmer/Cetus), were separated by gel electrophoresis (agarose 1.4%) and photographed (Polaroid 667) under U.V. light illumination after Ethidium bromide staining.

In these experiments four primers were used: BY 11 (5'-ATCCACTGCA-3'); BY 13 (5'-CCTTGACGCA-3'); BY 15 (5'-CTCACCGTCC-3') BY 12 (5'-GGTCGCAGGC-3').

Cluster analysis (UPGMA) of the similarity indices was carried out using NT-SYS software (5) in order to determine similarities between samples. Fragment sizes of RAPD were estimated from the gel by comparison with a 1Kb ladder marker. The bands were recorded as present (1) or absent (0) and assembled in a data matrix table.

Genomic fingerprinting, revealed by PCR technique, gave several molecular fragments of varying sizes ranging from 0.25 to 2.5 Kb. Cluster analyses revealed the pattern of genetic distance in relation to physical distance (e.g. geographical position) between the two populations of *Z. marina.*

From a comparison of samples from San Pietro in Volta (A), an average similarity of 72% appears, while the average value of similarity for Alberoni (B) is 74%. Similarity drops to 43% when samples of group A and group B are compared.

The genetic variability we encountered may be correlated to the phenological and physiological variation of *Z. marina* in bloom at the Alberoni site. The morphological differences observed among plants of diverse provenance (length of leaves, presence of one or more leafy shoots, strength of stem) are a direct response to the environment, which at Alberoni presents greater environmental stress in general (sedimentary, torbidity, etc.) than at San Pietro in Volta.

The eelgrass *Z. marina* can reproduce both sexually and vegetatively. For species with two reproductive modes, molecular-genetic techniques are useful in assessing the relative importance of the two modes in determining population distribution and structure. Such information is relevant to many basic and applied questions in marine ecology because colonizers resulting from vegetative reproduction all have identical genetic composition, whereas sexual reproduction results in genetically diverse individuals. Genetic variation within and between populations of the same species may, for example, indicate the sensitivity of a given population and its recovery from disturbance (7). Because of the vigorous rhizomatic growth of *Z. marina* and its wide distribution and ecological success, vegetative reproduction was expected to prevail. A high degree of genetic similarity within and even between not-too-distantly separated populations is expected. However, RAPD, used to quantify the genetic similarity of two geographically and morphologically distinct populations of *Z. marina* from Venice lagoon, showed just the opposite. *Z. marina* revealed a high genetic variability within and between the two populations located only 5 km apart, in Malamocco basin, confirming the role of this plant as a cosmopolitan species for its phenotypic plasticity. It appears from our analysis of *Z. marina* that sexual reproduction contributed to the expansion and maintenance of these populations. The RAPD analyses demonstrated significant genetic distinctions among disjunt eelgrass populations and may offer insight into the widespread distribution and ecological success of *Z. marina* in a diversity of temperate coastal habitats. The capacity for a high level of genetic variation in this cosmopolitan species probably also accounts for diversity in leaf and shoot morphologies in different habitats and argues that these features may not be as useful as taxonomic characters at the species level as previously thought.

References

1 - Amzallag G.N, 1999. Plant evolution toward an adaptative theory. Pp. 171-245. In: Lerner H.R. (ed.), Plant responses to environmental stresses. From phytohormones to genome reorganization.
2 - Rismondo A., Curiel D., Marzocchi M., Scattolin M., 1995. Sesonal pattern of *Cymodocea nodosa* biomass and production in the lagoon of Venice. *Aquatic Botany*, 58: 55-64.
3 - Curiel D., Rismondo.A., Scarton F., Marzocchi M., 1997. Flowering of *Zostera marina* in the Lagoon of Venice (North Adriatic, Italy). *Botanica Marina*, 40: 101-105.
4 - Dellaporta S.L., Wood J. and Mc Coy T.J., 1983. A plant DNA minipreparation: version II. P.M.B.R. 14: 19-21.
5 - Rohlf F.J, 1993. NTSYSpc Numerical Taxonomy and Multivariate Analysis system .
6 - Franconi R., Barcaccia G., Paglialonga A., Micheli C., 1995. Investigation of genomic polymorphism in *Posidonia oceanica* collected in different areas of Mediterranean sea using RAPD markers. *Rapp, Comm. int. Mer Médit.,* 34: 29.
7 - Grassle J.F. and Grassle J.P., 1978. Life histories and genetic variation in marine invertebrates. Pp. 347-364. In: B. Battaglia and J. Beardmore (eds.), Marine Organisms. Plenum, New York.

EGYPTIAN SANDY BEACH MEIOFAUNA AND BENTHIC DIATOMS

Hanan Mitwally [1, 2], Paul Montagna [1], Youssef Halim [2 *], Adel Ghani N. Khalil [2], Mohamed M. Dorgham [2], and Manal M. Atta2

[1] University of Alexandria, Faculty of Science, Oceanography Department, Egypt - * youssefhalim@hotmail.com
[2] University of Texas at Austin, Marine Science Institute, Port Aransas, Texas, USA.

Abstract

Egyptian Mediterranean meiofauna has received limited attention until now. The earlier studies were qualitative rather than quantitative (1, 2, 3). This first quantitative analysis of meiofauna along the Mediterranean coast of Alexandria, Egypt was carried out at three different sandy beaches (El Mamoura E-M, Bir Masoud B-M, and El Shatby E-S) from April to December 1996. It was primarily aimed at a comparative description of meiofaunal population abundances and composition in two habitats within each of three beaches. Physicochemical factors (temperature, salinity, grain size, and total organic matter) and samples of suspected food (diatoms) were measured in conjunction with meiofaunal samples from April to December 1996. At each survey, meiofaunal was sampled within two habitats, supralittoral and intertidal to characterize within site variability at the three beaches (Fig. 1).

Key words: Meiofauna; Alexandria; Egypt; Diatoms; Harpacticoida; Nematoda; grain size



The E-S beach which is intermittently exposed to waste water pollution is differed from both E-M and B-M. The sea water temperature (SW^NC) varied from 29^NC in July and 18^NC in December. The sea water salinity (SWl) and pore water salinity (PWl) separated E-M and B-M beaches from E-S.

Overall mean PWl was 37.62l, 37.89l, and 36.55l respectively at E-M, B-M, and E-S. The median grain size (N) at E-S showed medium coarse sand especially in the intertidal habitat while at E-M and B-M was fine grain sand. Overall mean N ranged between 2.00 (E-M and B-M) and 1.08 (E-S). The highest total organic matter (%TOM) was recorded twice at E-S (1.25% in April) and at B-M (1.85% in July). Overall mean %TOM was 0.56% (E-M and B-M) and 0.63% (E-S).

Mean total meiofaunal abundances ranged from 2434 individuals 10cm $^{-2}$ at E-S, 1225 individuals 10cm $^{-2}$ at E-M, and 1083 individuals 10cm $^{-2}$ at B-M (Fig. 2). They were more abundant in the supralittoral than in the intertidal habitat. The communities comprised sixteen groups. Seven were dominant averaging 98.1% overall (Ciliophora, Harpacticoida, Nematoda, Archiannelida, Gastrotricha, Foraminifera, and Turbellaria).

Mean Harpacticoida abundances showed maxima in the moderately warm months (spring-autumn) at all three beaches and minima during summer. Eight interstitial and one phytal species were recorded. One Cylindropsyllidae (*Arenopontia nesaie*), one new subspecies Paramesochridae (*Kliopsyllis constrictus egyptus*), two new Ectinosomatidae (*Arenosetella bassantae* and *Noodtiella toukae*), one Ameiridae (*Nitocra spinipes*), two Diosaccidae (*Amphiascus parvus* and *Amphiascus* sp.), one Peltidiidae (*Alteutha* sp.), and one Tetragonicipitidae (*Phyllopodopsyllus pauli*). Two new species and one new subspecies were published separately (4).

Nematodes were analyzed to trophic guilds. Four different trophic groups were distinguished (deposit feeders, epistrate, scavengers, and predators)? Mean variance of deposit feeders and epistrate was lower at E-S compared to E-M and B-M. Scavengers were higher at E-S. Predators were different among beaches.

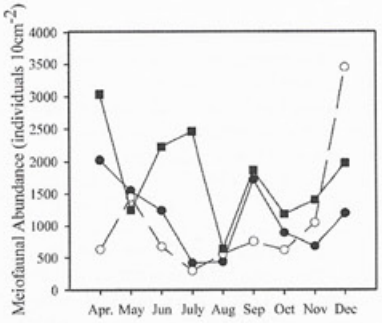
The abundance of benthic diatoms was high at E-M (ranging from 15 10^3 cells $^{-3}$ to 665 10^3 cells^{-3}) and low at E-S (ranging from 2 10^3 cells $^{-3}$ to 11510^3 cells $^{-3}$). Over the year and at all three beaches, the diatom abundance sustained two peaks one during spring – summer and one in winter.

To assess the importance of benthic diatoms as a food source for different meiofaunal groups, Principal Component Analysis (PCA) was done. The data set consisted of factor scores resulting from the PC analyses on diatom species data, PC analyses on Harpacticoida species, log transformed total data of meiofauna, dominant meiofaunal groups data, and arcsine transformed Nematode trophic groups data. This analysis was called "**Biotic analysis**". Results indicated that diatoms have a different relationship with different meiofaunal groups especially with Harpacticoida, Archiannelida, Foraminifera, Ciliophora, Turbellaria, and Nematoda. This relationship differs in sign and magnitude.

To illustrate typical associations of organism groups in relation to their physical environment,

Another PCA analysis was performed. The data set of the Biotic analysis was used after merging with the square root-root transformed data of %TOM, PWl, N, SW^NC, sorting , and log transformed SWl. This analysis was named **"Biotic and abiotic analysis".** Results revealed that, on PC2 all the biotic variables loaded negatively, while all abiotic variables loaded positively. On PC1, Hapacticoida, meiofauna, predators, and scavengers loaded negatively. In contrast, diatoms, epistrate, deposit feeders, N, PWl, SW l, and SW^NC loaded positively on PC1. The relation between biotic and abiotic variables was generally negative.

The biotic and abiotic analyses were used to differentiate among beaches. The E-S beach was different from E-M and B-M which were similar. The E-M and B-M beaches were similar with high abundance of diatoms and high percentage composition of nematode deposit feeders and epistarte. Their pore and sea water salinity and their grain size were also higher. In contrast, E-S beach which is downstream from effluent had higher grain size, lower salinity, and its %TOM was 0.1% higher. It was occupied by a higher abundance of meiofauna and Harpacticoida, and a high predators and scavenger's percentage.



References

1 - Gurney. R., 1927. Report on the Crustacea-Copepoda (littoral and semi parasitic). Zoological results of the Cambridge expedition to the Suez Canal, 1924. No., 35. *Trans Zool. Soc. Lond.*, 22:451-577, figs. 108-168.
2 - Steuer. A., 1943. Variablitat und Verbreitung einiger Copepoda Harpacticoida der Gattungen *America* und *Mesochra* aus dem-stlichen Mittelmeer (Alexandria). *Thalassia,* 6:1-19.
3 - Remane, A., and E. Schulz, 1964. WissenSchaftliche Ergebnisse einer Forschungsreise von Adolf Remane und Eric Shultz nach dem Roten Meer. 169 p.
4 - Mitwally, H., and P.A. Montagna, 2001. Egyptian interstitial Copepda Harpacticoida with the description of two new species and one new subspecies. *Crustaceana.* 74 (6):513-544.

HABITAT SUITABILITY AND SIGHTINGS OF THE MEDITERRANEAN MONK SEAL IN THE NATIONAL PARK OF AL HOCEIMA (MOROCCO)

G. Mo [1] *, H. Bazairi [2], E. Salvati1, S. Agnesi [1], A. Limam [3], L.D. Nachite [4], C. Rais [3], I. Sadki [5], L. Tunesi [1], N. Zine [6]

[1] ICRAM, Rome, Italy - * giulia_mo@virgilio.it
[2] Université Hassan II Aïn Chock, Casablanca, Morocco
[3] RAC/SPA, Tunis, Tunisia
[4] Université Abdel Malek Essaadi, Tetouan, Morocco
[5] Université Ibnou Zohr, Agadir, Morocco
[6] Université Meknes, Morocco

Abstract

Coastal habitat suitability and *Monachus monachus* sighting information was collected in the National Park of Al Hoceima (Morocco). Two coastal sectors have caves that are most suitable for the species. Fishermen interviews indicate the species' historical and recent presence in the park and external areas.

Keywords: Mediterranean monk seal, Morocco

Introduction

A significant information gap exists on Mediterranean monk seal (*Monachus monachus*) distribution along north African coasts (1). Consideration of these areas is crucial for a species conservation strategy (2) and identification and recovery of small groups should be undertaken. Seal presence in the last decades hypothetically occurred between Al Hoceima and Cap des Trois Fourches (3) and the population may consist of 10 individuals (1). This study enriches the knowledge of the coastal habitat suitability and provides an update on *M. monachus* sightings in the National Park of Al Hoceima.

Methods

The terrestrial National Park of Al Hoceima is situated about 50 km from the Straits of Gibraltar with a 47 km long coast. Fieldwork was undertaken within the MedMPA project, coordinated by UNEP-MAP's RAC/SPA and funded by the EC. Information on monk seal coastal habitat and sightings was collected, during summers 2002 and 2003. Rocky cliff sectors were first identified and subsequently aquatically investigated to verify for caves. Cave characteristics (protection from wave action, elevation of emerged beach, difficulty in observing the cave from the outside, protection from exposure to major motor traffic) were analysed in terms of their capacity to confer protection and these were ranked (1 =low, 2=medium, 3=high). Caves with highest ranking represent optimal locations for the species. Information on *M. monachus* sightings was collected by interviewing fishermen operating from the park's landing sites and to the east until Sidi Chaib (20km). The questionnaire collected information on fishing activities and seal sightings through the use of cards (4) depicting images of other marine species as well.

Results

The area has rocky calcareous cliffs forming steep overhangs alternated to rock slides and pebble beaches. Five sectors of rocky coast (M1-M5) present medium-large fractures (Fig. 1). Sectors M1-M3 are of compact dolomitic limestone while sectors M4 and M5 appear composed of bent strata of limestone. Sectors M1-M4 were fully inspected. 25% of sector M5 was inspected due to logistical difficulties. Small caves (<3mx3m), visible from sea, were disregarded. Eight caves were identified: one in M2, three in M3, two in M4 and two in M5. The obtained ranking was: high for two in M3 and one in M4, intermediate for two in M5 and low for the remaining caves. Forty-five fishermen were interviewed. *M. monachus* was recognised by 35 of the interviewees and of these observations, 9 occurred in the period 2001-2002. Table 1 indicates the areas in which interviewees reported observing seals.

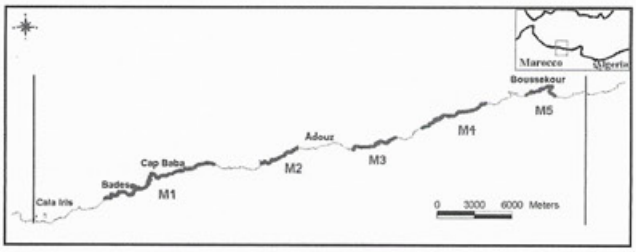


Fig.1. Rocky sectors (M1-M5) of the study area.

Table 1. Monk seal sightings recorded through interviews.

Date	Location and number of the sightings	
	Within the park	External to the park
1970-1979	Bades (1)	Al Hoceima (3)
1980-1989	Boussekour (1), Bades-Topos (1), Tala Youssef (1)	Mestassa (2), Carmela (1), Al Hoceima (4), Sidi Abed (1), Morra de Chica (1), Cap de l'Eau (1)
1990-1999	Cala Iris (1), Boussekour (3),	Sidi Abed (3), Sidi Chaib-Cap Quilate (1), Sidi Assein-Cap Quilate (2)
2000-2002	Topos (1), Bades (1)	Mestassa (1), Sidi Abed (1), Al Hoceima (2), Tofino (1), Sidi Chaib-Cap Quilate (1), Cap Trois Fourches (1)

Discussion

The study area has interesting physical coastal habitat for the species. Sectors M3 and M4 have caves that are most suitable for *M. monachus* and require adequate protection and monitoring measures. The observations drawn from the interviews indicate the historical and recent presence of *M. monachus* in the coastal stretch of the study area, confirming the need for a species-specific conservation plan. Various sightings reported in areas external to the park, as east as Cap de l'Eau and as far as Tofino, (18nm north of Al Hoceima) highlight the need to conduct further investigations and conservation initiatives in a wider geographical area, still appearing to host monk seal individuals.

Special thanks are extended to T. DiNora, M. Manca, E. Piccione, the Ministère des Eauxs et Forets, the National Park of Al Hoceima, and I.T.P.M. for their assistance.

References

1 - Aguilar A., 1998. Current status of Mediterranean monk seal populations. In: Meeting of experts on the implementation of the Action Plans for marine mammals (monk seal and cetaceans) adopted within MAP. Arta, Greece, 29-31 October 1998. *UNEP (OCA)/MED WG.146/4.*

2 - Reijnders P.J.H., 1998. Vulnerability of small Mediterranean monk seal groups and conservation policy. Meeting of experts on the implementation of the Action Plan for marine mammals (monk seal and cetaceans) adopted within MAP. Arta, Greece, 29-31 October 1998.

3 - Bayed A., and Beaubrun P.C., 1987. Les mammifères marins du Maroc: Inventaire préliminaire. *Mammalia*, Fr., 51: 437-446.

4 - Boyd I.L., and Stanfield M.P., 1998. Circumstantial evidence for the presence of monk seals in the West Indies. *Oryx* 32(4): 310-316.

FISH ASSEMBLAGES OF THE MOROCCAN COASTAL AREA OF AL HOCEIMA (MEDITERRANEAN SEA)

Molinari A., Salvati E., Tunesi L.*
ICRAM, Rome, Italy - a.molinari@icram.org

Abstract

The fish assemblage of the marine coastal area of the Al Hoceima National Park has been studied in the framework of a research program for the elaboration of the zoning proposal of the marine park. Collected data show the presence of rich and well diversified assemblages, characterised by a general dominance of small and medium sized specimens.

Keywords: Visual census, Marine Parks, Alboran Sea

Introduction

In the framework of the MedMPA project (regional project for the development of Marine and coastal Protected Areas in the Mediterranean region), financially supported by the European commission and coordinated by the Regional Activity Centre for Specially Protected Areas (RAC/SPA-Tunis), ICRAM has been charged with the scientific coordination of the study of the Al Hoceima National Park in Morocco.

Considering the relevance of fish as one of the most important components through which the effects of protection become evident in marine parks [1-3], and the importance of conceiving management measures for fishery and scuba diving activities [4], two surveys were carried out to characterise the coastal fish assemblages in the coastal area applying visual census techniques.

Material and Methods

The coastline of the Moroccan National Park of Al Hoceima interests about 47 km of Mediterranean coast, characterised by rocky impervious cliffs. The sampling activity was organised subdividing the coastal area into 5 sub-homogeneous coastal units (CU) (Fig. 1), identified on the basis of the main geomorphological features.

Scuba diving paths of 15 minutes were carried out in summer 2002 and 2003 along transects based on four sampling depth ranges (0-3; 4-7; 12-16; 24-30m), in order to acquire semi quantitative data on abundance and size class composition [5]. At least 3 transects were planned *per* CU. The main sea bottom typologies for each path were registered. A Chi-square test was applied to compare the size class composition recorded in the five considered CUs.

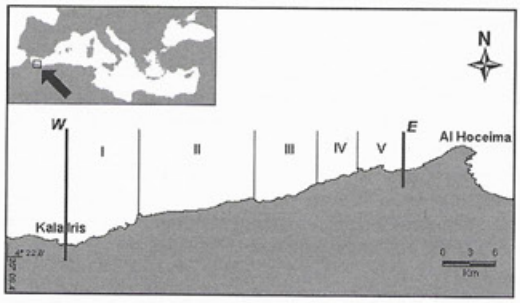


Fig. 1. Study area: the eastward (E) and westward (W) borders of the Al Hoceima National Park are shown. The 5 identified coastal units (I-V) are highlighted.

Results

The low slope encountered on certain transects sometimes did not allow to reach the 12-16 and the 24-30 m depth ranges. On the whole, 52 paths allowed to identify 69 species (10 Eastern Atlantic and South Mediterranean). Sparids, Labrids and Serranids were the most represented families (15, 14 and 8 species respectively).

Only 17 species occurred in all five CUs while another 17 were each censed only in one CU. This may be due specific characteristics like crypticity (*C.conger*, *P.phycis*, *S.notata*, *S.acus*), and rarity (*L.bergylta*, *S.cretense*, *E.aeneus*, *E.marginatus*, *P.auriga*, *S.aurata*, *T.nobiliana*) or because they are associated to soft bottoms (*B.podas*, *Callionymus* sp., *Gobius* sp., *S.cinereus*, *P.erythrinus*). The higher number of species were recorded in the costal unit IV (48). Highest species richness were recorded at 0-3 m and 4-7 m (47 species).

Excluding CU I, which is dominated by small specimens (65.8%), and significantly different from the others (chi-square test, $p<0.001$), the fish assemblage of the marine park was characterised by a general co-dominance of medium sized (from 43.9% to 56.0%) and small specimens (from 33.7% to 43.3%). The large size class is generally less represented (from 8.9% to 15.0%). Taking into account only the first depth range, the I, III and IV CUs were characterised by a high percentage of small specimens (higher than 60%). The higher percentages of large specimens were recorded in the deeper range (24-30 m) in the II and III CUs (23.6% and 24.3% respectively).

Table 1. Species recorded in the five coastal units identified along the study area. (•)) Eastern Atlantic and South Mediterranean species.

Family	Species	Coastal Unit
Atherinidae	*Atherina* sp.	I,III,IV,V
Apogonidae	*Apogon imberbis*	II,III,IV,V
Blenniidae	*Parablennius gattorugine*	I,III
	Parablennius incognitus	IV,V
	Parablennius pilicornis (•)	All
	Parablennius rouxi	II,III,IV,V
	Parablennius sanguinolentus	I,III
	Scartella cristata (•)	II,V
Bothidae	*Bothus podas*	IV
Callionymidae	*Callionymus* sp.	IV
Congridae	*Conger conger*	II
Engraulidae	*Engraulis encrasicholus*	III,V
Gadidae	*Phycis phycis*	IV
Gobiidae	*Gobius bucchichii*	I,IV,V
	Gobius cruentatus	II,III,V
	Gobius sp.	IV
Haemulidae	*Parapristipoma octolineatum*(•)	I
Labridae	*Coris julis*	All
	Ctenolabrus rupestris	II,III,IV,V
	Labrus bergylta (•)	II
	Labrus viridis	III,IV
	Symphodus cinereus	II
	Symphodus doderleini	I,II,III,IV
	Symphodus mediterraneus	All
	Symphodus melanocercus	II,III,IV,V
	Symphodus melops	All
	Symphodus ocellatus	All
	Symphodus roissali	All
	Symphodus rostratus	II,IV,V
	Symphodus tinca	All
	Thalassoma pavo (•)	All
Moronidae	*Dicentrarchus labrax*	I,II,V
Mugilidae	*Mugil* sp.	I,II,III,V
Mullidae	*Mullus barbatus*	III,IV
	Mullus surmuletus	All

Family	Species	Coastal Unit
Muraenidae	*Muraena melena*	I,V
Pomacentridae	*Chromis chromis*	All
Scaridae	*Sparisoma cretense* (•)	I
Scorpaenidae	*Scorpaena maderensis*	III,IV
	Scorpaena notata	IV
	Scorpaena porcus	I,II
Serranidae	*Anthias anthias*	II,III,IV
	Epinephelus aeneus (•)	IV
	Epinephelus costae (•)	II,III
	Epinephelus marginatus	I
	Serranus atricauda (•)	I,II
	Serranus cabrilla	All
	Serranus hepatus	II,IV
	Serranus scriba	I,III,V
Sparidae	*Boops boops*	All
	Dentex dentex	II,III
	Diplodus annularis	IV,V
	Diplodus cervinus cervinus	I,II,IV,V
	Diplodus puntazzo	I,III,IV,V
	Diplodus sargus	All
	Diplodus vulgaris	All
	Oblada melanura	All
	Pagellus acarne	II,III,IV,V
	Pagellus erythrinus	IV
	Pagrus auriga (•)	IV
	Pagrus pagrus	II,III,IV
	Sarpa salpa	All
	Sparus aurata	IV
	Spondyliosoma cantharus	II,III,IV,V
Syngnathidae	*Syngnathus acus*	IV
Torpedinidae	*Torpedo nobiliana*	V
Trachinidae	*Trachinus draco*	III,IV
Tripterygiidae	*Tripterygion delaisi*	I,V
	Tripterygion tripteronotus	All

Discussion and Conclusion

The fish assemblage of the Al Hoceima National Park is rich in species and characterised by the relevant presence of Eastern Atlantic and South Mediterranean elements, which testifies the role of the proximate Gibraltar strait. These peculiarities stress the importance of this national park in protecting a very unique Mediterranean fish assemblage in the framework of a network of Mediterranean marine protected areas.

The scarce occurrence of large specimens highlights a relevant fishing pressure, thus emphasizing the importance of implementing new specific protection measures.

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References

1 - Villa F., Tunesi L., Agardy T., 2002. Optimal zoning of marine protected areas through spatial multiple criteria analysis: the case of the Asinara Island National Marine Reserve of Italy. *Conservation Biology*, 16(2): 1-12.

2 - Tunesi L., Rais C., Benhissoune S., Agnesi S., Bazairi H., Benhamza A., Di Nora T., Franzosini C., Limam A., Manca Zeichen M., Mo G., Molinari A., Nachite D., Piccione M.E., Sadki I., Salvati E., in press. Zoning of the marine component of the national park of Al Hoceima (Mediterranean, Morocco): a case study. *Biol. Mar. Medit.*, 11.

3 - Halpern B.S., 2003. The impact of marine reserve: do reserve work and does reserve size matter? *Ecological Applications*, 13 (1) Supplement: S117-S137.

4 - Agnesi S., Di Nora T. and Tunesi L., 2001. The study of diving tourism to support the adaptative management in an Italian marine protected area (Ustica island). *Rapp. Comm. Int. Mer. Médit.*, 36: 347.

5 - Harmelin-Vivien M.L., Harmelin J.G., Chauvet C., Duval C., Galzin R., Lejeune P., Barnabe G., Blanc F. and Chevalier R., 1985. The underwater observation of fish communities and fish populations: Methods and problems. *Rev. Ecol. Terre Vie*, 40: 467-540.

ZOOPLANKTON AS A POLLUTION MONITOR IN A COASTAL MARINE ENVIRONMENT (TOULON BAY, FRANCE)

Radin F. [1] *, Richard S. [2], Jamet J.L. [2] and B. Pavoni [1]

[1] Dipartimento di Scienze Ambientali, Università Cà Foscari di Venezia, Venezia, Italia
[2] Université de Toulon et du Var, Equipe de Biologie des Milieux Aquatiques EBMA, Laboratoire PROTEE, La Garde, France

Abstract

Polychlorinated Biphenyls (PCBs), Organochlorine Pesticides and Polycyclic Aromatic Hydrocarbons (PAHs), were measured in samples of zooplankton collected in spring-summer 2002 in two separate areas of Toulon Bay, Petite Rade and Grande Rade. Abundance and diversity of zooplankton community were also evaluated. Zooplankton samples from the more polluted Petite Rade, had significantly higher PCB concentrations than those of Grande Rade. Moreover, compared to Grande Rade, Petite Rade had lower diversity and evenness indices, and higher dominance index due to a single species (*Oithona nana*). PCB pollution can be regarded as a probable factor causing stress to the Petite Rade's zooplankton organisms.

Key words: zooplankton, bioaccumulation, PAH, PCB, organochlorine pesticides, biodiversity

In zooplankton samples collected between May and July 2002 in the Toulon Bay the concentrations of Polychlorinated Biphenyls, Organochlorine Pesticides (HCB, DDT, DDD, DDE and HCH) and Polycyclic Aromatic Hydrocarbons were determined.

The semivolatile, chemically-stable and lipofilic nature of organochlorine compounds combined to their resistance to biodegradation and photolysis and the low water solubility and hydrophobic properties of PAHs, cause these compounds to be accumulated in the marine organism's lipid rich tissues. All these compounds are included in the list of persistent organic pollutants and are of great concern because of their toxicity and suspected or manifest carcinogenic activity.

Zooplankton and particulate matter represent the organic contaminants' main route for entering the living matter cycle and the food webs in the marine environments. Organic compounds adsorb onto particulate matter and are taken up by smaller organisms because of their high lipid content and relatively higher biomass in the smaller sizes (1). Therefore, zooplankton can be used as a monitor of **recent pollution** because of its short life-cycle.

Moreover, abundance and diversity of zooplankton communities can be affected by **long term disturbances** due to anthropogenic inputs. Arfi *et al.* (2) reported that some species tend to cluster in facies characteristic of polluted environments and affected by a low diversity index. They emphasized that the copepods *Acartia clausii*, *Oithona nana* and the appendicularian genus of *Oikopleuridae* were the most abundant organisms in perturbed ecosystems, because of their euriecious and tolerant nature.

In this study, chemical and ecological analyses of the zooplancton community were coupled in order to evaluate interactions between pollutants' body burden and community structure modifications.

An artificial breakwater divides the Toulon Bay into two different basins, Petite Rade and Grande Rade, contaminated by different pollutants' loads.

Zooplankton samples were collected every 1-2 weeks at four stations, in both Petite Rade (S1, S2), heavily polluted, and Grande Rade (S3, S4), less affected by human inputs.

The highest abundance of zooplankton was found in Petite Rade, where human activity is more intense because of the commercial and military port. The copepod *Oithona nana* was the most abundant species of the overall community in S1 (53-78%) and S2 (11-71%) for the entire period. Petite Rade had low diversity and evenness indices and high dominance index due to the single species *Oithona nana*.

Grande Rade, on the other hand, had low zooplankton abundance and higher diversity and evenness indices. Dominance index was on average lower than in Petite Rade and *Oithona nana* was not the dominant species, until the beginning of July, when it represented 72% of the community. This situation was probably due to strong N/W winds that made waters of the two basins mix together.

Differences in zooplankton communty structure between Petite Rade and Grande Rade were also described by Jamet *et al.* (3) and Richard and Jamet (4).

Chemical analyses were performed on lyophilised plankton samples using solvent extraction (n-hexane, dichloromethane) clean up and separation with column chromatography (alumina and silica gel) and HRGC-LRMS determinations (5).

Results showed no temporal trends for the concentrations of pollutants.

A significant difference was found between PCBs concentrations in Grande Rade and Petite Rade where PCBs were significantly higher. On the other hand, Pesticides and PAHs in zooplankton of Petite Rade and Grande Rade were not significantly different.

In Petite Rade, PCBs concentrations could be ten times higher in zooplankton than in sediments (6), whereas concentrations in Grande Rade's zooplancton and sediments were similar.

The concentrations of the parent compounds o,p'- and p,p'-DDT in zooplankton were in most samples below the detection limits, while the metabolite, *p,p'*-DDD, was at relatively high levels. A DDT/DDE ratio lower than 1 and the *p,p'*-DDD high concentration are probably the result of a past DDT contamination. Total pesticides concentrations were much more abundant in zooplankton than in sediments (6).

PAHs were quite abundant in zooplancton, and concentrations were similar to those in sediments. Despite the zooplankton ability to metabolise and excrete PAHs (7), concentrations of these compouds remained quite high in all cases suggesting a continuous input of these contaminants into the bay.

Considering that Pesticides and PAHs did not show different concentrations in Petite Rade and Grande Rade, they were thought to be hardly responsible for the differences in zooplankton community structure between the two basins.

Therefore, only the correlation between PCBs concentrations in zooplankton and some ecological indices was investigated. A negative correlation between richness, evenness and diversity indices was found. A positive correlation resulted between dominance index and PCBs concentrations.

These preliminary results indicate that PCB pollution can be reasonably considered as a probable factor causing stress to the Petite Rade's zooplankton organisms, which suffered a reduced diversity in response to perturbed environmental conditions (8).

References

1 - Hargrave B.T., G.C. Harding, W.P. Vass, P.E. Erickson, B.R. Fowler, V. Scott, 1992. Organochlorine Pesticides and Polychlorinated Biphenyls in the Arctic Ocean Food Web. *Archives of Environmental Contamination and Toxicology,* 22: 41-54.

2 - Arfi R., G. Champalbert, G. Patriti, 1981. Système planctonique et pollution urbaine: un aspect des population zooplanctoniques. *Marine Biology*, 61: 133-141.

3 - Jamet J.L., G. Bogè, S. Richard, C. Geneys, D. Jamet, 2001. The zooplankton community in bays of Toulon area (Northwest Mediterranean Sea, France). *Hydrobiologia,* 457 : 155-165.

4 - Richard S. and Jamet J.L., 2001. An unusual distribution of *Oithona nana* Giesbrecht (1892) (crustacea : cyclopoida) in a bay: the case of Toulon bay (France, Mediterranean Sea). *Journal of Coastal Research,* 17(4) : 957-963.

5 - Pavoni B., Caliceti M., Sperni L., Sfriso A. Organic micropollutants (PAHs, PCBs, Pesticides) in seaweeds of the lagoon of Venice. *Oceanol. Acta* (in press).

6 - RNO 1998. Surveillance du Milieu Marin. Travaux du RNO. Edition 1998. Ifremer et Ministère de l'Aménagement du Territoire et de l'Environnement.

7 - Neff J.M., 1979. Polycyclic Aromatic Hyrocarbons in the Aquatic Enironment. Sources, Fates and Biological Effects. Applied Science Publishers Ltd.

8 - Odum E.P., 1983. Basic Ecology. CBS College Publishing.

LE MACROBENTHOS DES MILIEUX PORTUAIRES DE LA CÔTE ALGERIENNE

Chafika Rebzani-Zahaf [1] *, Gérard Bellan [2]

[1] Faculté des Sciences Biologiques/USTHB, Alger Algérie - * chafika4@caramail.com
[2] Station Marine d'Endoume, COM, Marseille, France - gbellan@com.univ-mrs.fr

Résumé

Les peuplements macrobenthiques des milieux portuaires ont été étudiés au cours d'un cycle annuel en 1983-1984, au printemps 1996, 1997 et 2000 pour le port d'Alger et au printemps 1995 pour les ports de Béjaïa et Skikda (ancien et nouveau port). L'étude du cycle annuel du peuplement du port d'Alger a permis de mettre en évidence la spécificité de chacun de ses trois bassins. L'analyse descriptive des peuplements a permis de déterminer l'état de pollution de ces milieux perturbés et les peuplements observés dans le bassin du Vieux Port d'Alger sont similaires à ceux des ports de Béjaïa et Skikda.

Mots clés: macrobenthos, substrat meuble, bio-indicateurs, port, pollution

L'évolution inter annuelle des peuplements du port d'Alger (1) fait apparaître une relative stabilité dans leurs constitutions à l'exception du bassin Mustapha fortement pollué où le peuplement a été détruit en 1996/1997 à la suite des travaux de remblaiement d'une de ses darses. Une amélioration est constatée en 2000, le peuplement du port retrouve son développement habituel dont l'organisation structurelle est différente pour chacun de ses trois bassins.

Le bassin de Mustapha, au sud est soumis à divers types de pollutions industrielles et aux apports des eaux de la baie, transitant par la passe sud, sous influence des égouts de la partie est de la ville et de l'oued El-Harrach très pollué. Les fonds de darses sont azoïques. Le peuplement fluctue au niveau des sorties de darse et du bassin d'évolution et est essentiellement constitué par deux espèces indicatrices (2) de pollution d'ordre 1 (IP1): *Capitella capitata* et *Malacoceros fuliginosus*. Sans l'influence des eaux du bassin de l'Agha et sans l'apport des eaux de la baie, ce bassin serait azoïque toute l'année.

Le bassin de l'Agha est intermédiaire, le peuplement est plus diversifié (entre 8 et 19 espèces) et la densité est élevée sans atteindre les pics quantitatifs du bassin de Mustapha. L'influence de la pollution de ce dernier se fait sentir et l'évolution saisonnière du peuplement met en évidence la substitution des IP1 par les IP2 révélant une pollution moins intense. L'influence du bassin du Vieux port favorise la mise en place des Lre (*Corbula gibba*).

Le bassin du Vieux port est un bassin de marchandises, de voyageurs, de pêche et de plaisance. Les rejets d'eaux usées urbains et l'apport des eaux extérieurs par la passe nord provenant du large favorisent le peuplement constitué des espèces Lre *Apseudes latreilli, Lumbrinereis latreilli, Notomastus latericeus,...* Il est largement dominé par *Corbula gibba*. Le second groupe d'espèce correspond aux espèces indicatrices d'instabilité (*Tharyx marioni*) et caractéristiques de biocénoses (*Prionospio malmgreni, Glycera alba,...*). Ces espèces annoncent l'installation ou la préparation d'un peuplement de milieu naturel.

Dans le port de Béjaïa, (3) la richesse faunistique diminue et la densité augmente de l'avant-port vers l'arrière-port. Le peuplement est constitué d'espèces Lre et d'indicatrices d'instabilité. La principale espèce est *Corbula gibba*, sa densité augmente du bassin de l'avant-port vers le bassin de l'arrière-port. Les espèces indicatrices d'instabilité dominées par *Heteromastus filiformis*, *Tharyx marioni*,... évoluent en sens inverse.

Le peuplement de **l'Ancien Port de Skikda** (3) est plus dense et plus diversifié dans le bassin ouest que dans le bassin est. Il se distingue par la présence des indicatrices d'instabilité (*Abra alba*), des Lre (*Corbula gibba, Lumbrinereis latreilli* et *Notomastus latericeus*) et par l'installation des espèces caractéristiques de biocénoses.

Le peuplement du **Nouveau Port de Skikda** (3) est faible à l'exception de deux stations à proximité de l'entrée du port. La présence et le mouvement des gros pétroliers, la faible profondeur ainsi que les prises d'eau de refroidissement par les entreprises industrielles expliquent les faibles densités. L'espèce prédominante est le mollusque Lre *Corbula gibba*.

L'organisation structurelle des peuplements des différents secteurs et ports est liée aux facteurs abiotiques (quantité et qualité de la charge polluante, substrat, hydrodynamisme, profondeur, salinité,...) et biotique (compétition inter/intra spécifique, disponibilité des ressources nutritives) qui agissent soit indépendamment les uns des autres soit en synergie. Le peuplement est soit dense et peu diversifié soit hétérogène et aux groupes écologiques différents correspondant:

- aux espèces IP lorsque les conditions du milieu sont rudes ;
- aux Lre dominés par des espèces indicatrices de matière organique à proximité des rejets urbains et dans les milieux confinés ;
- à une dominance des indicatrices d'instabilité ;
- aux espèces indicatrices d'instabilité et caractéristiques de biocénoses aux secteurs sous l'influence des eaux extérieures aux ports.

La richesse faunistique diminue de l'extérieur vers l'intérieur des ports avec une augmentation quantitative liée à l'état de confinement du milieu. La baisse de la densité des espèces de biocénoses et l'augmentation des espèces indicatrices de matière organique et d'instabilité révèle les premiers signes de déséquilibre d'un peuplement. Ces résultats (4) concordent avec les travaux similaires en divers points du globe (5, 6, 7, 8 et 9).

En conclusion, il est mis en évidence d'une part la particularité du Port d'Alger qui regroupe trois bassins à degrés de pollution différents et à peuplements spécifiques et d'autre part, une similitude entre le bassin du Vieux Port d'Alger et les autres ports. Ce qui pourrait permettre d'envisager le port d'Alger comme référence pour l'analyse des peuplements des autres milieux perturbés de la côte algérienne.

Références

1 - Rebzani-Zahaf C., Bellan G., Bakalem, Romano J. C., 1997. Cycle annuel du peuplement macrobenthique du port d'Alger. *Oceanologica Acta,* 20, 2, 461-477.

2 - Bellan G., 1993. Les espèces indicatrices de pollution et leur repérage en milieu marin. *Biosystema*, 8: 45-60.

3 - Rebzani-Zahaf C., 2001. Organisation structurelle du macrobenthos des ports de Béjaïa et Skikda. *Rapp. Comm. int. Mer Médit.*, 36: 412.

4 - Rebzani-Zahaf C., 2003. Les peuplements macrobenthiques des milieux portuaires de la côte algérienne: Alger, Béjaïa et Skikda. Thèse d'Etat, Fac. Sci. Biol. / USTHB Alger: 244 p + annexes.

5 - Reish D. J., 1959. An ecological study of pollution in Los Angelos, Long Beach Harbors. Allan hancock Found. *Publ. Occas. Papers*, 22: 1-117.

6 - Bellan G., 1967 a et b. Pollution et peuplement benthiques sur substrats meubles dans la région de Marseille. *Rev. int. Océanogr. méd.* 8: 51-95 ; 6-7: 53-87.

7 - Bellan G., 1976. Recherches biologiques dans les grands ensembles portuaires: leurs enseignements. Tavola rotonda «Biologia marina per la difesa del mare», *Atti Tav. Rod. Intern.* : 31-56.

8 - Pearson T. H., Rosenberg R., 1978. Macrobenthic sucession in relation to organic enrichment and pollution of the marine environment. *Mar. Bull., Ann., Rev.* 16, 229-331.

9 - Glémarec M., Hily C., 1981. Perturbations apportées à la macrofaune benthique de la baie de Concarneau par les effluents urbains et portuaires. *Acta Oecologica. Applic.*, 2, 2, 139-150.

ECOLOGICAL MONITORING IN THE MONTENEGRIN COASTAL SEA

Dubravka Regner *, Nenad Vuksanovic, Branislav Stjepcevic and Danijela Joksimovic
Institute of Marine Biology, Kotor, Serbia and Montenegro - * biokotor@mail.cg.yu

Abstract

Investigations of the sea-water quality and the level of eutrophication in the Montenegrin coastal sea have been continued in 1999-2002 period. The increasing values of some parameters (indicators of eutrophication) as oxygen saturation at the surface and the microphytoplankton density have been established. The highest eutrophication was found in the inner and middle parts of the Boka Kotorska Bay, and in the Bojana river mouth. Sanitary quality of the sea was satisfying, yet. About 20% of the beaches in the Bay, and about 52% outside the Bay were the first category – up to 500 TC/100 ml of the sea-water.

Keywords: sea-water eutrophication, sanitary quality

Having in mind the importance of the Montenegrin coastal sea for tourism and all activities connected with it, the control of the marine environment and plankton community has been continued after 1998 (1) throughout next four years period. The main intentions were: to estimate the possible changes caused by eutrophication and to follow the sanitary quality of the sea. So, the material was taken at same 28 localities in the inner (Kotor Bay), middle (Tivat Bay) and outer part (Herceg Novi Bay) of the Boka Kotorska Bay, 26 outside the Bay and one at the Bojana river mouth. Standard methodology was used as before.

Although about 20 physical, chemical and biological characteristics have been investigated, only some of them would be presented here, owing to their importance for classification of the eutrophic level or sanitary quality of the sea water.

From physical characteristics, only transparency and sea-water color will be described here.

Transparency varied significantly in comparison with the previous results. It decreased along (near) the coast very often, at about 30% of the beaches in the Bay and at about 18% of the positions outside the Bay – including the Bojana river mouth. Such decreasing was caused by anthropogenic eutrophication as the consequence of yet unsolved system of waste- waters discharges and their direct impact to the shallowest coastal sea (2).

Sea-water color was changed in Kotor and Tivat Bays predominantly, to yellowish (XI-XII, XIII-XIV, XV-XVI) or even brownish (XVII-XVIII, XIX-XX, XXI) according to Forell- Uhle scale. So, the recent results affirmed that the color of the sea-water was changed occasionally, or usually at some positions in the Boka Kotorska Bay. Outside the Bay, changes were found rarely , because of direct exposition of this area to stronger influence of unpolluted oligotrophic waters of the open South Adriatic. The exception was locality at the Bojana river mouth, as freshwater impact and a lot of organic matter caused changed color to yellowish and brownish very often (3).

From chemical characteristics, oxygen saturation was measured between all others. At the whole area of the Montenegrin coastal sea, values increased at the surface, related to the higher phytoplankton production. So, mean values from the recent investigations (149-155.4%), were similar to the maximum values from 1995-1998 period. Such high values are characteristic of eutrophic and extremely eutrophic areas. (4).

Eutrophication was visible even more clearly throughout some biological parameters: composition and biomass of microphytoplankton, and heterotrophic bacteria. So, in the preceding period, microphytoplankton biomass increased to maximum values of 4.4 x 10^6 cells dm^{-3} and even 10^7 cells dm^{-3} or more, in the Kotor Bay (throughout summer, especially). Outside the Bay, up to 10^5 cells dm^{-3} were found, with the exception of the Bojana river mouth, where 8 x 10^5 cells dm^{-3} were established. Maximum values were always presented during summer everywhere, although usual spring and autumn maxima have been existed, yet (5). Dominant species were: *Chaetoceros affinis*, *Sceletonema costatum*, *Nitzschia seriata*, *Nitzschia delicatissima*, *Leptocylindrus danicus*, and eleven other species, indicator of eutrophic coastal sea. Their number was the highest in the Boka Kotorska Bay, and decreased outside the Bay to seven or eight species. Sometimes (in summer, too) *Sceletonema costatum* appeared in the Kotor Bay with maximum percentage of 55.5% among all other microphytoplankton species, while *Nitzschia delicatissima* was presented with 25.5% of the whole microphytoplankton density, simultaneously (6). In the area outside the Bay the percentage of above mentioned species decreased as their density, too. Nevertheless, throughout summer 2001, even in this part of the Montenegrin coastal sea microphytoplankton density was high enough to overtake values of eutrophic regions.

The density of heterotrophic bacteria varied in four years period to maximum values of 10^4/ml of the sea-water in the Boka Kotorska Bay, and 2.1 x 10^4/ml in the Bojana river mouth. In the area outside the Bay, values were between 10^2 and 1.9 x 10^3/ml of the sea-water. All these values are typical for eutrophic areas.

The recent investigations of the sanitary quality (bacterial pollution) of the coastal sea have been performed at the same well known beaches of the Montenegrin coast as before. From 28 localities in the Boka Kotorska Bay, the first category of the sea-water quality (up to 500 total coliforms/100 ml of the sea and up to 100 faecal coliforms/100 ml of the sea) was found at 20% of them (7). Second category (up to 10000 total coliforms/100 ml of the sea and up to 2000 faecal coliforms/100 ml of the sea) was found at about 72% of investigated positions. From time to time 8% of them exceeded allowed criteria. Some parts of the Bay (Kotor and Risan Bays in the inner area) were polluted more (7) and control would be continue with special attention to this fact. Outside the Bay, at about 52% of the beaches the first category was found, at 42% of them the second category was presented, and 6% of them exceeded mentioned criteria.

Conclusion

So, we can conclude that progressive eutrophication was found in the Montenegrin coastal sea throughout 1999-2002 period. Sanitary quality of the sea was satisfying, yet.

References

1 - Regner, D., N. Vuksanovic, B. Stjepcevic and M. Dutina 2001. The recent investigations of the sea-water quality in the Montenegrin coastal sea. *Rapp. Comm. int. Mer Médit.*, 36: 114.

2 - Regner, D., N. Vuksanovic, B. Stjepcevic and M. Dutina 2000. The present results of pollution investigations in the Montenegrin coastal sea. International conference: Water pollution control 2000, Mataruska Banja, Conference Proceedings, pp. 95-99.

3 - Regner, D., N. Vuksanovic, B. Stjepcevic and D. Joksimovic, 2002. Investigations of the sea-water quality in the Montenegrin coastal sea throughout summer 2001. International conference: Water pollution control 2001,Vrnjacka Banja, Conference Proceedings, pp. 297-303.

4 - Regner, D., N. Vuksanovic, B. Stjepcevic, M. Dutina and D. Joksimovic, 2002. Sea-water quality and the level of eutrophication in the Montenegrin coastal sea. *Stud. Mar.*, 23,1: 71-78.

5 - Vuksanovic, N., 2003. Estimation of the phytoplankton quantity in the area of the Montenegrin coastal sea as a consequence of eutrophication. International conference: Water pollution control 2003, Zlatibor, Conference Proceedings, pp. 383-387.

6 - Vuksanovic, N., 2002. Phytoplankton organisms as indicators of eutrophication in the Montenegrin coastal sea throughout summer, 2001. International conference: Water pollution control 2002, Vrnjacka Banja. Conference Proceedings, pp. 315-319.

7 - Stjepcevic, B. and A. Ivanovic, 2002. Some indicators of anthropogenic pollution of sea water in Kotor and Risan Bays. *Stud. Mar.* 23, 1: 65-71.

MACROFOULING OF MARINE FISH-CAGE NETS

G. Relini *, S. Merello

Dip.Te.Ris., Laboratori di Biologia Marina ed Ecologia Animale Università di GenovaGenova, Italia - * biolmar@unige.it

Abstract

Biofouling of meshes can create a severe problem to mariculture, since netting material is an ideal substrate for many organisms. Some net-panels were immersed at different time on a fish-cage in the Ligurian Sea for one year. Monthly settlement, development of fouling community and its biomass were described.

Key-words: fouling, mariculture, fish cages, meshes, Ligurian Sea

Introduction

The rapid growth of biofouling on floating net cages is a considerable problem for mariculture plants, since non-toxic netting material is an ideal substrate for many organisms (1). The main critical effects are a reduced water flow through the meshes (2, 3) and an increased load on fish cages. The aim of the paper is to describe settlement and development of mesh fouling in a marine farm in the Ligurian Sea.

Material and methods

The research has been carried out on the off-shore mariculture farm of Lavagna (Ligurian Sea). A nylon net (mesh=10 mm side, the same used for the fish cages) was assembled on 20x24 cm pvc frames to form "panels". Panels were suspended vertically on the floating cages at 6 and 12 m depth and removed monthly, every 3 months and after 6, 9, 12 months during a year since August 2001. Composition and abundance (as Covering Index and number) of fouling organisms were determined. Wet weight of fouling was measured (g/dm^2 net). Estimates of the percentage of mesh occlusion have also been done (4). Altogether 47 panels were examined.

Results and Discussion

Fouling settled down on nets consists of 76 species belonging to 15 taxa of algae and invertebrates (table 1). Polychaetes, algae, hydroids and molluscs shows the highest number of species. The amphipods *Caprella equilibra, Jassa marmorata* e *Stenothoe* sp. have the maximun percentage index of presence during a year study (100%). Some species such as hydroid *Tubularia crocea* and amphipods *C. equilibra* and *Stenothoe* sp. settled down on panels every month; bivalv *Mytilus galloprovincialis* since April and algae since June. The estimates of mesh occlusion by dominant fouling organisms (panels after 1,3,6,9 and 12 months immersion) are given in figure 1. Hydroids and bivalves are the most critical in fact, because of their quantity, dimension and growth rate, they occlude meshes most of all. Meshes are heavily fouled already after 6 months of immersion (about 90 g/dm^2 of net) mainly with mussels, hydroids and ascidians (Fig. 2).

Table 1. Number of taxa and most frequent species found on panels.

TAXA	Number of Species	Percentage Index of Presence	
Algae	13	Ceramium flaccidum	F=47%
		filamentose verdi n.c.	F=60%
Porifera	1	Calcarea n.c.	F=7%
Hydrozoa	10	Tubularia crocea	F=67%
		Campanularidae n.c.	F=57%
Anthozoa	1	Corynactis viridis	F=7%
Platyhelminthes	1	n.c.	F=30%
Polychaeta	22	Syllis zonata	F=33%
		Platynereis dumerilii	F=23%
Pantopoda	4	Tanystylum sp.	F=60%
Tanaidacea	1	n.c.	F=63%
Amphipoda	8	Caprella equilibra	F=100%
		Jassa marmorata	F=100%
		Stenothoe sp.	F=100%
		Caprella penantis	F=50%
		Elasmopus sp.	F=50%
Decapoda	1	n.c.	F=23%
Nudibranchia	1	n.c.	F=33%
Bivalvia	7	Mytilus galloprovincialis	F=60%
		Musculus costulatus	F=53%
		Hiatella arctica	F=27%
Bryozoa	4	Scruparia ambigua	F=23%
Echinoidea	1	n.c.	F=3%
Ascidiacea	1	Diplosoma listerianum	F=43%
Total	76		

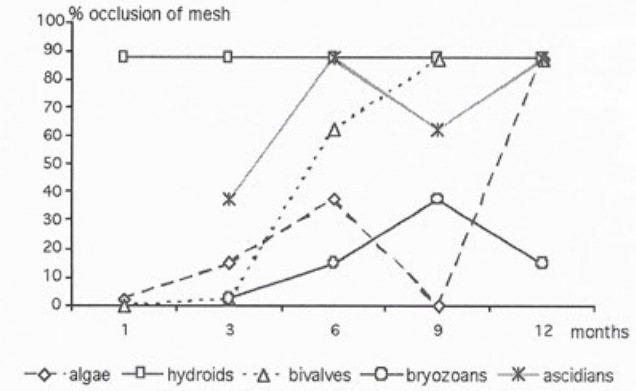

Fig. 1. Percentage of mesh occlusion for the main taxa.

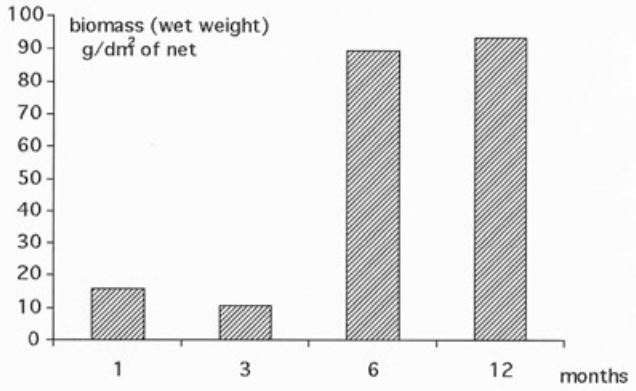

Fig. 2. Fouling biomass on panels after 1, 3, 6 and 12 months immersion.

References

1 - Hodson S. L., Lewis T.E., and Burke C.M., 1997. Biofouling of fish-cage netting: efficacy and problems of *in situ* cleaning. *Aquaculture,* 152: 77-90.

2 - Milne P.H. 1975. Fouling of marine cages, part 1. *Fish Farming Int.*, 2: 15-19.

3 - Huguenin J.E., and Ansuini F.J. 1981. Marine biofouling of synthethic and metallic screens. Oceans 81 Conference Record, Boston: 545-549.

4 - Rothwell G.N., and Nash C.E. 1977. Fouling of some netting materials in semi-tropical waters. Aquaculture in Tropical Oceans – year 01. Report to the Office of Sea Grant (NOAA) by the Oceanic Institute, Waimanalo, Hawaii: 2-29, 45-68.

CHEMICAL PHYSICAL PARAMETERS OF MARINE SEDIMENTS AND DISTRIBUTION OF RECENT BENTHIC FORAMINIFERA NEAR THE ARGENTARIO HEADLAND (NORTHERN TYRRHENIAN SEA, ITALY)

E. Romano [1] *, M.G. Finoia [1], L. Bergamin [1], V. Frezza [2], M. Celia Magno [1], M.G. Carboni [2], A.M. Cicero [1], A. Ausili [1] and M. Gabellini [1]

[1] ICRAM, Central Institute for Marine Research, Roma, Italia - * e.romano@icram.org
[2] Earth Science Department, La Sapienza University, Roma, Italia

Abstract

Grain size, PCBs, pesticides, PAHs, TOC, N and trace elements have been studied in marine sediments near the Argentario headland to investigate the accumulation and distribution mechanisms of some contaminants. In addition, benthic foraminiferal assemblages were analysed because they well reflect the ecological conditions of sea bottom and some single species may be considered as bio indicators of particular environmental parameters. A correspondence analysis on the analytical data enabled to understand that only agriculture is source of significant pollution. Pesticides are mainly distributed along a belt parallel to the coast, following the dominant currents.

Key words: Pesticides, Organic Matter, Grain Size, Foraminifera

Introduction

The marine area comprised between the Ombrone River mouth and the Argentario headland (Tuscany) was been the object of a broad interdisciplinary research aimed to study the depositional processes in the coastal environment near the Ombrone River mouth (1). In this context, the effects of human activity have been studied by means of analyses on trace elements (Cd, Cr, Cu, Ni, Pb), PCBs, pesticides (DDs, HCHs, HCB), TOC, N, taking into account the natural characteristics of sediments (grain-size). Benthic foraminiferal assemblages have been analysed because their composition and structure well reflect the ecological conditions of sea bottom, showing typical features as response to organic or chemical pollution (2). Six sampling sites have been selected on two perpendicular transepts: the first one has the inshore-offshore direction, between 30 and 120 m water depth (A15, A7, A5); the second one has the direction parallel to the coast, at water depth of about 90 m (A11, A10, A7, A3).

Results and Discussion

A correspondence analysis was performed processing the analytical data, to highlight possible associations among variables. The output is given in two distinct diagrams due to the large number of variables; dimension 1 and 2 cover 50.8% of variability (Fig. 1).

Grain-size analyses show silty clayey sediments for all stations, with very low sand contents (3). TOC and organic nitrogen have particular statistical affinity with the finest fraction of sediments.

PAHs and PCBs concentrations are always lower than the mean recorded by UNEP (1996), showing the highest correlation with stations A5 and A10, respectively. Pesticides, that show generally relevant concentrations, have lower correlation with both the shallowest (A15) and deepest (A5) station in the statistical analysis. Trace elements show generally low concentrations and have a narrow range of values for dimension 1 and 2, indicating similar distributional patterns.

Foraminifera are mostly distributed in the 2nd and 4th quadrant: positive values of dimension 2 characterise shallow water species (i.e. *Ammonia* spp.) while deep-water species (i.e. *Uvigerina mediterranea*) have negative values. Some species included in the 4th quadrant show statistical correlation with trace elements while *Valvulineria bradyana*, that is located in the 2nd quadrant, demonstrates a marked statistical affinity with TOC, silt and clay.

Conclusions

A preliminary evaluation about the human impact on the coastal marine environment suggests that only the agriculture input is source of significant pollution. Pesticides are mainly distributed along a belt parallel to the coast, following the dominant currents, without involving coastal and offshore areas. The correlation occurring between trace elements and some foraminifera probably indicates the preference for the same sediments characteristics, more than a direct link. Trace elements, due to their low concentration, do not influence negatively the assemblages that show a good species diversity and no significant percentages of deformed specimens. Finally, our results confirm the hypotheses that *Valvulineria bradyana* is a good indicator of organic matter-enriched environments (5).

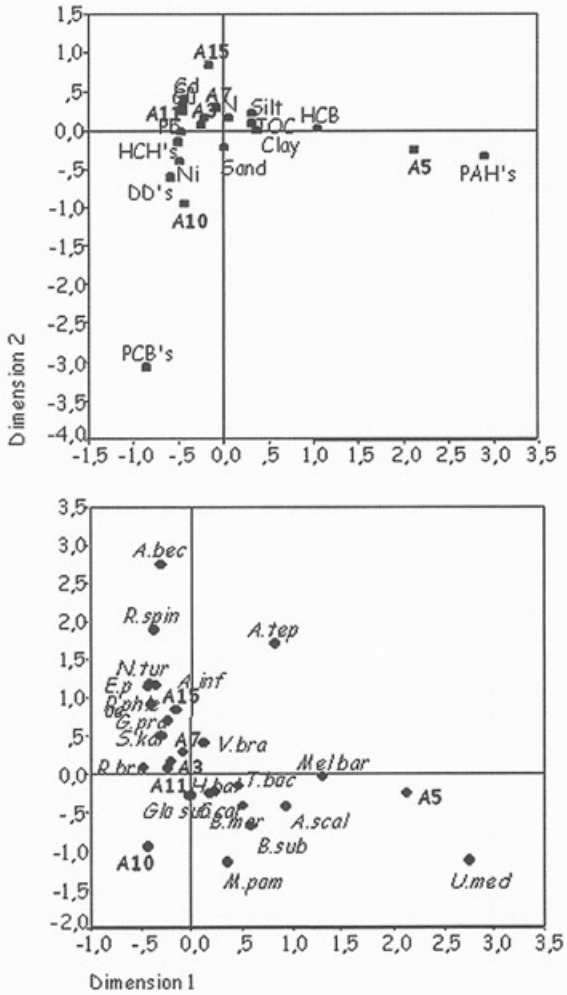

Fig. 1. Output of the correspondence analysis.

References

1 - Chiocci F.L., La Monica G.B. and Ombrone Scientific Party, 1997. Present day sedimentary processes on central Tyrrhenian continental shelf as the results of a 20 kyr environmental evolution. Abstract Volume International Progress in Oceanography of the Mediterranean Sea, pp. 263-264.

2 - Alve E., 1995. Benthic foraminiferal response to estuarine pollution: a review. *J. Foraminiferal Res.*, 25 (3): 190-203.

3 - Cicero A.M., Finoia M.G., Romano E., Celia Magno M. and Gabellini M., 2002. Composti organici persistenti in sedimenti marini costieri (Mar Tirreno centrale): un caso di approccio multivariato. *Studi Costieri*: 5: 23-34.

4 - UNEP, 1996. State of the marine and Coastal Environment in the Mediterranean Region. MAP Technical Report Series n° 100, UNEP, Athens.

5 - Bergamin L., Carboni M.G., Di Bella L., 1999. *Valvulineria bradyana* (Fornasini) in organic matter-enriched environments. *Il Quaternario*, 12 (1): 51-56.

NEW DATA ON THE ASSOCIATION BETWEEN SEA ANEMONES AND DECAPODS ALONG THE ITALIAN SHORES: SYMBIONTS INSIDE, SYMBIONTS OUTSIDE?

Rocco Rorandelli *, Fabrizio Bartolini, Marina Gomei, Stefano Cannicci

Dipartimento di Biologia Animale e Genetica "Leo Pardi", Università degli Studi Firenze, Italia

* rocco.rorandelli@unifi.it, fabriaran@yahoo.it, gomei@unifi.it, cannicci@dbag.unifi.it

Abstract

This work focuses on the association between decapods and some sea anemones. Previous studies mentioned fewer species of decapods associated with anemones than found in our work. Our surveys brought to the surface a more multifaceted and complex reality, and a discrete structure in their distribution and presence. Our goal is to concentrate on some of these species in order to learn more about the type and modes of this association: can it be considered a real symbiosis?

Keywords: decapod, association, anemone

The Actiniaria are often commensals of other organisms, best known are their relations with hermit crabs, which carry them on their shells. The study is centred on the association between two sea anemones, *Anemonia sulcata*, Pennant 1777 and *Aiptasia mutabilis*, Gravenhorst 1831, and decapod crustaceans. Previous studies showed that *Inachus phalangium, I. dorsettensis, Hyas araneus, Macropodia rostrata, Pisa armata* and *Periclimenes amethysteus* may be associated with *A. sulcata*, but only *I. phalangium* was known to be associated with *A. mutabilis* (4).

We collected data during several expeditions in coastal localities in southern and central Italy, in particular, northwestern Sicily and central and southern Tuscany. During the surveys each team of 2 divers covered a transect of 20 x 20 m^2 each in a restricted range of depths (0 to -10 meters), and for each encountered anemone the following information was recorded: species identity and dimension, depth, substratum, orientation. Anemones were closely analysed with non-invasive handling techniques in order to detect all the possible decapods living in association with them. Species, size, gender, and number of associates were recorded for a later analysis.

Our preliminary data, analysed by vigorous statistical methods, show the presence of never-seen-before crabs that dwell among or under anemone tentacles, in addition to a hierarchy in the incidence of associated species, demonstrating that the one offered by sea anemones is a multi-layer community with a real microhabitat structure, definitely more complex than previously thought (Table 1).

Future work will encompass two major issues: the ecology of the microhabitat, with particular attention to the mechanisms that enable them to share resources, to enable us to judge whether these decapods live in sympatry, hence in competition with one another, or else how they share their niche; and on the physiological and ethological bases of the decapod relationship with anemones. This will enable us to more specifically address the nature and the value of this mutualistic association.

Table.1. Decapods found in association with *Anemonia sulcata* and *Aiptasia mutabilis* in our sampling sites.
Sites number correspond to the following: Western Sicily, "Capo Gallo – Isola delle Femmine Marine Protected Area": Addura: Site 1; Avamposto: Site 2; Isola delle Femmine: Site 3; Barcarolo: Site 4. Central Tuscany: Castiglioncello – Calafuria: Site 1; Affrichella Island: Site 2. Southern Tuscany: Argentario: Site 3; Giglio Island: Site 4; Porto Santo Stefano – Scarlino: Site 5.

Anemone	Locality	Depth(m)	Associated species
Anemonia sulcata	Tuscany – Site 1	3-5	*Inachus phalangium*
		1-3	*Macropodia rostrata*
		3	*Pilumnus hirtellus*
		2	*Pisa armata*
	Tuscany – Site 2	4-6	*Inachus phalangium*
		4-6	*Periclimenes amethysteus*
	Tuscany – Site 3	4-5	*Inachus phalangium*
		4-5	*Macropodia rostrata*
		4-5	*Pilumnus hirtellus*
	Tuscany – Site 4	10-12	*Inachus phalangium*
		10-12	*Pilumnus hirtellus*
		10-12	*Pisa armata*
	Tuscany – Site 5	3-6	*Inachus phalangium*
		3-6	*Macropodia rostrata*
		3-6	*Pisa armata*
	Sicily – Site 2	3-4	*Inachus phalangium*
	Sicily – Site 3	2-3	*Inachus phalangium*
		1.5-2.5	*Periclimenes amethysteus*
		1.5	*Pilumnus hirtellus*
		2-3	*Pisa armata*
	Sicily – Site 4	1	*Acanthonyx lunulatus*
		0.5-2	*Inachus phalangium*
		1-2	*Pilumnus hirtellus*
		0.5-1	*Pisa armata*
		1-2	*Xantho poressa*
Aiptasia mutabilis	Sicily – Site 1	1.8	*Inachus phalangium*
		1.5 – 2	*Pilumnus hirtellus*
	Sicily – Site 2	5	*Inachus phalangium*

References

1 - P. Castro – M. E. Huber, 1992. Marine Biology (ed), Mosby Year Book, St. Louis.

2 - S. R. Santos, D. J. Taylor, and M. A. Coffroth, 2001. Genetic comparisons of freshly isolated versus cultured symbiotic dinoflagellates: implications for extrapolating to the intact symbiosis. *J. Phycol.*, 37(5): 900 - 912.

3 - T. C. LaJeunesse, 2001. Investigating the biodiversity, ecology, and phylogeny of endosymbiotic dinoflagellates in the genus Symbiodinium using the ITS region: in search of a "species" level marker. *J. Phycol.*, October, 37(5): 866 - 880.

4 - Taylor DL., 1969. The nutritional relationship of *Anemonia sulcata* (Pennant) and its dinoflagellate symbiont. *J Cell. Sci.*, 4(3): 751-62.

5 - P.Wirtz, R.Diesel, 1983. The social structure of *Inachus phalangium*, a spider crab associated with the sea anemone *Anemonia sulcata*. *Z. Tierpsychol*, 62: 209-234.

RÔLE TROPHIQUE DES PROTOZOAIRES DANS LA LAGUNE DE BIZERTE (CÔTE NORD DE LA TUNISIE)

Sakka Hlaili Asma * et El Grami Boutheina

Faculté des Sciences de Bizerte, Zarzouna, Bizerte; Tunisie - * asma_sakka@yahoo.fr

Résumé

La pression de broutage ‹‹g›› exercée par les protozoaires sur le phytoplancton ainsi que la croissance de ce dernier‹‹k›› ont été estimées par la méthode de dilution pendant 2002. Les taux ‹‹g›› et ‹‹k›› ont fluctué au cours des saisons et ont suivi les changements saisonniers des communautés des microalgues et des protistes. Le phytoplancton a été soumis à un contrôle sévère par les protozoaires, puisque les valeurs de ‹‹g›› ont été équivalentes ou supérieures à celles de ‹‹k››. Le protozooplancton joue donc un rôle trophique important puisque, à travers son broutage, il contribue au transfert du carbone biogène vers les consommateurs supérieurs.

Introduction

Les protozoaires ont reçu un grand intérêt particulièrement dans les eaux oligotrophes, où le phytoplancton de petite taille est dominant. En effet, les protistes, principaux consommateurs des pico- et des nanoalgues, constituent un lien trophique crucial entre ces petits phototrophes et les métazoaires (1, 2). Dans les systèmes eutrophes dominés par le phytoplancton de grande taille, on a longtemps pensé que le transfert du carbone biogène vers les métazoaires ne se produit qu'à travers le mésozooplancton. Or, plusieurs études ont révélé que le microzooplancton exerce de forte pression de broutage dépassant parfois la croissance des microalgues dans les régions eutrophiques (3). En outre, les diatomées peuvent être efficacement consommées par certains dinoflagellés hétérotrophes. Par conséquent, pour comprendre la dynamique planctonique dans les régions littorales, qui sont souvent le siège des efflorescences microalgales, la broutage par le protozooplancton doit être considérée comme un facteur important dans la structuration des assemblages phytoplanctoniques de ces régions.

Notre objectif est donc d'évaluer le rôle des protozoaires, dans un écosystème méditerranéen côtier en comparant leur pression de broutage à la croissance phytoplanctonique.

Matériel et méthodes

Les taux de broutage des protozoaires ‹‹g›› et les taux de croissance spécifique du phytoplancton ‹‹k›› ont été estimés pendant les 4 saisons de 2002 en utilisant le protocole de dilution (Landry-Hassett). Les concentrations en Chl *a* ont été déterminées selon la méthode spectrophotométrique. L'identification et le comptage des micoalgues et des protozoaires ont été réalisées sous microscope inversé selon la méthode d' Utermöhl.

Résultats et discussion

La concentration en Chl *a* a significativement fluctué entre les saisons. Elle a augmenté progressivement de l'hiver à l'été puis a chuté en automne (Tab. 1). La biomasse du phytoplancton a en fait varié de la même façon que son taux de croissance ‹‹k›› (Tab. 1). La stimulation de la croissance pendant le printemps et l'été ne peut être qu'une réponse logique à l'élévation de la température et des concentrations en nutriments (résultats non présentés). En effet, les taux ‹‹k›› ont été positivement corrélés avec ces deux facteurs abiotiques (r_s = 0,7** et 0,8**).

La structuration du phytoplancton a également changé entre les saisons (Fig. 1). Les flagellés ont dominé en hiver et en automne alors que les diatomées ont les plus fortes contributions pendant le printemps et l'été. En général, la succession saisonnière des microalgues est régie par le changement des facteurs abiotiques tel que la lumière, la température, la salinité et les nutriments (4,5). Dans cette étude, c'est la disponibilité des nutriments qui a commandé la dynamique des flagellés et des diatomées. En effet, les contributions relatives de ces deux groupes ont été significativement corrélées avec les teneurs en nutriments (flagellés: r_s= -0,7**; diatomées : r_s = 0,9**).

Tableau 1. Variation saisonnière de la Chl *a*, de l'abondance des protozoaires et des taux ‹‹g›› et ‹‹k›› dans la lagune de Bizerte durant l'année 2002.

	Chl *a* ($\mu g\ l^{-1}$)	Protistes (10^4 cell.l^{-1})	‹‹g›› (j^{-1})	‹‹k›› (j^{-1})
Jan.	1,9 ± 0,2	19,7 ± 2,6	0,53 ± 0,04	0,54 ± 0,03
Fév.	2,3 ± 0,7	16,3 ± 2,0	0,50 ± 0,00	0,55 ± 0,01
Avr.	3,0± 0,3	28,7 ± 5,0	0,84 ± 0,05	0,87 ± 0,03
Mai	3,5± 0,2	26,6 ± 1,5	0,89 ± 0,03	0,85 ± 0,04
Juin	5,9± 0,4	43,7 ± 3,4	1,48 ± 0,06	1,11 ± 0,04
Juil.	6,3± 0,5	50,2 ± 6,6	1,51 ± 0,02	1,02 ± 0,07
Oct.	1,1± 0,0	10,6 ± 1,4	0,65 ± 0,01	0,45 ± 0,08

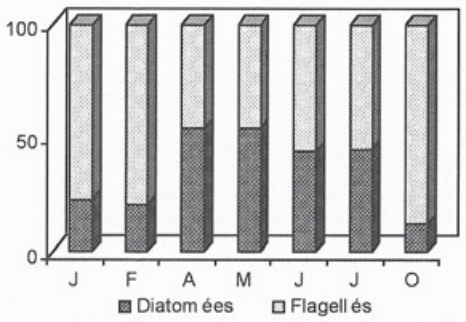

Fig. 1. Variation saisonnière de la structuration du phytoplancton dans la lagune de Bizerte pendant 2002.

La densité des protozoaires a montré une variation saisonnière semblable à celle de leur proies, la corrélation entre les protistes et la Chl *a* étant significative (r_s= 0,77**). En outre, ces consommateurs, principalement des ciliés, se trouvent positivement corrélés à la température (r_s = 0,58*).

Les taux de broutage ont fluctué au cours des saisons de la même façon que la Chl *a* et l'abondance des protistes. Ceci n'est pas surprenant puisque la quantité des brouteurs ainsi que celle des proies influence largement les taux ‹‹g›› (6). Outre la quantité, la qualité des proies peut également affecter les taux ‹‹g›› puisque les protistes peuvent sélectionner leurs proies selon leur taille, leur motilité et leur pouvoir de se diviser. Ainsi, la variation saisonnière de la structuration du phytoplancton dans la lagune (Fig. 1) pourrait influencer son taux de broutage. En outre, la variation saisonnière des taux ‹‹g›› se trouve régie par les mêmes facteurs (température et nutriments) qui ont commandé la fluctuation des taux ‹‹k›› puisqu'il existe une relation étroite entre les ‹‹g›› et les ‹‹k›› (r_s = 0,9**).

Les taux de broutage ont été équivalents à ceux de la croissance et peuvent même les dépasser au cours des différentes saisons. Ceci suggère donc que le phytoplancton de la lagune de Bizerte se trouve sous un sévère contrôle par le protozooplancton. Ce dernier constitue un lien trophique important qui achemine la production vers les niveaux supérieurs. Ceci met donc en doute le concept de la chaîne alimentaire dans cet écosystème eutrophe et supporte l'idée de l'existence d'autres voies trophiques.

Références

1 - Sherr E. B., Sherr B. F., Paffenhöfer G. A., 1986. Phagotrophic protozoa as food for metazoans: a "missing" trophic link in marine pelagic food web? *Mar. Microb. Food. Webs*, 1: 61-80.

2 - Sakka A., Legendre L., Gosselin M., Delesalle B., 2000. Structure of the oligotrophic planktonic food web under low grazing of heterotrophic bacteria: Takapoto Atoll, French Polynesia. *Mar. Ecol. Prog. Ser.*, 197: 1-17.

3 - Strom S. L., Strom W. M., 1996. Microzooplankton growth grazing and community structure in north Gulf of Mexico. *Mar. Ecol. Prog. Ser.*, 130: 229-240.

4 - Burford M. A., Pearson D. C., 1998. Effect of different nitrogen sources on phytoplankton composition in aquaculture ponds. *Aquat. Microb. Ecol.*, 15: 277-284.

5 - Macedo M. F., Duarte P., Mendes P., Ferreira J. G., 2001. Annual variation of environmental variables, phytoplankton species composition and photosynthetic parameters in a coastal lagoon. *J. Plankton Res.*, 23: 719-732.

6 - Sherr E. B., Sherr B. F., McDaniel J., 1991. Clearance rates of < 6 µm fluorescently labelled algae (FLA) by estuarine protozoa: potential grazing impact of flagellates and ciliates. *Mar. Ecol. Prog. Ser.*, 69: 81-92.

PRESENCE OF THE SCLERACTINIAN *DENDROPHYLLIA RAMEA* IN THE SHALLOW WATERS OF MEDITERRANEAN MOROCCO (AL HOCEIMA, ALBORAN SEA)

Salvati E., Tunesi L. *, Molinari A.
ICRAM, Rome, Italy - * e.salvati@icram.org

Abstract
During a diving survey at Al Hoceima (Mediterranean Morocco), colonies of *Dendrophyllia ramea* were discovered in a depth range of 24 –37 meters, the shallowest record at present recorded for this species. The measurement of the height of the colonies and their diameter close to the base allowed to calculate the correlation coefficient between 10 colonies.

Keywords: Dendrophyllia ramea, Benthic communities, Alboran Sea, Morocco

Introduction

Data on hard bottom benthic communities was collected within the MedMPA project of the Al Hoceima National Park (Morocco, Alboran Sea), coordinated by the Regional Activity Centre for Specially Protected Areas (RAC/SPA-Tunis) and financially supported by the European commission. Many colonies of *Dendrophyllia ramea* were recorded during surveys conducted between 24 and 37 meters. This species, present in the southern part of Mediterranean Sea, tolerates warm waters better than *D. cornigera* (1). Common at a depth lower than 80 meter, *D. ramea* was collected, in 1971 in the Alboran Sea at 40 meters, during a dredging in front of Malaga (1).

The record of this species in shallower waters allowed to collect morphometric data and information on its associated benthic assemblage.

Materials and Methods

The field survey was carried out during summer 2003. Underwater sampling, aimed at describing rocky bottom benthos communities, was carried out through coast-off coast transects, 100 meters long or up to 33 meters maximum depth.

On the whole 15 transects were carried on (Fig. 1). *D. ramea* was recorded within transects 3, 9 and 11 at a depth between 24 and 37m. At site 11, the height and the diameter (close to the base) of 10 colonies was measured .

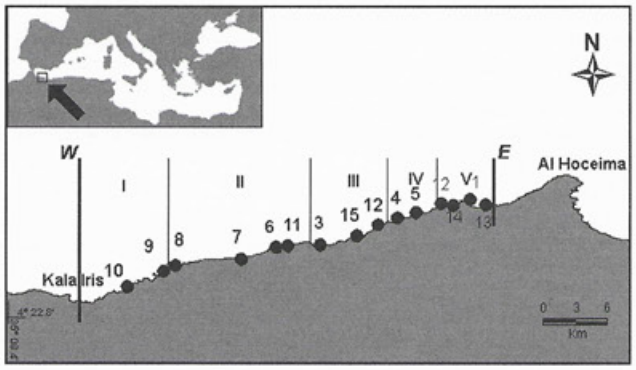

Fig.1. Study area and sampling sites.

Results

D. ramea colonies were recorded on rocky vertical cliffs between 24 and 37 meters of depth .Each of the three sites was characterised by high hydrodinamism, suspended particles and a temperature between 17 and 18°C.

The sites in which *D. ramea* was present were characterized by high species richness and especially a high presence of Antozoa (*Paramuricea clavata, Paramuricea sp., Eunicella verrucosa, Eunicella singularis, Leptopsammia pruvoti, Astroides calycularis, Leptogorgia ceratophyta*).

Within the same site, *D. ramea* colonies were observed with white or yellow polyps.

The correlation existing between the variables measured for each colony (height and diameter of the theca close to the base) was calculated through Spearman's correlation coefficient (r_s). ($P < 0.01$) (Fig.2).

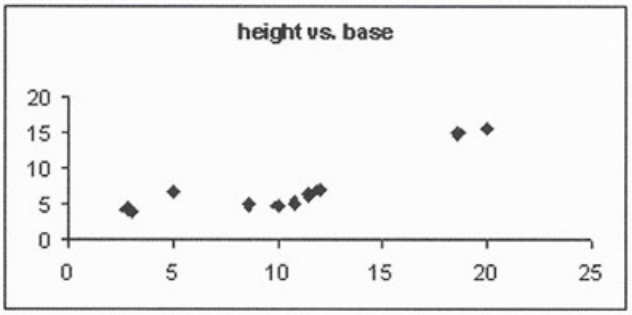

Fig. 2. Spearman's coefficient is *rs*=0.8545 (one tail test) showed an high positive correlation (P <0.01).

Conclusions

The knowledge on the distribution and ecology of *D.ramea,* unlike the other species of the *Dendrophyllia* genus (1-4), pertains to old studies often carried out by occasional collections. The presence of the species in shallower depths with a constant temperature of 17°C, could be linked to the presence of a thermal stability of the water column in the study area, which would favour the ascension of this species limited only by the light intensity. The presence of *D. ramea* in superficial waters could be a stimulus for future studies aimed at the ecological study of the species.

Acknowledgments. The authors are particularly grateful to the management of the Ministère des Eauxs et Forêts and the personnel of the I.T.P.M. of Al Hoceima for their valid assistance and collaboration. The authors would like to thank also S. Agnesi, T. Di Nora, M. Manca Zeichen, E. Piccione for cartographical support.

References

1 - Zibrowius H., 1980. Les scleractiniaires de la Méditerranée et de l'Atlantique nord-oriental. *Mem. Inst. Oceanogr. Monaco*, 11, 391 p.
2 - Pérès J.M. and Picard J., 1964. Nouveau Manuel de Bionomie Benthique de la mer Méditerranée. *Rec. Trav. Stat. Mar. Endoume*,13, 138 p.
3 - Zibrowius H. and Brito A., 1984. *Dendrophyllia laboreli* n.sp., an infralittoral and circalittoral coral from West Africa and Canary Islands (Cnidaria, Anthozoa, Scleractinia). *Bull. Mus. Natl. Hist. Nat. France, 4E Ser. A- Zool. Biol. Ecol. Anim.*, 6(3) : 641-657.
4 - Castric-Fey A., 1996. The scleractinian *Dendrophyllia cornigera* in shallow water, at Ushant (Brittany, NE Atlantic), related to the absence of a thermic barrier. *Oceanol. Acta,* 19 (6): 665-671.

SPREADING POTENTIAL OF AN INVADER: *RAPANA VENOSA* IN THE NORTHERN ADRIATIC SEA

D. Savini * and A. Occhipinti-Ambrogi

Dept. Genetics and Microbiology, Ecology Section, Pavia, Italy - * dario.savini@unipv.it; occhipin@unipv.it

Abstract

The population of the invasive gastropod *Rapana venosa* in the Northern Adriatic Sea showed continuous mating and spawning activities from March to September and high egg case deposition rates. Reproduction occurred mainly on the artificial reefs placed along the littoral for preventing beach erosion. The large availability of *Rapana* larvae could increase the transfer risk of the alien species via ballast water towards new international destinations.

Key-words: alien species, reproduction, spreading potential, Rapana venosa, Northern Adriatic

Introduction

The Asian gastropod *Rapana venosa* (Valenciennes, 1846) is recognised as one of the most unwanted nuisance species in the world (1). This large muricid (maximum shell length > 160 mm) is a predator of bivalves of commercial interest such as oysters, mussels and clams. Consequences of its introduction result in localised depletion of bivalves stocks and side effects on benthic-pelagic coupling. *R. venosa* was responsible for unbalancing the food web of the Black Sea (2). Feeding on bivalve preys led to a decrease in food availability for some of the local bottom-feeding fish, as well as some planktivorous fish which use bivalve meroplankton as food. This gastropod is characterised by high ecological fitness, being tolerant of low salinity, water pollution and oxygen deficiency at both the adult and the larval stage (3).

The world distribution of *R. venosa* is reported by Mann *et al.* (1). In the Northern Adriatic the whelk was introduced in the 1970s and it is now distributed from Trieste to Ancona. We found high densities of the gastropod in Cesenatico (Emilia-Romagna), where the bulk of the reproductive population is clustered on the rocky artificial reefs, 300 meters from the coastline (average density: 13 ind. 100 m^{-2}) (4).

In this paper we report our findings on the reproductive activity of *R. venosa* on the rocky artificial reefs off Cesenatico as an indication of the spreading potential of this alien species.

Materials and Methods

The length of *Rapana venosa* reproductive period was estimated on the basis of data obtained by local fishermen of squids, whose nets are clogged by *Rapana* egg cases. In order to assess egg cases maturation stages, on May 2001 three clusters, each bearing 20 egg cases, were collected (by scuba diving) from female whelks spawning on the support piles of a landing place in Cesenatico. The egg clusters were kept in three replicates 2 l glass jars filled with marine water taken near the collection place and maintained in observation till hatching. Egg cases morphological modifications during maturation were annotated. The experimental jars were kept on natural light conditions and water exchange was made daily checking for salinity and temperature values.

From 20/06/01 to18/07/01 all *Rapana* egg cases laid every week on three rocky reefs (submerged surface: 115 m^2) located 300 meters off the beach of Cesenatico were removed manually by SCUBA divers. Egg cases were scraped gently from the substratum using a broad knife and kept in net bags (one for each replicate); afterwards, they were separated and counted per maturation stages.

Results

The appearance of *Rapana venosa* egg cases on local fishermen's squid nets started from the end of March 2001 till the end of the fishing season (end of July 2001). We found the last egg case on the rocky reef at the end of September 2001; therefore, the spawning period lasted 5 months (water temperature range: 12-28° C).

The egg cases maturation experiment identified five stages from day 0 (collection) to day 14-21 (hatching):

1) day 0 = during deposition the egg case was whitish pale yellow and of gelatinous consistence.
2) day 1-3 = the wall case was pale yellow and eggs appeared inside as tiny whitish spots suspended in a gelatinous matrix.
3) day 3-7 = the wall case was deep yellow and eggs inside were well visible.
4) day 7-14 = the wall case lost its turgidity and colour, eggs develop in larvae with a pale grey shell.
5) day 14-21 = the wall case became very thin and of papery consistence, with evident actively black swimming larvae inside the capsule.

Considering the number of egg cases belonging to the 2nd and 3rd maturation stage (~ 7 days from spawning) collected weekly on 115 m^2 rocky reef, maximum average deposition occurred at the beginning of the investigation (20/6 = 2780 ± 1001 egg cases/week). A negative trend in deposition was evident (27/06 = 1895 ± 703; 05/07 = 1253 ± 560) with minimum values registered the last two weeks (12/7 = 994 ± 592 egg cases/week; 18/07 = 1121 ± 614 egg cases/week). For the entire experimental period the average weekly deposition rate was of 1340 ± 387 egg cases.

Discussion

Our results showed high reproduction activity of the gastropod *Rapana venosa*. Considering a minimum of 800 larvae produced per egg case, the minimum reproductive potential of *Rapana* on a rocky reef would be 800 x 994 (average minimum number of egg cases laid on a 115 m^2 rocky reef) = 795,200 larvae/week. The reproductive season of the gastropod in the area lasts about five months; rocky reef structures are lining most of the Northern Adriatic littoral (over 60% of Emilia Romagna shores are protected by rocky reef structures) (5); therefore the spreading potential of *Rapana* is extremely high. *Rapana* larvae are planktonic for a minimum of 14 to a maximum of 80 days prior to settlement and are resistant to salinity variations and other stress agents (1). The Northern Adriatic Sea is interested a by an intense interoceanic shipping activity representing 26% of the national traffic, with five large international harbours: Trieste, Porto Nogaro, Venice, Chioggia, Ravenna and Ancona (6); this would increase the transfer risk of alien species, such as *Rapana venosa*, whose larvae can be transferred via ballast water towards new international destinations.

References

1 - Mann R., Occhipinti A., and Harding J.M., 2002. ICES Special advisory report on the current status of invasions by the marine gastropod *Rapana venosa*. Report of the WGITMO, Gothenburg, Sweden, March 20-22, 2002. ICES, Copenhagen, Denmark, pp. 117-134.

2 - Drapkin E., 1963. Effect of *Rapana bezoar* Linné (Mollusca, Muricidae) on the Black Sea fauna. *Doklady Akademii Nauk SRR,* 151: 700-703.

3 - Mann R., and Harding J.M., 2000. Invasion of the North American Atlantic coast by a large predatory Asian mollusc. *Biol. Invasions*, 2: 7-22.

4 - Savini D., Castellazzi M., Favruzzo M., and Occhipinti Ambrogi A., 2003. The alien mollusc *Rapana venosa* (Valenciennes, 1846) (Gastropoda, Muricidae) in the Northern Adriatic Sea: population structure and shell morphology. *Chem. Ecol.*, in press.

5 - Baciocchi F., and Airoldi L., 2003. Distribution and dynamics of epibiota on hard structures for coastal protection. *Estuar. Coast. Shelf Sci.*, 56: 1157-1166.

6 - Occhipinti Ambrogi A., 2002. Susceptibility to invasion: assessing scale and impact of alien biota in the Northern Adriatic. In: Alien marine organisms introduced by ships in the Mediterranean and Black seas. *CIESM Workshop Monographs*, Monaco, 20: 69-74.

THE ECOTONE GRADIENT IN THE LAGOON ESTUARY OF THE RIVER NATISSA IN NORTHERN ADRIATIC SEA

Renato Sconfietti

Department of Genetics and Microbiology, Section of Ecology, University of Pavia, Italy - renato.sconfietti@unipv.it

Abstract

This paper emphasizes the strict analogy between the ecological zonation along the lagoon estuary of the river Natissa and the Atlantic schemes of estuarine zonation proposed by the literature. Like in other north Adriatic estuarine ecotones, the whole gradient is appreciable in only a few chilometres.The conservative feature of the true estuarine pool is pointed out.

Keywords: estuary, lagoon, Adriatic Sea, ecotone

Introduction

Our previous papers pointed out the estuarine features of the Grado-Marano lagoon [1, 2, 3], the second for wideness after the lagoon of Venice. This paper examines in detail its ecotonal communities on hard substrata, to identifie analogies with the Atlantic schemes of estuarine zonation [4].

Materials and Methods

During the summer in 2000 and 2001, biological samples have been obtained in eight stations (Fig. 1) from wooden piles, that mark the navigable canals. The lagoon and the sampling methods are extensively described in our quoted papers. Both sessile and mobile benthos have been investigated; data were analysed with the Primer 5.0 software for the community structure, MDS and cluster analysis.

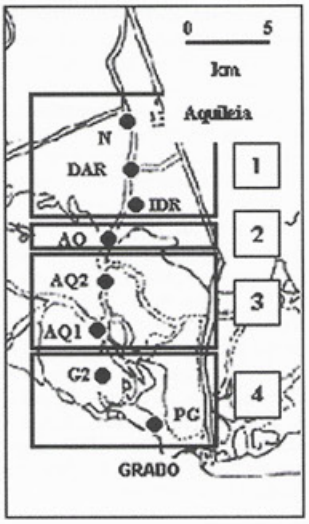

Fig. 1. The eight sampling stations with the four sectors (1-4) described in *Conclusion*.

Results and Discussion

More than 80 species have been identified, almost equally divided in sessile and mobile benthos. Among these, only a few species reach the town of Aquileia, where cohabit with elements of the continental domain. The richest communities, for both biomass and number of species, are placed in the middle part of the gradient, in the full lagoon sector.

This pattern is well esemplified by some structural parameters of the mobile communities (Fig. 2), whose distribution is less influenced by the aggregation of many sessile species.

The proposed example of the MDS applied on the whole community for 2001 show a clear separation in two blocks of stations (Fig. 3): the continental and the lagoon ones. The central position of the st. AQ corresponds

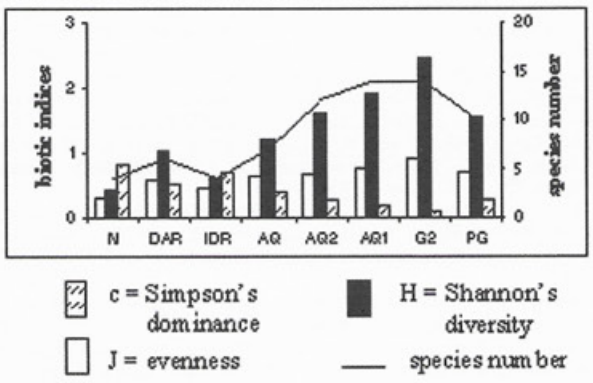

Fig. 2. Biotic indices for the mobile benthos in 2001.

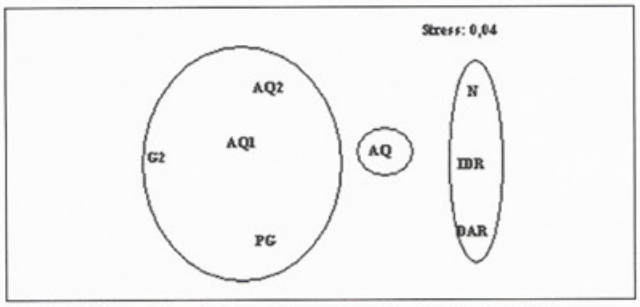

Fig. 3. MDS graph on both sessile and mobile benthos in 2001.

to the topographical collocation, at the interface between the continental and the lagoon course of the river Natissa. These assemblages are confirmed by the cluster analysis.

Therefore, the scheme proposed for Atlantic estuaries can be extended to this Mediterranean pattern, notwithstanding the reduction of the longitudinal extension.

In the upper stream, where salinities values range from 0 to 15 psu, a poor but original pool of species can be pointed out, which is recurring in analogous sectors of other estuaries [5]: the bryozoans of the family Victorellidae, the hydrozoan *Cordylophora caspia* (Pallas), the polychaete *Ficopomatus enigmaticus* (Fauvel), the tanaid *Heterotanais oerstedi* (Kroyer) and the amphipod *Leptocheirus pilosus* (Zaddach).

A few euryhaline species colonize the whole gradient, such as the bryozoan *Conopeum seurati* (Canu), the barnacle *Balanus improvisus* Darwin and the tubicle amphipod *Corophium insidiosum* Crawford.

Most of the species have been collected in the full lagoon portion of the estuary or near the sea mouth. Among these, the presence of the alloctone bryozoan *Tricellaria inopinata* (d'Hondt & Occhipinti Ambrogi) [6] is confirmed, together with a probable new species for the Mediterranean Sea, the other bryozoan *Anguinella palmata* van Beneden, whose identification must be approved by specialists.

Conclusion

The four classic sectors proposed by Mc Lusky [4] have been here recognized (Fig. 1): 1) the head of the estuary; 2) the middle reach, corresponding with the proper ecotonal transition; 3) the lower reach; 4) the mouth, near the sea port. The recurring occurrence of the same pool of species in the true estuarine portion of different estuaries signifies a strong conservative composition, whose enrichment is obstructed mainly by osmotic barrier coming from the marine domain toward the continental waters. On the contrary, the lagoon portion of the estuary is open to biological novelties, because of the little selective salinity and the favourable trophic conditions of the well vivified sectors.

References

1 - Sconfietti R., Marchini A., Occhipinti Ambrogi A., and Sacchi C.F., 2003. The sessile benthic community patterns on hard bottoms in response to continental vs. marine influence in northern Adriatic Sea. *Oceanologica Acta*, 26: 47-56.

2 - Gemelli A., Marchini A., Oleotto R., Sacchi C.F., Sconfietti R., and Tibaldi E., 2001. Ècosystèmes d'estuaire sur substrat cohérent dans la lagune de Grado-Marano (Adriatique du nord). *Rapp. Comm. int. Mer Médit.*, 36: 386.

3 - Sconfietti R., and Gemelli A., 2002. L'estuario del fiume Natissa nella laguna di Grado-Marano (Mare Nord-Adriatico): gradienti biocenotici di substrato duro. *Studi Trentini di Scienze Naturali – Acta Biologica*, 78: 219-226.

4 - Mc Lusky D.S., 1971. The estuarine ecosystem. Blackie & Son, Glasgow and London: 1-131.

5 - Sconfietti R., 1989. Ecological zonation and dynamics of hard-bottom Peracarid communities along the lagoon estuary of the river Dese (Lagoon of Venice, northern Adriatic sea). *Riv. Idrobiol.*, 28: 3-31.

6 - Occhipinti Ambrogi A., 2000. Recent developments in the history of the Bryozoans of the lagoon of Venice: biodiversity and environmental stress. Pp. 305-315. *In:* Proceedings of the 11th International Bryozoology Association Conference. Allen Press, Lawrence Kansas.

ECOLOGICAL STRUCTURE AND DYNAMICS OF THE SEAGRASS *CYMODOCEA NODOSA* IN MONTAZAH BAY OFF ALEXANDRIA, EGYPT

S. H. Shabaka [1] *, H. M Mostafa [2] H. Mitwally [2], Y. Halim [2]

[1] National Institute of Oceanography and Fisheries, Alexandria, Egypt

[2] Department of Oceanography, Faculty of Science, University of Alexandria, Egypt - youssefhalim@hotmail.com

Abstract

Cymodocea nodosa was sampled from different sites located within a seagrass bed in Montazah Bay, Alexandria, Egypt. Samples were collected at bimonthly during the period from February 2002 to December 2002. Physico-chemical parameters were measured in conjunction with seagrass phenological parameters. Generally, all phenological parameters except rhizome-root biomass showed maximum values in late spring (June), and minimum values during winter. Rhizome-root biomass, showed an opposite trend. It was concluded that although light and temperature are the major factors controlling seasonality of *C. nodosa* growth, during summer the growth is limited by other factors, mainly self-shading and nutrient limitation. Five environmental factors were identified as important in controlling biomass and abundance of *C. nodosa*. These include temperature, salinity, light, water and sediment nutrient concentrations. Qualitative determination of associated epiphytes was also performed.

Key words: Seagrasses; Cymodocea nodosa; Montazah; Alexandria; Egypt

The presence of the two species of seagrasses *Posidonia oceanica* and *Cymodocea nodosa* along the Egyptian Mediterranean waters is largely documented (1, 2,3, 4). Along Alexandria coastal waters, many beds have been badly damaged and seagrasses are reduced to scattered patches in inshore semi-closed bays. In front of Alexandria, seagrass beds are exposed to untreated wastewater pollution and turbidity. Growth of *C. nodosa* is continuous throughout the year with a unimodal cycle. Its foliage started to increase toward spring and became particularly dense in late spring (June), with maximum-recorded shoot density (131shootsm^{-2} ±44) and leaf density (368 leafm^{-2} ±473). These values decreased towards summer. Minimum shoot and leaf densities were recorded during winter (52 shootm^{-2}±8, 113 leafm^{-2}±13). Leaf area index, leaf length, epiphytic area, photosynthetic area and leaf biomass showed the same cyclic pattern as shoot and leaf densities. Rhizome-root biomass showed an opposite cyclic pattern to the other phenological parameters, where maximum values were recorded during winter (23.4gm dwm^{-2} ±6), and minimum values recorded June (4.7gm dwm^{-2}±2). Principal component analysis was used for "*C. nodosa* phenological-Physicochemical parameters relationship". Plotting PC1 against PC2 (Fig. 1) revealed that phenological parameters of the foliar system had positive correlations with temperature and PH, and negative correlations with dissolved nutrients and salinity and insignificant correlation with total sediment organic matter (TOM). Root-rhizome biomass showed completely opposite correlations to those of the foliar system. Seasonal variation of the foliar system of *C. nodosa* could probably be related to changes in temperature and light availability. Changes in temperature over the year seem to play an important role in the reproduction cycle of *C. nodosa*, which influence the leaf growth and production (5). In the meadow under study, a male flower and seeds were recorded at the end of April. It seems to be that seeds were dormant, buried in the sediment until germination started in April, coinciding with the rise in water temperature. It was observed that the potential production set by the incoming irradiance and water temperature was not met during summer. This deviation may be attributed to the following reasons: **a)** Increased epiphytic growth on plant leaves in late spring. **b)** Self-shading by the plants, where maximum leaf length was recorded during late spring. **c)** Higher turbidity observed in the bay during summer **d)** Nutrient limitation of summer growth, where minimum dissolved nutrient concentrations was recorded during late spring. This may be attributed to the active consumption of the seagrass to the dissolved nutrients. The reduction of salinity due to intrusion of fresh water that may carry high concentrations of dissolved nutrients caused the initiation of the foliar system growth in late winter. The opposite correlation between the underground biomass and foliar system biomass may be attributed to the dependence of the rhizome and roots on the extensive foliar system biomass during their growing season in absorption of the nutrients from the surrounding water. After the collapse of the foliar system that occurred in the summer season, rhizome and root system started to increase in biomass to compensate the reduction of dissolved nutrients in seawater by absorption of the nutrients from the sediments. The sediment is the main source for phosphorus in carbonate sediment seagrasses, the acquisition of phosphorus by both seagrasses *P. oceanica* and *C. nodosa* might be limited by sparse supply in water column and their ability of speeding up the uptake of phosphorus from the sediments (6). In Montazah Bay, turbidity caused by water sports and seagrass damaging are a threat to seagrass meadows. Despite these destructive factors, *C. nodosa* is a eurybiontic species tolerates considerable fluctuations in environmental variables. This may explain the dominance of *C. nodosa* over the *P. oceanica* when the conditions are unfavorable for the stenobiontic *P. oceanica* (4).

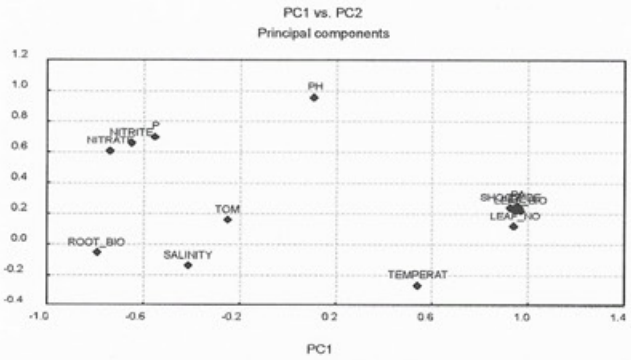

Fig. 1. Components loadings matrix of phenological parameters (leaf area index, leaf density, shoot density, photosynthetic area and epiphytic area and Physico-chemical parameters (salinity, temperature, PH, TOM and dissolved inorganic nutrients).

Cymodocea nodosa epiphytic associations:

Floral epiphytes: Blue green algae: *Anacystis aeruginosa, Oscillatoria lutea.* Red algae: *Audouinella thuretii, A. virgatula, Bangia atropurpurea, Chroodactylon ornatum, Erythrocladia carnea, Hydrolithon farinosum, Melobesia membranacea, Pneophyllum fragile kuetzing, Porphyrostromium ciliare, Sahlingia subintegra, Stylonema aslidii, S. cornu-cervi.* Brown algae: *Giraudia sphacelarioides, Myrionema orbiculare.* Green algae: *Cladophora socialis, Entocladia flustrae, Ulvella len* (Personal comm. Prof. Giusppe Giaccone).

References

1 - Steuer, A., 1935. The fishery grounds near Alexandria. I-Preliminary report. In notes and memories, no. 8 Cairo.

2 - Aleem, A.A., 1955. Structure and evolution of the seagrass communities *Posidonia* and *Cymodocea* in the southern Mediterranean. Essays in the natural science in the honor of Capitan Allan Hancock. Univers. Of S. Calif. press Los Angeles, Calif., pp. 279-298.

3 - Mostafa, H. M., 1996. Preliminary observations of the seagrass *Cymodocea nodosa* (Ucria) Asherson in the Mediterranean waters off Alexandria, Egypt. *Bull. Nat. Inst. Of Oceanogr. & Fish.*, A. R. E., (22): 19-28.

4 - Den Hartog, C., 1970. The seagrasses of the world. North- Holland publishing Co., Amsterdam, 275 p.

5 - Buia, M. L. Mazzella, 1991. Reproductive phenology of the Mediterranean seagrass *Posidonia oceanica* (L.) Delile, *Cymodocea nodosa* (Ucria) Ashers., and *Zostera notlii* Hornem. *Aquatic Botany,* 40 : 343-362.

6 - Mostafa, H. M., 1997b. Phosphorus content in seagrass meadows of *Posidonia oceanica* (L.) Delile and *Cymodocea nodosa* (Ucria) Ashers off Alexandria, (Egypt). A proceeding of the 7th International conference on Environment protection is a must, 20-22 May, Alex, Egypt, (NIOF) and (ISA) pp. 353-362.

BENTHIC COMMUNITIES OF ROCKY OUTCROPS IN THE NORTHERN ADRIATIC SEA: A QUANTITATIVE SURVEY

S. Soresi, A. Cristofoli, L. Masiero, S. Casellato *

Benthos Ecology Laboratory, Dipartimento di Biologia, Università di Padova, Italia - * sandra.casellato@unipd.it

Abstract

A total of 12 samplings, carried out between August 2002 and May 2003, by SCUBA diving, produced much data regarding the physical-chemical environment and the benthic communities of two rocky outcrops, 20 m deep, opposite Chioggia in the Gulf of Venice, Italy. Little data has been available regarding the floral and faunal communities of this environment. The richness of the community, and the high population density observed in the explored areas, highlight their importance as biodiversity oases in the northern Adriatic Sea.

Keywords: Adriatic, rocky outcrops, benthos, composition

Introduction

The northwestern Adriatic seabed is characterized by soft sediments, from mud and silt to sand. Even though reports of rocky outcrops have been made since 1792 (1), their underwater exploration begun only in 1967 (2-6). The numerous outcrops differ from the rocky matrix of the continental plate, and vary in size, distance from coast, and depth, ranging from 10 to 40 m. They may have originated by the cementing of the pebbly foreshore sediments in the waterline, between 3000 and 4000 years ago (7), or through methane surfacing through sediments (8). The erosion processes uncovered these outcrops, which were subsequently colonized by marine organisms. The encrusting biota incorporates sediment and shells, and itself becomes a substrate for other organisms. Thus complex coralligeneous structures evolve, overgrowing the rocky matrix and simulating reefs. The ecological role of these coralligeneous structures in the northern Adriatic is extraordinary, because, in addition to providing a solid substratum for benthic organisms, they introduce environmental gradients in the monotony of the Adriatic's soft bottoms, generating different ecological niches. Till now, these environments have been only partially studied (9).

Results and Discussion

270 species have been identified from our seasonal samples. Some are new records for the Mediterranean, and one species is new to science; their population density varied between 479 and 3022 ind/m^2 (Fig. 1). Marked differences were observed between the two outcrops, related both to different water turbidity, and the distance from the coast, and to the different origin. The filter feeders and suspension feeders (Fig. 2) predominate; the algae are restricted to few species of Rodophyceae and Corallinaceae. The Shannon-Index values, between 3,44 and 3,57, are much higher than those reported for neighbouring communities on soft sediments (10).

These outcrops represent a high diversity "oasis" in the North Adriatic, and their peculiar communities present characteristics intermediate between the biocenosis of coralligenous platforms (11) and the biocenosis of shelf edge rock (12).

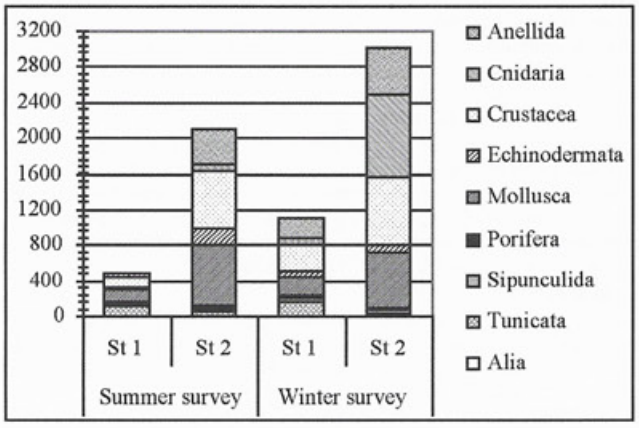

Fig. 1. Quantitative faunistic composition of the two outcrops.

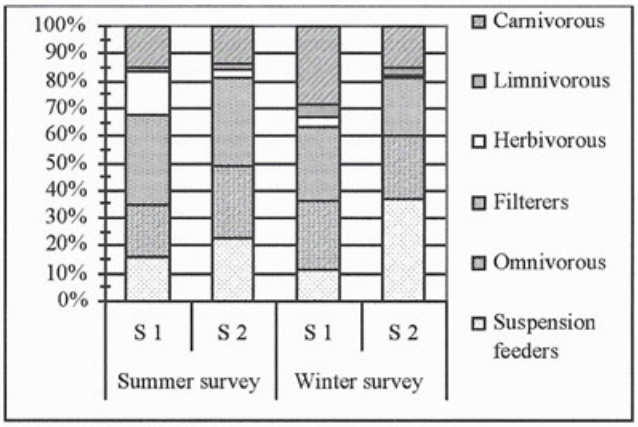

Fig. 2. Feeding guilds composition of the benthic communities of the two outcrops.

References

1 - Olivi G., 1792. Zoologia Adriatica, Bassano.

2 - Stefanon A., 1969. First notes on the discovery of outcrops of beach rocks in the Gulf of Venice (Italy). *Rapp. Comm. Int. Mer. Médit.*, 19 (4): 649.

3 - Stefanon A., 1970. The role of beachrock in the study of evolution of the North Adriatic Sea. *Mem. Biogeog. Adriat.*, 8: 79-99.

4 - Stefanon A., 1972. Beach rocks and Paleogeography in North Adriatic Sea. *Rapp. Comm. Int. Mer Médit.* (4): 606-608.

5 - Newton R.S. and Stefanon A, 1975a. The "Tegnue de Ciosa" area: patch reefs in the Northern Adriatic Sea. *Marine Geology*, 19: 27-33.

6 - Newton R.S. and Stefanon A, 1975b. Application of Side-scan Sonar in Marine Biology *Mar. Biol.*, 31: 287-291.

7 - Braga G. and Stefanon A., 1969. Beachrock e Alto Adriatico: aspetti paleogeografici, climatici, morfologici ed ecologici del problema. *Atti Ist. Veneto Sci. Let. Ed Arti*, 127: 352-361.

8 - Stefanon A. and Zuppi G.M., 2000. Recent carbonate rock formation in the Northern Adriatic Sea: hydrogeological and geotechnical implications. *Hidrogéologie,* 4: 3-10.

9 - Gabriele M, Bellot. M., Gallotti D., and Brunetti R., 1999. Sublittoral hard substrate communities of the Northern Adriatic Sea. *Cash. Biol. Mar.*, 40: 65-76.

10 - Casellato S., Masciadri S., Masiero L., Campi G., 2002. Impact of the hydraulic dredge on the benthos community of the North-western Adriatic coasts. *Biol. Mar. Med.*, 9: 170-179.

11 - Sarà M., 1971. Le peuplement du coralligène des Pouilles. *Rapp. Comm. Int. Mer. Médit.* 30 (3): 235-237.

12 - Gamulin Brida H., 1974. Biocenosis benthique de la mer Adriatique. *Acta Adr.*, 15 (9): 1-102.

BENTHIC COMMUNITY SETTLED ON AN ARTIFICIAL REEF IN THE WESTERN ADRIATIC SEA (ITALY)

Spagnolo A., Fabi G., Manoukian S.*, Panfili M.

CNR - Istituto di Scienze Marine - Sezione Pesca Marittima, Ancona, Italy - m.panfili@ismar.cnr.it

Abstract

Quantitative benthic samples were collected for two years from the horizontal and vertical walls of the concrete modules of Senigallia artificial reef (northern Adriatic sea) to investigate the community settled after about ten years from reef deployment. The artificial structures resulted colonised by a typical eutrophic water community dominated by filter-feeders and showed a different structure on vertical and horizontal surfaces, due to some environmental factors such as siltation, wave motion and currents.

Key-words: Adriatic Sea, artificial reef, benthic community

Introduction

A general assumption of artificial reef research is that the deployment of man-made structures on soft bottoms favours the increase of original benthic communities complexity (1) due to the development of hard-substrate species which could not find available settlement surfaces before.

This statement was confirmed in the central Adriatic Sea, where some studies carried out on the first artificial reef built on a soft-bottom area evidenced that the submersion of man-made substrates favoured the natural settlement of large banks of mussels (*Mytilus galloprovincialis*) and oysters (*Ostrea edulis*, *Crassostrea gigas*) which otherwise might be lost for the lack of suitable surfaces (2).

In order to obtain a more deep knowledge about the benthic communities which colonize these artificial structures in respect to the different depth levels and orientation, Senigallia artificial reef was investigated after ten years from its deployment.

Material and Methods

Senigallia artificial reef is an open-sea area exposed to winds and currents and affected by the Cesano river inflow. It was deployed in 1987 at 1.5 nm offshore, on a sand-muddy bottom (12-13 m deep), far from natural and artificial hard substrates and consists of 29 pyramids, each made of five, 2m-side concrete blocks (4 at the basis and 1 at the top; 3).

The benthic community settled both on basis and top blocks of the pyramids was seasonally investigated, from April 1997 to March 1999. Standard areas (40x40 cm) were sampled with a suction-sampler (horizontal surfaces) and scraping technique (vertical walls). Two replicates for each surface were taken at each survey. Mean abundance (N/dm^2), mean species richness (S_m) and Shannon-Weaver diversity index (H') were computed to quantify the role of the different group species within the community. Similarity among communities having different spatial settlement was evaluated using Cluster analysis based on species abundance and biomass.

Results

In the overall, 56,855 individuals belonging to 179 taxa were identified, 160 of which having a known link with a specific substrate type. Epifauna settled on the artificial modules was dominated by filter-feeders. Crustaceans (amphipods), polychaetes and molluscs represented the most abundant groups everywhere (Table 1). Crustaceans (i.e. *Corophium acherusicum*) were more numerous on the top of pyramids, while polychaetes (*Polydora ciliata*) dominated on the basis blocks. These groups were also the most important in terms of S_m without relevant differences between the two depth levels.

Table 1. Biotic parameters describing the benthic community.

Groups	BOTTOM			TOP		
	N/dm^2	S_m	H'	N/dm^2	S_m	H'
Cnidaria	84.7	4.0		102.2	5.0	
sd	28.6	0.0		23.3	0.0	
Crustaceans	876.4	36.5		1174.1	36.0	
sd	118.5	2.1		159.1	1.4	
Echinoderms	3.7	4.0		6.2	4.5	
sd	1.0	0.0		1.8	0.7	
Molluscs	145.3	34.5		176.2	35.0	
sd	9.0	7.8		14.8	7.1	
Polychaetes	711.7	32.0		242.5	31.5	
sd	75.6	5.7		21.7	2.1	
Others	16.2	10.0		16.1	10.5	
sd	2.1	0.0		1.8	0.7	
Total	**1838.0**	**121.0**	**0.85**	**1717.3**	**122.5**	**0.78**
sd	**23.5**	**0.9**	**0.02**	**10.1**	**0.5**	**0.01**

Very similar H' values were observed concerning the overall communities settled at the two depth levels (Table 1).

Regardless of the block level, S_m was higher on the horizontal surfaces (130.0±11.3) than on the vertical ones (113.5±4.9) mainly colonised by hard-substrate species, above all filter-feeders like bivalves (*M. galloprovincialis*, *O. edulis*, *C. gigas*), hydroids (*Obelia dichotoma*, *Bougainvillia ramosa*) and barnacles (i.e. *Balanus trigonus*, *Balanus perforatus*), which represented 57% of the species having a known link with a specific substrate. In addition to them, deposit and suspension-feeders were found on the horizontal surfaces, always covered by a thin layer of sand-muddy sediment. These were typical soft-bottom organisms, e.g. gastropods and bivalves, representing 51% of the species linked to a specific substrate. These results were confirmed by Cluster analysis that grouped the surfaces according to their orientation (Fig. 1).

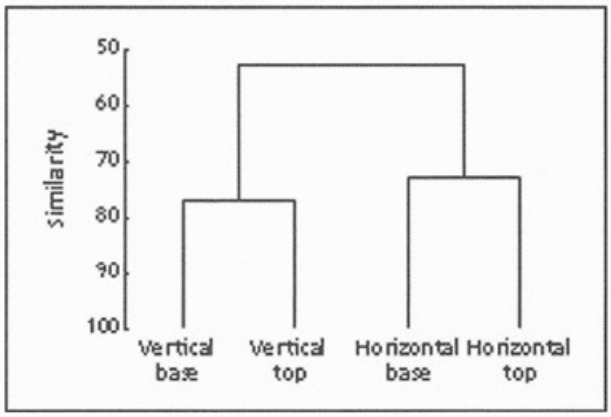

Fig. 1. Cluster analysis based on abundance and biomass of the species.

Conclusions

About ten years from the deployment, the concrete blocks of Senigallia artificial reef resulted colonised by a typical eutrophic water community showing a different structure on vertical and horizontal surfaces, due to the environmental conditions. On the horizontal walls, where siltation caused by Cesano river inflow and bottom sediment resuspension due to wave motion are more intense, the community was more heterogeneous and included a higher number of species than the vertical ones, without consistent differences among the depth levels.

Differently, the strong hydrodynamism plays a basic role in the vertical surface community composition inducing a continuous turn-over of suspended material. On the basis blocks such hydrodynamism was less intense, favouring a higher settlement of sand species (i.e. *Sabellaria spinulosa*) limiting the occurrence of hard-substrate filter-feeders in respect to the top of the pyramids.

References

1 - Bohnsack J.A., Johnson D.L., Ambrose R.F. 1991. Ecology of artificial reef habitats and fishes. Pages 61-107, *in:* Seaman W.Jr., Sprague L.M., (Eds.), Artificial Habitats for Marine and Freshwater Fisheries. Academic Press Inc., San Diego, California.

2 - Bombace G., 1989. Artificial reefs in the Mediterranean sea. *Bull. Mar. Sci.*, 44 (2): 1023-1032.

3 - Fabi G., Luccarini F., Panfili M., Solustri C., and Spagnolo A., 2002. Effects of an artificial reef on the surrounding seabed community (central Adriatic sea). *ICES J. Mar. Sci.*, 59 (suppl.): 343-348.

VARIATIONS TEMPORELLES DES PARAMÈTRES PHYSICO-CHIMIQUES ET PHYTOPLANCTONIQUES DU PORT D'URLA (GOLFE D'IZMIR- MER EGÉE)

F. Sanem Sunlu [1] *, Baha Büyükisik [1], Ugur Sunlu [2], Nesrin Yurterin [2]

[1]Université Egée, Fac. de Pêcherie, Dept. Marine biologie, Bornova-Izmir, Turquie – izgoren@sufak.ege.edu.tr
[2] Université Egée, Fac. de Sciences, Dept. Hydrobiologie, Bornova-Izmir, Turquie

Resumé

L'eutrophisation du Golfe d'Izmir a gravement augmenté ces dernières années. Nous avons observé que les changements de concentrations hebdomadaires et annuelles des élements nutritifs liés à des activités d'origine continentale comme les silicate et phosphate se font en corrélation avec la variation des espèces phytoplanctoniques et leur abondance dans l'eau de mer du Port d'Urla (Golf d'Izmir).

Mots clés: Coastal zone, paramètres physico-chimiques et biologiques,variations temporelles

Introduction

Le Golfe d'Izmir, à l'ouest de la Turquie, est trés peuplé. Sa partie intérieure peu profonde (max; 12 m) possède une petite surface. Les déchets domestiques et industriels s'y déversent ainsi que plusieurs ruisseaux (1). L'eutrophisation a augmenté à cause de la circulation trés limitée avec l'extérieur du Golfe. On la remarque particulièrement dans le centre et l'intérieur du Golfe. La région de notre travail, le Port d'Urla, se trouve à 33 km dans le sud-ouest du Golfe d'Izmir. Le but de notre travail est de rechercher les premiers éléments liés à des activités d'origine continentale en déterminant pour ces élements, les variations temporelles du phytoplancton du Port d'Urla.

Matériel et méthodes

Nous avons recherché les variations du phytoplancton du Port d'Urla et celles des paramètres physico-chimiques d'octobre 1999 à octobre 2000 dans l'eau de surface : ont été analysés chaque semaine la température (°C), pH, salinité (‰), nitrite (µgat/l), nitrate (µgat/l), ammonium (µgat/l), silicate (µgat/l), phospate (µgat/l), chlorophylle-a, féo-pigment et particule organique carbone. En outre, on a déterminé un changement quantitatif du phytoplancton hebdomadaire dans la station. On mesure le changement nutritif avec la méthode spectrophotométrique. On mesure la température par (YSI Model 33 SCT metre), la salinité par la méthode de Harvey, le pH par Orion 420A model pH mètre dans notre laboratoire. Chlorophylle-a, féo-pigment et POC sont mesurés avec la méthode spectrophotometrique. En même temps, on a mesuré la chlorophylle-a par Turner 10-Au fluoromètre. La description des espèces de phytoplancton a été réalisée selon 2,3,4,5,6.

Résultats et discussion

Nous avons réalisé régulièrement et en grande dimension des prélèvements, à partir de fin octobre 1999. Jusqu'à la sixième semaine on a observé: *Prorocentrum triestinum, P. gracile, Phytodiscus noctiluca* peu nombreux, *Ceratium lineatum, Protoperidinium depressum* avec *Navicula transitrans, Licmophora ehrenbergii, Thalassiosira subtilis, Thalassionema nitzschoides*. Au cours de la semaine 6, (30 novembre), on a observé une augmentation de la chlorophylle-a à cause des grandes diatomées (2000 cellules/litre). Cette augmentation de chlorophylle est corrélée avec l'augmentation de *Ceratium lineatum.* On pense que *Favella* sp. exerce une influence sur *C. lineatum* par une pression d'alimentation avec l'augmentation de concentration féo-pigment. Cette situation montre une harmonie avec la chute de concentration des phosphate et nitrate (Fig. 1).

La semaine 21 (21 mars), la salinité et la température sont tombées à des valeurs minimum avec l'augmentation des phosphate, silicate et nitrate à cause de l'eau de pluie et du mélange vertical de fond. En même temps, on a observé une augmentation élevée de l'abondance de *Cylindrotheca closterium.* Mais cette situation renvoie à la chute de la concentration de chlorophylle, à cause de la taille minimale de l'espèce.

Semaine 25 (18 avril): l'abondance de *Scripsiella trochoidea* nous montre chlorophylle-a entièrement.

Semaine 26 (25 avril): augmentation élevée de l'abondance de *Dinophysis accuminata*; en même temps, *S.trochoidea* a disparu et on constate l'augmentation maximum de féo-pigment, *D. accuminata* sur *S. trochoidea* et pendant les 7 semaines suivantes sur *Prorocentrum micans* et *Protoperidinium pellucidum.*

Semaine 35 (27 juin): l'abondance de *P. micans* diminue, par contre *Favella sp.* augmente. Dans cette situation probablement *Favella sp.* exerce une influence sur *P. micans* à cause de la pression du broutage.

Semaine 36. *Favella sp.* a disparu et pourtant *P. micans* a commencé à se multiplier.

Semaine 37 (11 juillet): les kystes de dinoflagellates ont augmenté comme la température, par contre la salinité est tombée, probablement à cause des mouvements des vagues. Le milieu n'est pas commode pour les dinofagellates car le stress de viskos dû aux vagues brise leur armure. Les diatomées, plus résistantes au stress de viskos, sont dominants dans le milieu qui contient moins de sel sous l'effet du mouvement des vagues. La population d'une espèce benthique *Striatella unipunctata* plus abondante nous indique que l'eau de fond est remontée vers la surface.

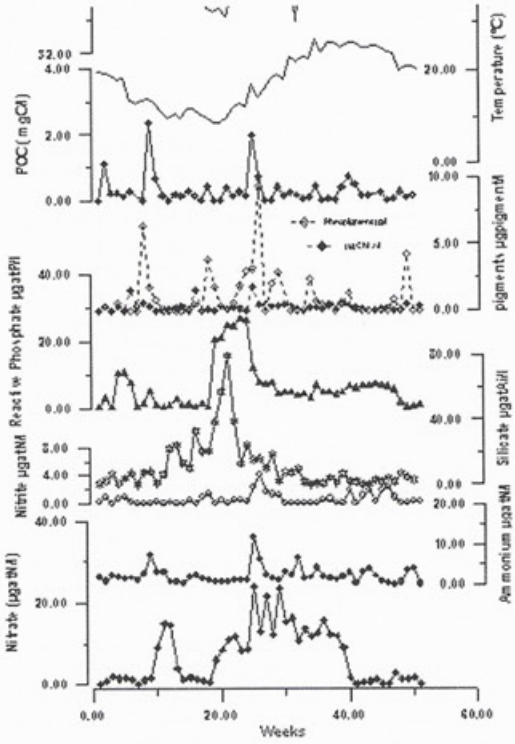

Fig. 1. Les changements temporels des paramètres physico-chimiques et biologiques sur les cotes du port d'Urla.

Pendant les six dernières semaines, l'augmentation de *Ceratium lineatum* a correspondu avec l'élévation du nitrate et la baisse du phosphate.

Dans cette période l'élévation de féo-pigment nous prouve que *Favella sp.* se nourrit sur *C. lineatum* bien que Nieslen (7) rapporte que les Ciliates n'aiment pas se nourrir sur *Ceratium.*

Nous avons observé que les changements de concentration hebdomadaire et annuel des élements nutritifs comme le silicate et le phosphate se fait en corrélation avec la variation des espèces phytoplanctoniques et leur abondance dans l'eau de mer.

L'influence continentale joue un rôle important sur les concentrations de ces éléments dans l'eau de mer tandis que les vagues, les courants marins, les vents ont un effet sur les côtes qui controlent le changement de la composition phytoplanctonique dans le temps.

Comme résultat de ce travail, nous avons montré que *D. accuminata* et les Ciliates, avec ou sans lorica, contrôlent les changements temporels de *Scripsiella trochoidea* et *Prorocentrum micans.*

Références

1- Basoglu, S. 1978. Izmir Körfezi Hidrografisi ve Sedimentolojisi. Doktora tezi. Izmir. Pp. 5-104.

2- Thomas, C.R. 1997. Identifying Marine Phytoplankton, Academic Press. 867 p.

3- Cupp, E.E. 1977. Marine Plankton Diatoms of the West Coast of North America, University of California Press, Otto Koeltz Science Publishers. 236 p.

4- Hendey, N.I 1964. An Introductory Account of the Smaller Algae of British Coastal Waters. Ministry of Agriculture, Fisheries and Food. Fisheries Investigations Series IV. 317 p.

5- Paulmier, G. 1997. Atlas des diatomophycées des côtes françaises et des aires océaniques adjacentes, IFREMER, France. 428 p.

6- Werner, D. 1977. Introduction with a note on taxonomy. in The Biology of Diatoms. (Ed. D. Werner) University of California Press. 498 p.

7- Nielsen, T.G. 1991. Contribution of Zooplankton Grazing to the Decline of a Ceratium Bloom. *Limnol. Oceanogr., 36(6), 1091-1106.*

THE MACROZOOBENTHIC INVERTEBRATE FAUNA IN THE MARMARA SEA

Bülent Topaloğlu *, Bayram Öztürk, F. Saadet Karakulak
Istanbul University. Faculty of Fisheries, Laleli, Istanbul, Turkey
Turkish Marine Research Foundation, Beykoz, Istanbul, Turkey
topalbl@istanbul.edu.tr, ozturkb@istanbul.edu.tr, karakul@istanbul.edu.tr

Abstract

Macrobenthic invertebrate were collected from 12 stations in the Marmara Sea. A total of 48 taxons were identifed. The highest species diversity was found in the southern Marmara with 19 taxons, whereas in the northern Marmara, only 2-9 taxons were identified. *Macropipus depurator* has the highest presence with 11, and *Parapenaeus longirostris* has highest dominance with 59.34 and highest abundance with 2853 specimens. A high diversity of species was found between 30-63 m in the stations around the Marmara islands. In the northern Marmara, 5-9 species were found between 66-174 m, and only two species at the 298 m station. As a result, the species diversity was found to be higher in the Southern Marmara Sea especially around the Kapıdağ Peninsula.

Keywords: Marmara Sea, Benthic Ecology, Diversity

Introduction

The Marmara sea is an important biological corridor/barrier between the two different marine ecosytems of the Black and Mediterranean seas (1, 3). Therefore, biological diversity research is important, for the development of conservation strategies within the Marmara Sea. The Marmara Sea has a two layer current system with different ecological conditions in the upper and deep layers, it has three depressions in the east-west direction down to 1000 meters (2). Few studies have been made on the ecology of the Marmara Sea (1, 4, 5). The present research studied the general composition of macrozoobenthic invertebrates, focusing on the difference between the northern and southern parts of the Marmara Sea.

Material and Method

This study was carried out between 1 and 19 August 2001. Twelve stations were sampled using a bottom trawl net with our research vessel R/V *Yunus*. The samples were collected at depths between 33 m and 298 m. Stations 6-8,10-12 were located in the northern Marmara and stations 1-5 and 9 were located in the southern Marmara. Each sample was described, measured, counted and weighed. An echosounder was used to measure depth.

Calculations of abundance, presence and dominance were made. Abundance (A) is the mean number of the individuals from the total number of samples, presence (P) the number of observations of a species from the total number of samples. A "P" value of 11 indicates 11 stations and dominance (D) is the propotion of the total number of one species to the total number of all organisms.

Results and Discussion

A total of 48 taxons were determined including two classes, two families and 15 genera. Abundance, presence and dominance were calculated after the description. *Macropipus depurator* has the highest presence (in 11 out of 12 stations), and *Parapenaeus longirostris* the most dominant with 59,34 and most abundant with 2853 specimens. The highest diversity of species was found between 30-63 meters (stations 3 and 5, 19 species; 16 species at station 4, 13 species at station 1; and 12 species at station 2, around the Marmara islands). In the northern Marmara between five and nine species were found in the 66-174 meter range and only two species in the 298 m. range (Table 1.).

The Marmara Sea has a two layer current system with different oceanographic conditions. The upper layer originated in the Black Sea and has low salinity waters. The lower layer is originally from the Mediterranean Sea and has a higher salinity and the southern part of the Marmara Sea is shallower than northern part. The Marmara Sea has three depressions down to 1000 m in an east-west direction. All these oceanographic and morphometric conditions affect the distribution of macrozoobenthic invertebrate fauna. As a result, the species diversity was found to be higher in the southern part of the Marmara Sea, especially around the Kapıdağ Peninsula.

Table 1. Species with number of individuals, values of abundance (A), presence (P) and dominance(D) in sampling stations.

Taxon	Sta.1	Sta.2	Sta.3	Sta4	Sta.5	Sta.6	Sta.7	Sta.8	Sta.9	Sta.10	Sta.11	Sta.12				
Depth (m)	61	33	63	37	38	70	298	83	47	174	66	82	TOTAL	A	P	D(%)
CNIDARIA																
F. quadrangularis	1	5	5										11	0.92	3	0.019
A. palmatum			7	4	4								15	1.25	3	0.025
P.phosphorea			26										26	2.2	1	0.044
Pennatula rubra	19												19	1.58	1	0.033
V. cynomorium		11			1								12	1	2	0.02
Veretillum sp.										1			1	0.08	1	0.002
ANNELIDA																
Hirudinea (sp.)	1												1	0.08	1	0.002
MOLLUSCA																
Cassidaria sp.	5		4										9	0.75	2	0.016
Arca sp.				2	2						27		31	2.58	3	0.053
Natica sp.											1		1	0.08	1	0.002
Bullomorpha sp.		175	10	442	802								1591	132.5	4	2.753
A. tuberculata				5	1								6	0.5	2	0.010
Pinna sp.				1									1	0.08	1	0.002
Pteria sp.						3							3	0.25	1	0.005
Eledone sp.					1								1	0.08	1	0.002
Illex coindetii		1											1	0.08	1	0.002
Loligo sp.	10	25	140	6	38	5			4				228	19	7	0.394
Sepia officinalis			5						69				74	6.16	2	0.128
Sepia orbignyana		21	5		3	4		2	21				59	4.91	6	0.102
Sepia rondeletti									1				1	0.08	1	0.002
Sepia sp.		102	21		115								238	19.8	3	0.412
Sepiola sp.			5										5	0.42	1	0.009
Sepiidae (sp.)	15												5	0.42	1	0.009
CRUSTACEA																
C. macendrea												1	1	0.08	1	0.002
P. typhlops										1			1	0.08	1	0.002
P.longirostris	4592		2046		5	5152	345	9731	4652	4300	370	3102	34295	2858	10	59.34
Plesionika sp.				1				6478		1573		3033	11084	923.6	4	19.18
M. depurator	111	2799	9	43	161	22		236	3304	14	13	61	6773	564.4	11	11.72
M. longirostris				7	2								9	0.75	2	0.016
Pilumnus hirtellus					1								1	0.08	1	0.002
Pilumnus sp.				2									2	0.16	1	0.002
G. rhomboides			3									1	4	0.33	2	0.009
Cancer sp.				2								7	9	0.75	2	0.015
Dorippe sp.			1										1	0.08	1	0.002
Paguride (sp.)					1								1	0.08	1	0.002
ECHINODERMATA																
A.arranciacus	2												2	0.16	1	0.002
A. spinulosus		25	93	344	210	78		7	7		176		940	78.3	8	1.626
A.irregularis	164												164	13.6	1	0.284
Asteroidea (sp.)									17	1			18	1.5	2	0.031
E. sepositus			1										1	0.08	1	0.002
Peltaster placenta	1												1	0.08	1	0.002
A. mediterranea			4	4									8	0.66	2	0.015
M. glacialis	20	21	4	4	3			2	3	1			58	4.83	8	0.100
Ophiura sp.				158	3+								161	13.42	2	0.279
Cidaris cidaris		6											6	0.5	1	0.010
S.purpureus						5	1841			8		2	1856	154.6	4	3.212
Stichopus regalis	4	2	26		1			2		1		1	37	3.08	7	0.064
Cucumaria planci			5	8	4							1	18	1.5	4	0.031
TOTAL													57790			

References

1 - Öztürk B., 2002. The Marmara Sea, A Link Between The Mediterranean and The Black Sea. Pp. 337-340. *In:* E. Leppekoski et al (eds), Invasive Aquatic Species of Europe. Kluwer Academic Publ., Netherlands.

2 - Beşiktepe Ş.T., Özsoy E. and Latif M.A., 2000, Marmara Denizi'nin hidrografisi ve dolaşımı. Pp. 293-313. *In:* Öztürk B., Kadıoğlu M. and Öztürk H., (eds), Marmara Denizi 2000 Sempozyumu Bildiriler Kitabı. TÜDAV Publ. No: 5., İstanbul.

3 - Öztürk B. and Öztürk A.A., 1996. On the biology of the Turkish Strait system. Monaco No: special 17; CIESM Science Series.

4 - Balkıs H., 1995. Ecology of the Crabs Living in the Sea of Marmara. Pp. 1-23. İ.Ü Fen Fak. Biyoloji Dergisi. 58, İstanbul.

5 - Balkıs H., 1992. Marmara Adası littoralinin makrobentosu üzerine bir ön araştırma. Pp. 309-327. İ.Ü. Deniz Bilimleri ve Coğrafya Enstitüsü Bülteni. No: 9., İstanbul.

PULLULATION DU MACROPLANCTON GELATINEUX DANS LA BAIE DE SOUSSE EN SAISON ESTIVALE

Touzri C. [1] *, Daly Yahia M.N. [2], Goy J. [3] et Romdhane M.S. [1]

[1] Laboratoire Aquaculture et Milieu, Institut National Agronomique de Tunis, Tunis Tunisie
[2] Groupe de Recherche en Hydrologie et Planctonologie, Laboratoire de Biosurveillance de l'environnement, Faculté des Sciences de Bizerte, Tunisie - dalyyahya.ons@inat.agrinet.tn
[3] Institut Océanographique, Paris, France

Résumé

Des observations journalières en saison estivale et un suivi saisonnier des paramètres hydrologiques et du plancton gélatineux ont été réalisés dans la baie de Sousse, afin de comprendre les phénomènes de proliférations de certaines espèces du plancton gélatineux. Parmi ces organismes, le macroplancton est représenté par *Rhizostoma pulmo* qui prolifère surtout dans la zone côtière (isobathe -2m) et dont les densités atteignent 200 individus/1000m^3 et par l'espèce *Olindias phosphorica*. Durant le mois de juillet 2001, le bloom d'*Olindias phosphorica* précède celui de *R. pulmo* et atteint des densités proches de 2000 individus/1000m^3.

Mots clés : Plancton gélatineux, Méditerranée orientale

Introduction

La baie de Sousse est située sur la façade orientale de la Tunisie, au sud du golfe de Hammamet, entre 10°38'30" de longitude Est et 35°45'10"et 35°50'00" de latitude Nord. Elle ne reçoit pas de grands organismes hydrographiques à l'exception de l'oued Hamdoun, susceptible de fournir à la côte une bonne alimentation en sédiments (1).

Matériel et méthodes

Dans la baie de Sousse, durant la saison estivale (juillet 2001) des prélèvements d'eau (bouteille Ruttner) et de plancton (Filet conique 220µm et échantillonnage manuel) ont été effectués au niveau de 5 radiales côte-large composées chacune de 3 stations positionnées au niveau des isobathes -2m, -5m et -10m de profondeur (Fig. 1). La station BS4 a fait l'objet d'un monitoring journalier durant la période de prolifération.

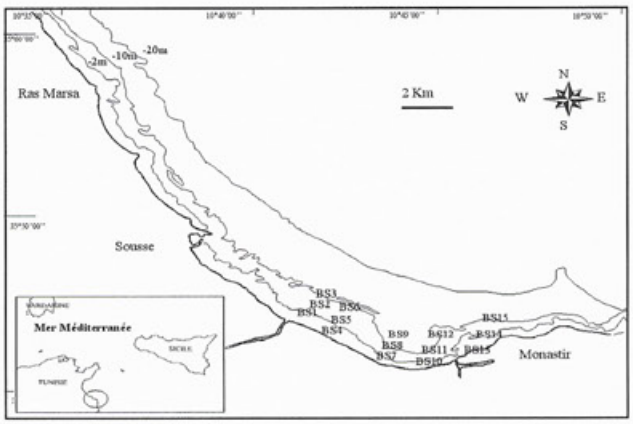

Fig. 1. Situation géographique et stations de prélèvements dans la baie de Sousse.

Résultats et discussion

Dans la baie de Sousse, durant la période d'étude, la température de l'eau montre généralement un minimum en hiver au mois de janvier de l'ordre de 14,2°C et un maximum au mois de juillet de l'ordre de 27,3°C.

Au cours du mois de juillet les températures maximales sont enregistrées au niveau de l'isobathe -2m (28,74°C) sous l'influence de la station BS1 (32,6°C) proche de l'oued Hamdoun. La salinité moyenne des eaux de surface de la baie est de l'ordre de 36,93 psu.

Le Macroplancton gélatineux est représenté par la Scyphoméduse *Rhizostoma pulmo* (Macri, 1778) et la Limnoméduse *Olindias phosphorica* (Delle Chiaje, 1841). Ces deux espèces ont proliféré simultanément dans la baie de Sousse avec un décalage dans leur période d'abondance maximale (Fig. 2). Ainsi *O. phosphorica* atteint des densités maximales le 13 juillet 2001 (2000 individus/1000 m^3) et le 17-18 juillet 2001 (100 ind./1000 m^3), tandis que *R. pulmo* se développe plus tard et atteint son effectif maximum du 24 au 26 juillet 2001 (200 ind./1000 m^3).

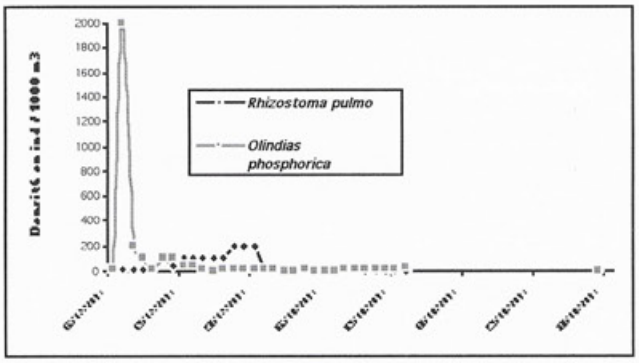

Fig. 2. Fluctuations journalières de la densité de *R. pulmo* et *O. phosphorica* durant le mois de juillet.

A l'échelle spatiale c'est uniquement dans la zone côtière (isobathe -2m) que *R. pulmo* s'accumule et se maintient en relation probablement avec la forte température des eaux et leur richesse en microplancton. *O. phosphorica* qui présente aussi un développement côtier, s'observe également au niveau des isobathes -5 et -10m et semble plutôt liée aux herbiers de posidonies (2 et 3).

Références

1 - Oueslati, A., 1993. Les côtes de la Tunisie : Géomorphologie et Environnement et Aptitudes à l'Aménagement. Publication de la Faculté des Sciences Humaines et Sociales de Tunis, Université Tunis I., 387 p.

2 - Brinckmann-Voss, A., 1987. Seasonal distribution of Hydromedusae (Cnidaria, Hydrozoa) from the gulf of Naples and vicinity, with observations on sexual and asexual reproduction in some species. Pp. 133-141. In: Bouillon J., Boero F., Cicogna F. and Cornelius P. (eds.). Modern trends in the systematics, Ecology and Evolution of Hydroids and Hydromedusae. Oxford Science Publications.

3 - Goy, J., 1972. Les Hydroméduses de la mer Ligure. *Bull. Mus. Nat. Hist. Nat.*, 62, 3e série (83): 965-1008.

NEW RECORDS OF ALIEN DECAPODS FROM THE SOUTHWESTERN COAST OF TURKEY

B. Yokes [1] * and B.S. Galil [2]

[1] Dept. of Molecular Biology & Genetics, Bogazici University, Etiler, Istanbul, Turkey - * bakiyokes@turk.net
[2] National Institute of Oceanography, Israel Oceanographic & Limnological Research, Haifa, Israel

Abstract

The marine biota off the southwestern coast of Turkey was studied by diving between 1996 and 2003. Six alien decapod crustaceans of Red Sea origin have been noted: one is a new record for the Mediterranean, two constitute new records for Turkey, and for three we report significant range extensions within Turkey.

Key words: Alien, Decapoda, Red Sea, Turkey

The decapod crustaceans of the Mediterranean coast of Turkey have been studied since the early 20th century (1-13). Many of these studies have reported the presence of Red Sea taxa that had invaded the Mediterranean through the Suez Canal. The recent *CIESM Atlas of exotic species in the Mediterranean Sea* (14) recorded the occurrence of 27 Indo-West Pacific and Red Sea decapods along the Turkish coast.

The marine biota off the southwestern coast of Turkey, at depths between 3 and 26 m, was studied by diving between 1996 and 2003. The specimens were photographed *in situ* and some were collected and subsequently deposited in the National Collections, Tel Aviv University, Israel. Six IWP species have been recorded: one is a new record for the Mediterranean, two constitute new records for Turkey, and for three we report westward range extensions within Turkey.

Melicertus hathor (Burkenroad, 1959)

Melicertus hathor was collected from the coast of Israel 70 years after it had been reported from the Suez Canal (15). In May 2002 it was collected Yumurtalik bight, SE Turkey (M. Kumlu, O.T. Eroldogan, M. Aktas and M. Gocer, pers. comm.), but this record is a remarkable extension of its range.

Metapenaeopsis aegyptia Galil, 1990

Metapenaeopsis aegyptia was recently described from Rhodes Island (16). The present report constitute the first record of the species from the Turkish coast. The species is common near Tekirova and Uc Adalar.

Urocaridella antonbrunii (Bruce, 1967)

The specimens collected off the Mediterranean coast of Turkey fit the type's description (17). These nocturnal cleaner shrimps are quite common in Kas, where they were observed on Moray eels, but were mostly occur in small groups (5-6 individuals) in *Posidonia* and *Cymodocea* meadows. The carapace and pereiopods are nearly transparent, with a red stripe across the third abdominal segment, the uropodal exopods are red and white, the rostrum with ubterminal red band, and the prereiopods banded white and red. Widely distributed in the Indo-Pacific: from the Red Sea to Japan, Australia, Palau Island (18). This is the first record of this handsome species from the Mediterranean.

Carupa tenuipes Dana, 1851

The specimen photographed off the Kas Peninsula is similar to the single specimen collected off the Mediterranean coast of Israel (www.ciesm.org/atlas/crustaceans). The species, of nocturnal habits, was collected on biogenic rubble and rocky bottoms in the Mediterranean though it is known to inhabit coral reef and coral rubble bottoms in the IWP. A new record for Turkey, where it has been established as far back as 1996, and is apparently quite common between Kalkan and Tekirova from the evidence of its shed exoskeletons.

Charybdis (Charybdis) hellerii (A. Milne Edwards, 1867)

A westward extension of its range, as it was reported before only from southeastern Turkey (13). The species is quite common off Tekirova.

Atergatis roseus (Rüppell, 1830)

A westward extension of its range, as it was reported before only from southeastern Turkey (12).

References

1 - Gruvel A., 1928. Répartition géographique de quelques crustacés comestibles sur les côtes d'Égypte et de Syrie. *C. R. Soc. Biogéogr.*, 5 (39): 45-46.

2 - Gruvel A., 1930. Les richesses marines et fluviales de la Syrie. Explotation actuelle-Avenir. *Rev. Sci.*, Paris, 68: 33-41.
Monod Th., 1930. Über einige indo-pazifische Decapoden der Meeresfauna Syriens. *Zool. Anz.*, Leipzig, 92 (5/6): 135-141.
Holthuis L. B., and Gottlieb E., 1956. Two interesting crabs (Crustacea, Decapoda, Brachyura) from Mersin Bay, S. E. Turkey. *Zool. Meded.*, Leiden, 34 (21): 287-299.

5 - Holthuis L. B., 1961. Report on a collection of Crustacea Decapoda and Stomatopoda from Turkey and the Balkans. *Zool. Verh.*, Leiden, 47: 1-67.

6 - Geldiay R., and Kocatas A., 1968. The species of Penaeidae family from the Mediterranean Coast of Turkey. *Scient. Rep. Fac.Sci. Ege Univ.*, 58: 1-15.

7 - Geldiay R., and Kocatas A., 1969. Stomatopods of Turkey: *Squilla mantis* (Linnaeus) and *Squilla massavenis* Kossmann. *Scient. Rep. Fac.Sci. Ege Univ.*, 71: 1-11.

8 - Geldiay R., 1969. A report on the collection of Natantia (Crustacea, Decapoda) along the coast of Turkey from the Eastern Mediterranean to the vicinity of Izmir. *Scient. Rep. Fac.Sci. Ege Univ.*, 74: 1-17.

9 - Geldiay R., Kocatas A., 1972. A report on the occurrence of Penaeidae (Decapoda, Crustacea) along the coast of Turkey from Eastern Mediterranean to the vicinity of Izmir, as a result of migration and its factors. 17th Congres International de Zoologie, Monte Carlo, September 1972, 7 p.

10 - Grippa G., 1982. First record of *Leucosia signata* Paulson, 1875 from the South-Western Turkish coast (Decapoda, Brachyura, Leucosidae). *Quad. Lab. Tec. Pesc. Ancona*, 3(2-5): 335-338.

11 - Enzenross L., Enzenross R., Niederhöfer H.J., 1990. Wissenschaftlich interessante Funde aus der Sammlung Enzenross (Marine Invertebraten). *Jh. Ges. Naturk Wurtt.*, Stuttgart, 145: 283-294.

12 - Enzenross R., Enzenross L., Kocatas A., 1992. Lessepsian migration : Two Indo-Pacific crab species (Crustacea, Decapoda) found on the Turkish Mediterranean coast. *J. Fac. Sci. Ege Univ.*, Izmir, (Series B), 14 (2): 3-10.

13 - Enzenross R., Enzenross L., 1995. Erstnachweise indopazifischer Brachyura (Crustacea: Decapoda) von der türkischen Mittelmeerküste. *Stuttg. Beitr. Naturk.*, Serie A (Biologie), 521: 1-4.

14 - Galil B., Froglia C., Noel P., 2002. CIESM Atlas of Exotic Species in the Mediterranean. Vol. 2. Crustaceans: decapods and stomatopods. (F Briand, Ed). 192 p. CIESM Publishers, Monaco.

15 - Galil, B.S., 1999. *Melicertus hathor* Burkenroad, 1959 – a Red Sea penaeid prawn new to the Mediterranean. *Crustaceana*, 72(9): 1226-1228.

16 - Kevrekidis K., Galil B.S., Kevrekidis T., 1998. Three Lessepsian migrant penaeids (Decapoda) in Rodos island (Greece). *Crustaceana*, 71 (4): 474-478.

17 - Bruce A. J., 1967. Notes on some Indo-Pacific Pontoniinae III-IX. Descriptions of some new genera and species from the Western Indian Ocean and the South China Sea. *Zool. Verh.* 87: 1-73.

18 - Chace F. A., Bruce A. J., 1993. The caridean shrimps (Crustacea: Decapoda) of the *Albatross* Philippine Expedition, 1907-1910, Part 6: Superfamily Palaemonoidea. *Smiths. Contr. Zool.*, 543:
i-vii, 1-152.

LESSEPSIAN OPISTHOBRANCHS FROM SOUTHWESTERN COAST OF TURKEY; FIVE NEW RECORDS FOR MEDITERRANEAN

B. Yokes [1] * and W. B. Rudman [2]

[1] Dept. of Molecular Biology & Genetics, Bogazici University, Istanbul, Turkey - * bakiyokes@turk.net
[2] Malacology Section, Division of Invertebrate Zoology, Australian Museum, Sydney, Australia - billr@austmus.gov.au

Abstract

The opisthobranchs from the southwestern coast of Turkey were studied by diving. The species are either collected or photographed. Ten lessepsian species have been identified, with five new records for the Mediterranean, and four new records for Turkey. The observation of *Hypselodoris infucata* in Fethiye extends its distribution range westward on the Turkish coast.

Key words: Lessepsian, Opisthobranch, Turkey

The Indo-West Pacific (IWP) originated gastropods from Turkey are well studied and some lessepsian opisthobranchs have already been reported (1). The lack of shell makes it difficult to trace the presence of opisthobranchs, unless specimens are observed or collected alive in their habitat. Exotic opisthobranch species from the southwestern coast of Turkey, between Bodrum and Tekirova, were identifed from living specimens or from photographs. Of the ten lessepsians identified, *Haminoea cyanomarginata, Oxynoe viridis, Elysia grandifolia, Elysia tomentosa, Syphonota geographica* are new records for the Mediterranean. *Bulla ampulla, Plocamopherus ocellatus, Melibe viridis* and *Flabellina rubrolineata* are new records for Turkey. The observation of *Hypselodoris infucata* in Fethiye extends its westernmost limit on the Turkish coast. Photographs and identifications have been verified on the Sea Slug Forum (http://www.seaslugforum.net).

Haminoea cyanomarginata Heller & Thompson, 1983

Material photographed: Uc Adalar: 15m, July 2002; 24m, September 2003; Cesme: 15m, September 2002; all on rocky habitat.

Remarks. *Haminoea cyanomarginata* was described from the Sudanese Red Sea, the only known record for IWP (2). Another record from Greece is in press (3). Its abundance suggests that it has a wide distribution on the southwestern coast of Turkey (4).

Bulla ampulla Linnaeus, 1758

Material collected: Uc Adalar: 18m, sediment from *Cymodocea nodosa* field, May 2001; 22m, sediment from *Halophila stipulacea* field, September 2003.

Remarks. Living animals have not been observed, but three shells were collected, which are new records for Turkey.

Oxynoe viridis (Pease, 1861)

Material photographed: Uc Adalar, 6m, April 2002; Tekirova, 8m, September 2002.

Remarks. *Oxynoe viridis* is variable in colour in IWP, but all Turkish specimens had a yellowish body covered with blue spots. It is rarely, but always observed on *Caulerpa* species (5).

Elysia grandifolia Kelaart, 1858

Material photographed: Uc Adalar: 5m, September 2001; 7m, August 2003.

Remarks. Both *Elysia ornata* (Swainson, 1840) and *E. grandifolia* have almost identical colouration, but *Elysia grandifolia* is larger, 10 cm or more, its parapodia are large and thin, the black and orange bands at the edge of the parapodia are not separated by white. Some authors consider them as conspecific, but more anatomical study is needed to clarify the relation. Due to body size and parapodial structure, the Turkish individuals are classified as *Elysia grandifolia* (6). Rare, always on rocky habitat, more common in Lebanon (Jose Templado, pers. comm.).

Elysia tomentosa Jensen, 1997

Material photographed: Uc Adalar: 6m, September, 2001; 20m, April 2002; 18m, October 2002; 24m, September, 2003; Tekirova, 10m, September 2002.

Remarks. Olive green, more or less covered with tiny yellowish white dots. Body extremely papillose, almost invisible in its habitat. Common, always on *Caulerpa racemosa* (7).

Syphonota geographica (Adams & Reeve, 1850)

Material photographed: Fethiye, 10 m, on sand, December 2002; Uc Adalar, 27m, on *Caulerpa prolifera*, May 2003.

Remarks. *Syphonota geographica* can be distinguished from species of *Aplysia* by the position of the rhinophores, close together and set back between the parapodial lobes. Rarely observed on seagrass beds on the southwestern coast of Turkey, its distribution range may be extended to as far as Italy (8).

Plocamopherus ocellatus Ruppell & Leuckart, 1828

Material photographed: Kas, 10m, on rocky habitat, August 1998.

Remarks. The unique colouration distinguishes this species form Mediterranean congenerics. The single specimen recorded here is the third Mediterranean record, the others being from Israel (9) and Lebanon (10). For photographs and discussion see ref. 11.

Hypselodoris infucata Rüppell & Leuckart, 1830 or 1831

Material photographed: Fethiye: 12m, rocky habitat, June 2000.

Remarks. Previously reported from Iskenderun Bay, southeastern Turkey (12, 13).

Melibe viridis Kelaart, 1858

Material photographed: Kas: 7m, June 2000; Tekirova: 6m, on sand, August 2001.

Remarks. Seemingly well established on the Levantine basin, but never reported from Turkey before (14). Rarely observed in shallow water on muddy sand (15).

Flabellina rubrolineata (O'Donoghue, 1929)

Material photographed: Always on hydroids. Uc Adalar: 20m, July 2001; 8m, September 2002; Kas: 18m, September 2002; Bodrum: 10m, on rocky habitat, August 2003.

Remarks. Only a single specimen has been previously reported from Israel (16). It is the most abundant *Flabellina* species observed on hydroid colonies (*Eudendrium* sp). See ref. 17 for photographs and discussion.

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References

1 - Ozturk, B., Onen, M., Dogan, A. and Urkmez, D., 2002. The lessepsian molluscs of the Mediterranean and their distribution along the Turkish coasts. Pp. 62-70. *In:* Ozturk, B., & Basusta, N. (eds.), Workshop on Lessepsian Migration Proceedings, Turkish Marine Research Foundation Publ.: 9, Istanbul.

2 - Heller & Thompson, T.E. 1983 Opisthobranch molluscs of the Sudanese Red Sea. *Zoological Journal of the Linnean Society, 78(4)*: 317-348.

3 - Zenetos, A., Gofas, S., Russo, G., Templado, J. 2003. CIESM Atlas of exotic species in the Mediterranean, Vol. 3. Molluscs. CIESM, Monaco, 376 p.

4 - Rudman, W.B., 2003 (January 3) *Haminoea cyanomarginata* Heller & Thompson, 1983. *Sea Slug Forum.* http://www.seaslugforum.net/hamicyan.htm

5 - Rudman, W. B., 1999 (July 12) *Oxynoe viridis* (Pease, 1861). *Sea Slug Forum.* http://www.seaslugforum.net/oxynviri.htm

6 - Rudman, W.B., 2001 (November 19). *Elysia grandifolia* Kelaart, 1858. *Sea Slug Forum.* http://www.seaslugforum.net/elysgran.htm

7 - Rudman, W.B., 2003 (July 23). *Elysia tomentosa* Jensen, 1997. *Sea Slug Forum.* http://www.seaslugforum.net/elysgran.htm

8 - Rudman, W.B., 1999 (May 26). *Syphonota geographica* (Adams & Reeve, 1850). *Sea Slug Forum.* http://www.seaslugforum.net/syphgeog.htm.

9 - Barash, A. and Danin, Z., 1982. Mediterranean Mollusca of Israel and Sinai: composition and distribution. *Israel Journal of Zoology*, 31: 86-118.

10 - Valdés, A. & Templado, J. 2002. Indo-Pacific dorid nudibranchs collected in Lebanon (eastern Mediterranean). *Iberus* 20 (2): 23-30.

11 - Rudman, W.B., 2002 (November 27). Comment on *Plocamopherus ocellatus* from Turkey by Erwin Koehler. *Sea Slug Forum.* http://www.seaslugforum.net/find.cfm?id=8516

12 - Çevik, C., Ozturk, B., 2001. A new lessepsian mollusc *Hypselodoris infucata* (Ruppell & Leuckart, 1828) (Gastropoda: Nudibranchia) for the coasts of Turkey. Turkish journal of Zoology, 25, p. 27-30.

13 - Rudman, W.B., 2003 (Feb 11). Comment on *Hypselodoris infucata* from the Mediterranean Sea by Orhan Aytur. *Sea Slug Forum.* http://www.seaslugforum.net/find.cfm?id=9145

14 - Thompson T.E. and Crampton D.M., 1984. Biology of *Melibe fimbriata*, a conspicuous opistobranch mollusc of the Indian Ocean, which has now invaded the Mediterranean Sea. *Journal of Molluscan Studies*, 50: 113-121.

15 - Rudman, W.B., 1999 (January 7) *Melibe viridis* Kelaart, 1858. *Sea Slug Forum.* http://www.seaslugforum.net/meliviri.htm.

16 - Gat, G., 1993. *Flabellina rubrolineata* (O'Donoghue) and *Phidiana indica* (Bergh) (Nudibranchia Aeolidioidea), two new Lessepsian immigrants in the Eastern Mediterranean. *Journal of Molluscan Studies*, 59: 120.

17 - Rudman, W.B., 1998 (January 9) *Flabellina rubrolineata* (O'Donoghue, 1929). *Sea Slug Forum.* http://www.seaslugforum.net/flabrubr.htm.

SEX STEROIDS IN FEMALE *DIPLODUS SARGUS* IN EGYPTIAN MEDITERRANEAN WATERS

Zaki M.I. [1], Baghdadi H.H. [2 *], El-Gharabawy M.M. [1], and El-Greisy Z.A. [1]

[1] National Institute of Oceanography and Fisheries, Alexandria, Egypt - DrMagdaZaki@hotmail.com
[2] Institute of Graduate Studies and Research, University of Alexandria, Egypt - * Hodabaghdadi@yahoo.com

Abstract

The annual reproductive cycle and variations in plasma sex steroids levels were studied in female white seabream, *Diplodus sargus*. The gonadosomatic index (GSI) and the plasma testosterone (T), progesterone (P) and estradiol (E2) levels were measured monthly. The steroids were correlated positively with the GSI, with the maximum values to be attained at the spawning season.

Keywords: Sparidae, Diplodus sargus, Reproductive cycle, Sex steroids

Introduction

Sex steroids are very important hormones regulating the gonadal function in teleosts. The present study determined the seasonal cycle in gonadosomatic index (GSI) and sexual plasma testosterone (T), estradiol (E2) and progesterone (P) levels in the female white seabream, *Diplodus sargus*. The purpose of the present investigation was the identification of sex steroids hormones in the blood plasma for further elucidation of the mechanism of hormonal regulation of reproductive function in *D. vulgaris*

Materials and Methods

Fish used in the present study were captured alive three times a month from the Mediterranean Coast near Kayet Bey Castle at Anfoushy region, Alexandria, Egypt. Sampling took place during September 1996 to August 1997.

Blood samples for hormone assay were collected from the caudal vessels. After centrifugation, the plasma was drawn off and stored at – 20 °C until steroid analysis. Following blood sampling, the gonads were excised and weighed in order to determine the GSI (GSI = 100 x gonad weight / body weight). Hormones were determined by radio immunoassay (RIA) using the procedures depending on using radioactive iodine I^{125} by kits assembled in U.S.A. by diagnostic system laboratories.

Results and Discussion

The levels of androgens and estrogens exhibited clear variations throughout the annual reproductive cycle (Fig. 1). A positive correlation was found between the GSI and the serum T levels in female white seabream ($P<0.001$). Their values increased gradually in the pre-spawning period, reaching the maximum values during the spawning season in February, followed by a decline in the spent and recovery periods. This observation is in general agreement with what has been observed for female of several other species, e.g. *Oblada melanura* (1), *Mugil cephalus* (2) and *Diplodus vulgaris* (3).

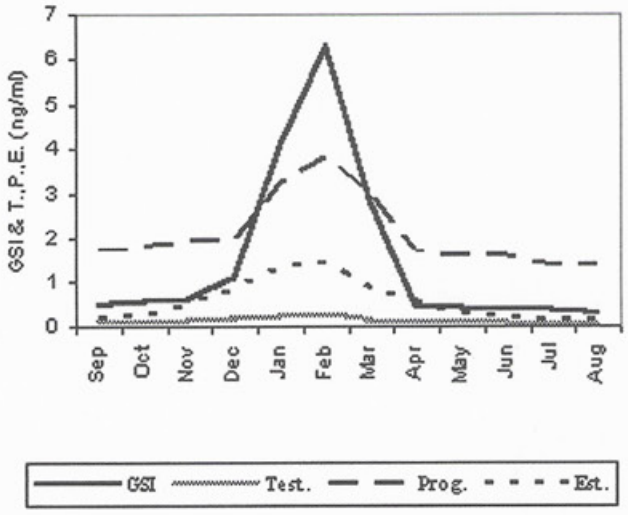

Fig. 1. Monthly gonadosomatic index (GSI) and serum concentrations of testosterone, progesterone and estradiol in female *Diplodus sargus*.

For P, an increase was recorded from September to December, followed by a sharp increase in January ($P<0.005$). The highest levels were observed during the spawning season with a maximum value recorded in February. After spawning, a sharp decrease was observed until it reached the minimum value, in August ($P<0.001$). This is similar to the results of several other species, e.g. *Chanos chano* (4), rainbow trout (5) and *Salvelinus leucomoenis* (6). In several species, oocyte maturation and ovulation are regulated by progestines and corticosteroids as reported (7).

The present study also showed monthly variation in serum E2 level throughout the annual reproductive cycle. It is clear that the highest values were within the breeding season. The E2 levels increased gradually from the maturation stage to reaching the maximum value during the prespawning period. The maximum values were recorded in February, i.e. just before the onset of the spawning process ($P<0.001$). A sharp significant decrease was recorded during March and April ($P< 0.0001$), i.e. after the starting of the spawning process. After April, E2 levels continued to decrease and reached its minimum value in August. Plasma E2 levels of female white seabream was correlated with the GSI. The results of E2 in the present study, were similar to those for other species, e.g. *Oblada melanura* (1), *Diplodus vulgaris* (3), *Rhabdosargus haffara* (8), where the levels of E2 reached a maximum value in the prespawning period, then decreased throughout the spawning season to reach a minimum value in spent female.

References

1 - Zaki M.I, Assem s.s, and Abu- Shabana M.B. 2001. Gonadotropin and steroid hormones in the plasma and pituitary gland of *Oblada melanusa* at various stages of maturation. *Rapp. com. int. Mer Médit., 36: 337.*

2 - Zaki M.I., El-Garabawy M.M. and Kamil S.A. 1995. Seasonal changes in the Gonadotropic and sex steroid hormones in the blood serum of the Grey Mullet, *Mugil cephalus*, in the sabkhet el Bardawil of the Mediterranean sea. *Jour. of Ichthy.*, 35(3).

3 - Abdallah M. 1996. Reproductive biology and physiology of *Diplodus vulgaris* in the Mediterranean Sea. Ph. D. Thesis, Faculty of Science, Tanta University.

4 - Marte C. L. and Lam, T. J. 1992. Hormonal changes accompanying sexual maturation in captive milkfish *Chanos chano* (Forskal). *Fish Physiol. Biochem.*, 10 (4): 267-275.

5 - Campbell C. M., Fostier A., Jalabert B. and Truscott B. 1980. Identification and quantification of steroids in the serum of rainbow trout during spermiation and oocyte maturation. *J. Endocrinol.*, 85: 371-378.

6 - Kagawa H., Takano K. and Nagahama Y. 1981. Correlation of plasma 17ß - Estradiol, progesterone levels with ultrastucture and histochemistry of ovarian follicles in the white spotted char, *Salvelinus leucomoenis*. *Cell Tissue Res.*, 218: 315-329.

7 - Jalabert B. 1976. *In vitro* oocyte maturation and ovulation in rainbow trout, *Salmo gairdneri*, northern pike, *Esox lucius*, and goldfish, *Carassius auratus*. *J. Fish. Res. Board Can.*, 33: 974-988.

8 - EL-Boray K. F. 1997. Reproductive biological studies on *Rhabdosargus haffara* in different water fish farms. Ph. D. Thesis, Faculty of Science, Zagazig University.

AMINO ACIDS' PROFILE OF *OREOCHROMIS SPECIES* IDENTIFICATION IN MEDITERRANEAN LAKES - A SUGGESTED MARKER FOR AQUACULTURE PURPOSES

Magda I. Zaki and Samir G. Ghabrial *

National Institute of Oceanography and Fisheries (NIOF), Kayed Bay, Alexandria, Egypt - * esamgabriel1@hotmail.com

Abstract

Two *Oreochromis species* were collected from Mediterranean lakes near Alexandria according to their morphological characteristics. Those which were known to belong to the pure strain were induced for spawning in order to obtain the pure offspring and the resulting hybrid. The protein content and amino acid profile were studied. The suspected wild species was found to be a hybrid. Thus advice must be taken into consideration when choosing the brood stocks in aquaculture practices.

Keywords : Freshwater fish / protein content/ amino acid / identification / hybrid

Introduction

Species identification is an important issue when choosing fish for culture activities. The offspring will be similar to the parental brooders in a way or another. Amino acid's analysis is used in the present study to differentiate the pure strains from the hybrid. The experimental hybrids are also needed to be compared with those of the wild.

Materials and Methods

Two species of *Oreochromis* were investigated: *Oreochromis niloticus* and *Oreochromis aureus*. The samples were collected from three sites; two Mediterranean lakes near Alexandria and one Nile estuary as a control.

The main taxonomic criteria for species identification were determined morphologically.

Spawning of the pure parental species was induced by manipulating the environmental conditions. The hybrid was achieved by crossing male *O. niloticus* with female *O. aureus* to produce male and female hybrids (A1&A2) respectively while crossing male *O.aureus* with female *O.niloticus* produced the male hybrid (B).

The total protein of the white muscle in the pure strain and the resulting hybrid was determined using the microkeldahl method (1) and amino acid extracts were prepared (2) then injected in instrument capsule of Beckman 116 GI amino acid analyzer apparatus. Suspected hybrids (C) from the former wild locations were also investigated. All fish were reared under the same condition.

Results and Discussion

The majority of both selected pure strains had the same characteristics described at the beginning of the last century (3) and assured later (4) deviating little than Avault (5).

The present study demonstrated large differences in the concentration of protein content and amino acid profile from one species to another and from one sex to another. The highest crude protein content (15.31%) was found in male hybrid B followed by female *O. niloticus* (14.85%) while hybrid A1 showed the third ranking order in its crude protein.

Male hybrid A1 had the highest total aminoacid content over all pure species and hybrids (17.474 g/100 g fresh weight) followed by male hybrid B (17.106 g/100 gfw). The suspected wild male hybrid C, collected from lake Edku, had 17.085 g./100gfw; quite close to the experimentally resulting hybrids but still significant. The lowest values of total aminoacid content belonged to male *O. niloticus*, female *O. aureus* and female hybrid A2. Gunasekera *et al.*(6) found a significant difference in the free aminoacid content of two groups of *Oreochromis niloticus* larvae – their mothers were originally fed on 10.2 and 35% crude protein – but not in the total protein content values.

Concerning the aminoacid's profile (Fig. 1), Glutamic acid, Aspartic acid and Lysine were shown to be the highest aminoacids in the muscles of *Oreochromis* species and their hybrids while systine was the lowest aminoacid. Eight aminoacids possessed the highest values in the resulting male hybrid A 1over all other species and sexes. Four aminoacids had the highest values in male hybrid B. The suspected natural male hybrid C had both Valine and Tyrosine as the highest values over all other species and sexes. This reveals the significant differences in the aminoacids quality and composition of the species under consideration and its hybrid although other species (7) had no significant differences in their aminoacid composition when

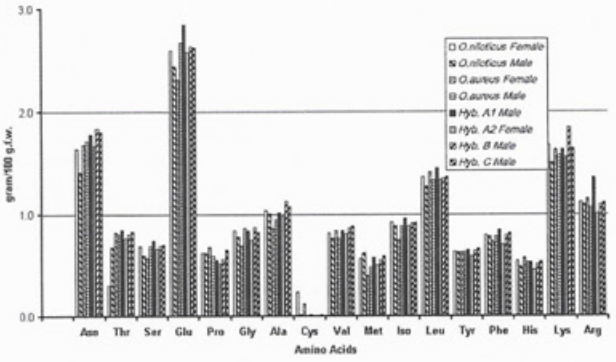

Fig. 1: Amino acid's content in the muscles of the pure strains of Oreochromis species and the resulting hybrids. Asn. = Aspartic acid, Thr. =Threonine, Ser. =Serine, Glu. = Glutamine, Pro. =Proline , Gly. =Glycine, Ala. =Alanine , Cys. Cysteine, Val.= Valine, Met. =Metionine, Iso. =Isoleucine, Leu. =Leucine, Tyr. =Tyrosine, Phe. = Phenylealanine, His. = Histidine, Lys. = Lysine & Arg. = Arginine.

expressed as g/100g aminoacids and suggested that the aminoacid requirements of flatfish may not be greatly different among species.

The problem of species identification for aquaculture practices is further complicated with the presence of hybrids which are usually intermediate in appearance to both parental species and biased to the maternal gamete (8,9) .

References

1 - Association of Official Agricultural Chemists,1980. Official methods of analysis. AOAC , Washington D.C., USA.

2 - Moore, S., Speckman, D.H. and Stein, W.H., 1958. Chromatography of amino acids on sulphonated polysterine resins. *Anal. Chem.:* 1185-1187.

3 - Boulenger F.R.S., 1907. Zoology of Egypt. The fishes of the Nile. Pub. Hugh Rees Limited, London, 577 p.

4 - Trewavas, E., 1983.Tilapiine fishes of the Genera *Sarotherodon*, *Oreochromis* and *Danakilia* (1983). Trustees of the British Museum (Natural History), Publication Number 878, 583 p.

5 - Avault, J.W., 1970. Miristic, morphometric and physiological comparisons of *T.aurea* (Trewavas), *T. mossambicus* (Peters) and their experimentally produced hybrids. Presented at annual meeting of the Louisiana Academy of Sciences, 9 p.

6 - Gunasekera , R.M., Shim, K.F., Lam, T.J., 1996. Influence of protein content of broodstock diets on larval quality and performance in Nile tilapia, *Oreochromis niloticus* (L.). *Aquaculture*, 146(3-4): 245-259.

7 - Lall, S.P., Dae Kim, Jeong, 2000. Amino acid composition of whole body tissue of Atlantic halibut (*Hippoglossus hippoglossus*), yellowtail flounder (*Pleuronectes ferruginea*) and Japanese flounder (*Paralichthys olivaceus*). *Aquaculture*,187(3-4): 367-373.

8 - McAndrew, B.J., Majumdar, K.C.1983. Tilapia stock identification using electrophoretic markers. *Aquaculture*, 30: 249-261.

9 - Ghabriel, S.G., 1990. Induced spawning and developmental criteria of two *Oreochromis species* and their hybrid. M.Sc. Thesis, Fac.of Science, Alexandria Univ., 101 p.

LE ZOOPLANCTON DES EAUX DE BALLAST REJETÉES DANS LE GOLFE DE GABÈS (TUNISIE)

Zouari Leila [1] *, Ayadi Habib [1], Bouaïn Abderrahmen [1], Bradai Mohamed Najmeddine [2]

[1] Laboratoire de Planctonologie, Unité de recherche 00/UR/0907, Ecobiologie et Ecophysiologie animales, Département des sciences de la vie, Faculté des Sciences de Sfax. Tunisie - * Leila@tunet.tn, Habib.Ayadi@fss.rnu.tn

[2] Institut National des Sciences et Technologie de la Mer, Sfax, Tunisie

Résumé

Un des phénomènes les plus graves qui pèse sur les écosystèmes marins est l'introduction d'une espèce exogène qui peut se faire par différentes voies comme le vidange des eaux de ballast des bateaux lorsqu'ils arrivent près de leurs ports de chargement. Le présent travail consacré à l'étude qualitative et quantitative des zooplanctons trouvés dans le Golfe de Gabès dans les eaux de ballast des bateaux provenant des côtes nord méditerranéennes.

Mots-clés : Eaux de ballasts – Zooplanctons - Golfe de Gabès - Espèce exogène

Introduction

L'introduction dans les eaux territoriales d'espèces exogènes peut se faire par les eaux de ballast qui servent à maintenir l'équilibre et la flottaison des réservoirs quand les tankers sont vides. Avant de charger la cargaison, les bateaux relâchent les eaux de ballast avec tout ce qu'ils contiennent (larves, graines, phytoplancton, zooplancton…), parfois à plusieurs milliers de km de leur port d'origine. Dans de nombreux pays, il n'existe aucune législation interdisant le déversement des eaux de ballast qui peuvent causer l'invasion des espèces exogènes. Ces dernières peuvent dans certains conditions menacer les espèces autochtones.

Matériel et Méthodes

On a pris 6 échantillons d'eau de ballast ayant chacun 50 l de volume provenant directement des citernes de navires. On a filtré ce volume sur un tamis à soie à Bluter de porosité 80µm. On a cherché le nombre de zooplancton dans le volume filtré (ind/l). Le comptage se fait à l'aide d'une cuve de Dollfus sous une loupe binoculaire et la détermination des espèces de copépodes nécessite en plus d'un examen microscopique une dissection lente et minutieuse des appendices. L'identification des copépodes s'est réalisée grâce à l'utilisation des ouvrages de détermination adéquate.

Résultats et Discussions

Le zooplancton existant dans les échantillons collectés des citernes d'eaux de ballast des bateaux provenant des côtes nord méditerranéennes (Italie, qui déballastent dans le golfe de Gabès se compose des principaux groupes suivants : Copépodes, Appendiculaires, Larves de Gastéropodes et d'Annélides, Zoé, Métazoé, Œufs divers, …

Nous nous sommes intéressés particulièrement au groupe de copépodes. La composition spécifique de ces échantillons nous a permis d'identifier 9 genres de copépodes représentés par 6 calanoïdes, 2 cyclopoïdes et 1 harpacticoïde. Les espèces calanoïdes sont plus nombreuses que celles des cyclopoïdes. Les espèces rencontrés sont : *Paracalanus nanus, Paracalanus parvus, Lucicutia* sp., *Calanus finmarchicus, Spinocalanus* sp., *Scolecithricella minor, Oïthona nana, Oncaea méditerrannea, Oncaea conifera, Pseudocyclops* sp., *Euterpina acutifrons.*

Une étude quantitative des différents groupes zooplanctoniques dans les différents échantillons montre que les copépodes acquièrent les densités les plus importantes avec un maximum de 33 ind/l au niveau de l'échantillon E6, mais leur abondance relative la plus importante est enregistrée au niveau de l'échantillon E4 (99%).

Aussi on a révélé l'importance relative des larves d'annélides au niveau de l'échantillon E5 avec une abondance de 42%, 22% des œufs divers au niveau de E6. Pour les autres formes zooplanctoniques elles sont de moindre importance et leur abondance ne dépasse pas 12% au niveau de tous les échantillons (Fig. 1).

Le groupe de copépodes est dominant dans tous les échantillons et acquiert une moyenne de 80,17%. Cette importance quantitative met en évidence le rôle trophique important au sein de leur écosystème d'origine ainsi que leur adaptation aux mauvaises conditions (puisqu'ils s'installent dans les citernes de ballast présentant des conditions de vie défavorables, à savoir élévation de température, diminution du taux d'O2, l'existence de produits polluants …).

Les cyclopoïdes présentent des densités plus importantes que les harpacticoïdes qui sont accidentellement rencontrés.

L'espèce *Oithona nana* est d'origine essentiellement atlantique ancienne et *Euterpina acutifrons* est d'origine néritique. Leur présence dans les eaux des côtes nord méditerranéennes s'explique soit par un transport par les eaux de ballastes des navires, soit par le fait que

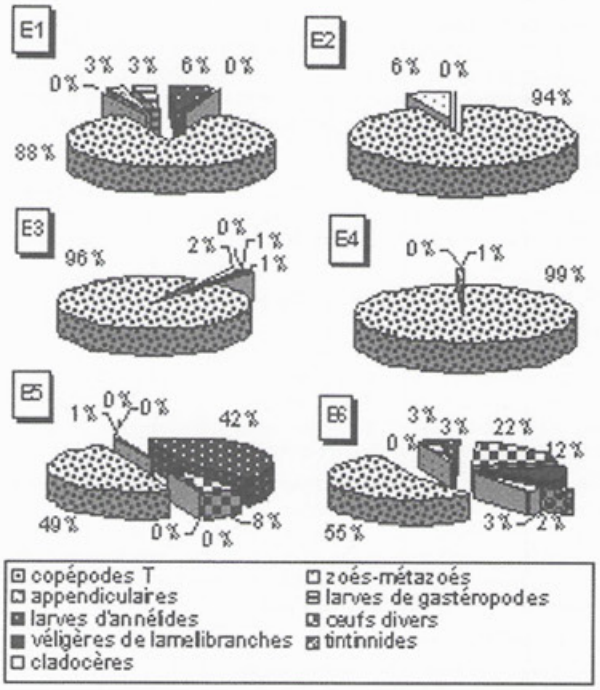

Fig. 1. Abondance relative des différents groupes zooplanctoniques des eaux de ballast.

ces espèces seraient des répliques boréales présentes depuis longtemps dans cette région de la Méditerranée.

Les densités zooplanctoniques sont généralement faibles. Ceci pourrait être dû au manque de prédateurs naturels des copépodes, tel que les chétognathes qui fuient les zones du ballastage et qui ne peuvent pas supporter les conditions sévères des citernes à ballast.

La richesse spécifique en Méditerranée est connue depuis longtemps puisqu'on a dénombré plus de 469 espèces de copépodes planctoniques marins (dont 26 espèces sont douteuses)(1).

Conclusion

Cette étude nous a permis de dégager un aspect positif quand au suivi des échantillons des eaux de ballast. Toutefois un suivi rigoureux est indispensable pour sauvegarder nos côtes et prévenir les contaminations par des espèces exogènes introduites accidentellement, essentiellement des espèces de copépodes pathogènes parasites des poissons et autres. Ces espèces allochtones peuvent proliférer aux détriments des espèces autochtones, causant ainsi des dégâts et un déséquilibre dans la chaîne alimentaire.

D'après cette étude, il est nécessaire d'équiper tous les ports d'installations de réception des eaux de ballast qui doivent être analysées afin de détecter d'éventuels espèces nuisibles, et d'implanter une réglementation internationale en vue de spécifier les rejets d'eaux de ballast qui doivent être faites en haute mer, au moins à 200 miles marins des côtes (projet en convention OMI en cours).

Références

1- Razouls., et Durand., 1991. Inventaire des copépodes planctoniques méditerranéennes *Vie et milieu*, Volume 41 (1).

Index alphabétique des auteurs

A

Aajjane A. 50
Abboud-Abi Saab M. 79, 259
Abdallah M. 461
Abdel-Moati M.A.R. 166
Abelló P. 421
Abid O. 469
Abkhar F. 3
Abou-Zaid F. 461
Acosta J. 56, 57
Acri F. 487
Adamidou A. 303
Agnesi S. 538
Aguilar A. 304, 316, 327, 328
Aguilera B. 305, 330
Ahel M. 248, 249
Akoumianaki I. 165
Aktan Y. 470, 486
Alam El-Din Kh. A. 166
Alberotanza L. 321
Albertelli G. 532
Alcaraz M. 295, 306
Alcaro L. 343
Alegre F. 316
Alexandri S. 60, 66
Alexis M. 297
Ali Malek 430
Aliani S. 510
Allemand D. 471, 499
Almogi-Labin A. 6, 525
Alonso B. 31
Alonso L. 285
Aloui-Bejaoui N. 444, 492
Altay O. 215
Altug G. 260
Alvarez E. 100
Alvera-Azcárate A. 80, 81, 84
Amarouayache M. 472
Amato E. 343
Amblas D. 4
Aminti P.L. 140
Ammar I. 473
Anagnostou Ch. 110
Andral B. 178
Andrianos H. 187
Angel D. 390
Angelidis M.O. 201
Anglés S. 455
Annabi-Trabelsi N. 474
Antolić B. 466, 475
Antón M.P. 167
Antoniadou C. 476, 477, 505, 506
Antonopoulou E. 450
Ćosović B. 180, 198
Ćosović V. 9
Aplikioti M. 400
Apostolaki E. 377
Aranda A. 478
Arcos J.M. 307
Ardizzone G.D. 415
Ariani A.P. 479
Arín L. 96
Arko-Pijevac M. 480, 481
Armstrong R.A 204, 219, 246
Arnau P. 5
Arnaud M. 168
Arnone R. 116
Arrieta J.M. 261
Artegiani A. 220
Arvanitidis Ch. 400
Arvanitidis Ch. 529
Asioli A. 16
Asses R. 482
Assimakopoulou G. 92, 237
Astraldi M. 101, 149
Atta Manal M. 537
Attia El Hili H. 262, 272
Aubertin E. 82
Auger Y. 228
Auladell M. 134
Ausili A. 544
Avcı M. 64, 70
Avila A. 200
Avital A. 6
Ayada M. 359
Ayadi H. 446, 463, 469, 516, 521, 560
Ayari W. 262
Azemard S. 196
Azzaoui Kheir E. 26
Azzaro F. 154, 268, 483, 511
Azzaro M. 169, 263
Azzurro E. 519

B

Baccarella A. 326
Bacher C. 178
Badalamenti F. 326, 514
Badalucco C. 398
Badesso A. 336
Badin C. 393
Baghdadi H.H. 484, 558
Baines S.B. 251
Bakhrouf A. 256, 273, 282
Balaban D.P. 485
Balagué V. 264
Baldi F. 299
Balkıs N. 486
Ballas D. 60, 66
Balopoulos E. 120
Barale V. 83
Barbanti R. 147
Barbot C. 223
Bárcenas P. 7, 72
Bardaji T. 68
Barišić D. 20, 170, 195
Barić A. 9, 213, 216, 222, 226
Barker E. 168
Barth A. 80, 81, 84
Bartoli G. 225
Bartolini F. 545
Bartulović V. 308
Barusseau J-P. 17
Bastianini M. 329, 487

Batel R. .193
Batistic M. .309, 532
Bavaru A. .179
Bayed A. .488, 503, 504
Bayon G. .34, 48
Bayrak Y. .260
Bazairi H. .488, 489, 538
Beckers J.M. .80, 81, 84
Bédir M. .8
Beg Paklar G. .105, 129, 130, .216
Bekas P. .454
Beker B. .259
Belaidi M. .317
Belayouni H. .205, 230
Belcari P. .310, 435
Belias Christos .171
Bellakhal-Fartouna M. .490
Bellan G. .422, 541
Bellan-Santini D. .422
Bello G. .491
Bellucci L.G. .27
Belluscio A. .415
Beltrano A.M. .311, 458
Ben Bouallègue Z. .81, 84
Ben Hadj Hamida N. .320
Ben Maiz N. .474
Ben Rehouma A. .492
Ben Souissi J. .312, 320, 523
Benac Č. .480, 481
Benedicto J.M. .167, 172, 177, .194
Benhissoune S. .489
Benjamini C. .6, 525
Bennoui A. .317, 318
Benović A. .338
Berdalet E. .313, 330
Bergamasco A. .512
Bergamin L. .544
Bermanec V. .41
Bernardi Aubry F. .487
Bernasconi S. .24
Berraho A. .464, 465
Bertilsson S. .286
Berto D. .173, 174
Berton A. .321
Betzler Ch. .65
Bevilacqua S. .493
Bianchi A. .293
Bianchi C.. .510
Bianchini A. .336
Bigazzi D. .220
Bignami F. .91
Bihari N. .193
Black K. .390
Blažina M. .265
Blanc-Valleron M.M. .34
Blasco D. .96
Boetius A. .29
Boge G. .494, 527
Bogner D. .9, 222
Böhm E. .91
Bojanić D. .314
Bojanić N. .290, 315
Bolaños-Sanchez R. .90, 104
Boldrin A. .138
Bolotin J. .338, 410, 381, .472, 497
Bonacci S. .336, 343
Bonanno A. .495
Bonnet S. .175
Bono G. .311, 458
Book J.W. .85, 138
Borg J. .496
Borghesi N., .336
Borin S. .275
Borrell A. .304, 316
Bosch D. .42
Bosman A. .10
Botsou F. .176
Bottari T. .365
Botter M. .255
Bou Maiza M. .218
Bouaïn A. .271, 278, 319, 320, 346, 416, 417, 433, 446, 463, 469, 516, 521, 528, 560
Bouaziz A. .317, 318
Boudabbous A. .266
Boudaya L. .319
Bouillin J-P. .11, 21
Boukef I. .266
Boukhris M. .446, 516
Boulahdid M. .208
Bourlès D. .11
Boussaid M. .447
Bouzinac C. .86
Bozzano R. .87, 139
Bracène R. .21
Bradai M.N. .312, 320, 433, .528, 560
Braga F. .321
Brahmi B. .317
Branica M. .20, 185, 228, .254
Bratoš A. .338, 472, 497
Braucher R. .11
Brautovic I. .322
Bravo I. .358, 455
Brenner J. .323
Brenner S. .88
Brocard G. .11
Bruach J.M. .55, 199, 200
Brückner H. .12
Brunet C. .267, 329
Brusa T. .275
Budillon G. .101
Buecher E. .403
Bulagakova J. .437
Burić Z. .270, 498
Busalacchi B. .365
Bussotti S. .509
Bustamante P. .223
Busuricu F. .485
Buttino I. .324, 325
Büyükisik B. .553

C

Cabiddu S. .356, 357
Cacho I. .30
Calafat A. .55, 75, 240

Calais E. 21
Calbet A. 306
Caligara C. 499
Camera L. 13, 54
Camp J. 358, 455
Campanelli A. 220
Campillo J.A. 177, 194
Canals M. 4, 5, 18, 30, 43, 45, 55, 71, 75, 240
Cannicci S. 326, 545
Cannizzaro L. 311, 458
Capotondi L. 24
Capozzi R. 14
Cappa C. 87, 139
Cappelletti A. 87, 140
Cappietti L. 140
Caput K. 498
Carazeanu I. 179
Carbo P. 207
Carbone M. 280
Carbonel P. 24
Carboni M.G. 544
Cardin V. 89, 112
Cardona L. 327, 328
Carić M. 180, 500, 526
Carniel S. 138, 150
Carpentieri P. 351
Carré C. 532
Carreras C. 327, 328
Carrias J.-F. 446, 516
Carruesco C. 3, 50, 74
Caruso G. 154, 268, 269
Casadevall M. 394, 431, 456
Casamor J.L. 18
Casanova J.-P. 362
Casas D. 15
Casas S. 178
Casavola N. 491
Casellato S. 551
Casotti R. 267, 329, 487
Cassi R. 196
Castelli S. 174
Catalán I.A. 330
Cateura J. 90
Cattaneo A. 16
Cau A. 356, 357
Celia Magno M. 544
Centanni E. 233
Certain R. 17
Cetinić I. 270, 498
Cetinić P. 373, 442
Chakroun-Marzouk N. 404
Chamot-Rooke N. 13
Chaoui L. 331
Chaouti A. 488, 501, 502
Charmasson S. 168
Chartosia N. 332
Chauvet F. 42
Cherkaoui E. 503, 504
Chiaverini J. 175
Chilari A. 333, 386, 419
Chintiroglou C. C. 476, 478, 505, 506
Chiocci F.L. 10
Chirila E. 179, 188
Christensen J.P. 231
Christidis G. 386, 408, 454
Christodoulou M. 529
Christou E. 437
Cicero A.M. 279, 507, 544
Çifçi Günay 23
Ciglenečki I. 180
Cikeš Keč V. 438, 462
Çinar M-.E 350, 508
Civitarese G. 122
Clarke J.H. 45
Coatu V. 188
Cochran J.K. 181, 219, 245, 246
Cocito S. 510
Colàs S. 18
Coll M. 334, 335
Collavini F. 182, 255
Colmenero E. 30
Comisso S. 277
Company J.B. 63
Conides A. 308
Cook E. 390
Coppini G. 160
Coraci E. 182
Corsi I. 336, 343
Cortés D. 238, 337, 360
Cossa D. 178
Costa F. 153
Cotou E. 183
Cotret O. 223
Courp T. 24
Coute A. 359
Coutelle A. 19
Criado F. 100
Crisafi E. 154, 269
Crise A. 184
Crispi G. 184
Cristofoli A. 551
Crnčević M. 338, 472, 497
Cuculić V. 185
Cukrov N. 20
Curiel D. 321, 536
Curtis J.H. 30

D

D'Acunzo E. 91
D'Ambrosio P. 509
D'Archino R. 91
D'Auria G. 275
D'Onghia G. 424
D'Ortenzio F. 329, 487
Dağli E. 350, 508
Dadić V. 105, 126, 130
Daffonchio D. 275
Dailianis A. 453
Dakovac T. 236
Daly Yahia M.N. 339, 340, 474, 482, 532, 555
Daly Yahia-Kéfi O. 339, 340, 482, 490, 532
Damalas D. 401
Damianidis P. 506

Dammak Zouari H. 271
Dando P.R. 510
Dañobetia J.J. 73
Darilmaz E. 186, 215
Dassenakis M. .....171, 176, 187, ...217,
Davini M.A. 356
De Biasi A.M. 510
De Bona S. 233
de Bovee F. 293
De Casabianca M.L. 341, 517
De Domenico F. 495
de Mora S. 196
De Ranieri S. 436
De Sousa L. 494
Decembrini F. .....268, 483, 511, ...512
Degobbis D. 236
Deidun A. 496
Del Árbol J. 342, 427
Del Negro P. 277
Del Río J. 100
Della Torre C. 343
Demant A. 42
Demestre M. 69, 423, 434
Demirov E. 155
Derbal F. .....203, 344, 411, ...472
Desaubies Y. 161
Despalatović M. .....345, 466, 475, ...520
Deudero S. 513
Déverchère J. 21, 32
Devincenzi J.M. 18
Dhieb K. 346
Di Carlo G. 514
Diamant A. 524
Diapoulis A. 506
Díaz del Río V. 7, 22, 28
Díez B. 264
Dimitriadis Ch. 347
Dimitriou E. 452
Djakovac T. 382
Djavidnia S. 94
do Espirito Santo M. 324
Dobrinas S. 188
Dobrović S. 94, 338
Domijan N. 151
Domzig A. 21, 32
Dondurur D. 23
Dorgham M.M. 537
Drago A. 157
Dragun Z. 189
Drakopoulos P. 92, 156
Draredja B. 93, 515
Droz L. 47
Druon J-N. 94
Ducassou E. 24
Dulac F. 190
Dulčić J. .....348, 349, 373, ...399, 418, 442
Duman M. 64, 70
Duperron S. 48
Durand J.-P. 223
Dzhurova B. 242

E, F

El Abed A. 262, 272
EL Bour M. 262, 266, 272
El Bouzidi R. 25
El Cafsi M. 221
El Foughali A. 26
El Grami B. 546
El Khatab M. 55, 191, 192
El Moumni B. 27
El-Gharabawy M.M. 484, 558
El-Greisy Z.A. 484, 558
El-Hogaraty E.E. 166
Elmnasser N. 273
Emelianov M. .....95, 96, 102, ...313
Emonet S. 274
Ercilla G. 15, 31
Ergen Z. 350, 508
Ergün M. 23, 33
Erk M. 189
Ersoy Ş. 70
Escartín E. 385
Escutia C. 73
Espino M. 117
Estrada F. 31
Estrada M. .....96, 281, 287, ...295, 296, 313
Eyrolle F. 168
Fabi G. .....52, 351, 369, ...552
Fabres J. 55, 240
Facca C. 341
Facca C. 341, 517, 518
Fakhri M. 79, 259
Fanelli E. 519
Farchi C. 343
Faure E. 447
Fehri-Bedoui R. 352
Felipe J. 287, 295
Fenoglio-Marc L. 97
Fera M.T. 280
Fernández A.M. 353, 361
Fernandez B. 194
Fernández de Puelles M. L. 354, 432
Fernández G. 316, 327, 328
Fernández J.L. 397, 426
Fernández-Salas L.M. 7, 22, 28
Ferrari C.R. 236
Ferrier-Pagès C. 471
Fichaut M. 120
Fine M. 530
Finoia M.G. 544
Fiorentino F. 355
Fischer J-C. 195
Fisher N.S. 245, 246, 251
Flores J-A. 30
Focardi S. 336, 343
Follesa M.C. 356, 357
Fonda Umani S. 277
Font J. .....82, 86, 98, 107, ...134, 135

Forcioli Didier 499
Foucher D. 195
Foucher J.P. 29, 38
Fouquet Y. 34
Fowler S.W. 181, 196, 223, 227, 245, 246
Fraga S. 358
Fragopoulou N. 420
France J. 405
Francesconi B. 436
Franco M. 177
Francour P. 499
Franičević M. 438, 462
Fraschetti S. 493, 509
Frau A. 513
Frehi H. 359
Frezza V. 544
Frignani M. 27
Frigola J. 30, 240
Friligos N. 197
Frka S. 198
Fuks D. 265, 392

G, H

Gačić M. 89, 112, 153
Gabarró C. 98
Gabellini M. 507, 544
Gabtni H. 8
Gaertner J.-C. 422
Galdies C. 99
Galil B.S. 214, 414, 524, 530, 556
Galletta M. 511
Galletta M.G. 268
Gangemi E. 512
Garcés E. 358, 455
García A. 337, 360
García de la Parra M.L. 385
García J. 75
García Lafuente J. 100
García M. 31
García M.J. 120, 144
García-Ladona E. 102, 107, 134
Garcia–Orellana J. 55, 199, 200
García-Rodríguez M. 353, 361
Garcin J. 293
Gardner W.D. 110
Gargouri Ben Abdallah L. 448
Garreau P. 94
Gascó C. 167
Gasol J.M. 285, 287, 296
Gasparini G.P. 101, 149
Gasparini S. 460
Gasser B. 181, 196, 227
Gattuso J.P. 276
Gaullier V. 21, 32, 47
Gavriil A.M. 201
Gdoura R. 278
Gelizo O. 67
Georgakopoulos-Gregoriades E. 202
Georgiou G. 155
Georgiou P. 15, 66
Gertman I. 127, 156
Ghabrial S.G. 559
Gharbi H. 352
Gharsallah Z. 203
Ghiglione J.F. 274
Ghirardelli E. 362
Ghorbel M. 320, 346
Giacobbe M. 358
Giani M. 173, 174
Giannoulaki M. 363
Gil de Sola L. 342, 427
Ginoux J.-M. 364
Giordano D. 365, 457
Giordano P. 343
Giorgetti A. 120
Giuliano L. 275, 293
Giusto G.B. 398
Glamuzina B. 308, 348
Glavić N. 338, 366, 381, 405
Gobat J. 116
Golani D. 367
Gomei M. 326, 545
Gomez B. 102
Gönenç T. 33
Goñi R. 397, 426
Gontharet S. 34
Gonthier E. 24
Gonzalez J.L. 178
González Marco D. 104
González R. 358
González-Benítez N. 276
González-Hernández F.M. 68
González-Pola C. 103, 118, 148
Gorsky G. 460
Got P. 266
Gotsis O. 358
Gotsis-Skretas O. 237
Goudard F. 223
Gourmelen L. 161
Goutx M. 204, 219
Goy J. 555
Goy J.L. 68
Gràcia E. 31, 35, 73
Gras D. 368
Grati F. 351, 369
Grbec B. 105, 125, 126, 129, 130, 216
Greco S. 365
Grezio A. 159
Gržančić Ž. 480, 481
Grilli F. 220
Grubelić I. 345, 475, 520
Grubesic M.-S. 249
Guarnieri G. 509
Guermazi W. 521
Guerrero Juan 172
Gugliandolo C. 280
Guichard F. 44
Guieu C. 175
Guigue C. 204
Guillén J. 46, 53, 61, 63, 69, 102
Guimet J. 67
Gutscher M.-A. 36
Hafferssas A. 370

Halim Y. 522, 537, 500
Hamad N. 106
Hamani M. 27
Hammami M. 212, 256
Hamouda R. 205, 230
Hamza A. 271, 463
Haralambides L. 239
Hatzianestis I. 206, 244
Hédouin L. 223
Hernández M.R. 394, 431
Herndl G.J. .....261, 283, 291, ...294
Herut B. 207,214, 525
Hirschberg D. 181
Hodell D.A. 30
Holst R. 303
Horton T. 524
Houma F. 208
Hristova O. 242
Hübscher Ch. 65
Huguen C. 37, 38
Hugues-Clarke J.E. 4
Hyams O. 525

I, J, K

Iacocca A. 336
Ianora A. 324, 329
Ibanez F. 403, 460, 532
Idelhaj A. 464
Ignatiades L. 237
Inanmaz O.E. 371, 380
Iona A. 120
Irigoien X. 306
Irrera G.P. 280
Isari S. 420
Isern-Fontanet J. 107
Isinibilir M. 372
Isla E. 192
Ismael A.A. 522
Ivanković D. 126, 130, 189
Jakšić Ž. 209
Jamet D. 527
Jamet J.L. 364, 527, 540
Janekovic I. 108
Jannet E. 516
Jarboui O. 320
Jardas I. 348, 373, 442
Jasprica N. 500, 526
Jean N. 527
Jiménez J.A. 323
Johannessen J. 86
Joksimovic D. 542
Joksimovich A. 374
Jones Burton H. 116
Jornet A. 172
Jribi I. 528
Julià A. 109
Juračić M. 9
Kaberi H. 39, 66
Kalianiotis A. .....303, 311, 379, ...453
Kamidis N.I. 210
Kantha L. 150
Kapiris K. 375
Kara M. H. 93, 203, 331, 344, 359, 411, 472, 515
Karachle P.K. 376
Karageorgis A.P. 110
Karakassis I. 377, 390, 443
Karakulak F.S. 378, 554
Karani I. 332
Karavoltsos S. 211
Karuza A. 277
Kastritis T. 187
Katselis G. 452
Katz T. 390
Kavadas S. 379, 408, 419
Keskin C. 371, 380
Khadr A.M. 40
Khalil Adel Ghani N. 537
Khedir-Ghénim Z. 212, 256
Khériji S. 221
Kherroubi A. 21
Khomsi S. 8
Khouider A. 208
Kırbasoğlu Ç. 250
Kirinčić M. 480, 481
Kirmitzoglou I. 529
Kitsos M.-S. 332, 400, 529
Klein B. .....89, 111, 112, ...122, 137
Klerman A. 530
Kljajic Z. 393
Kljaković-Gašpić Z. 213
Kniewald G. 41, 170
Kožul V. .....338, 366, 381, ...405
Kolovoyiannis V. 531
Kontas A. 215
Koukouras A. 332, 400, 529
Kousteni V. 505
Koutsikopoulos C. 363, 420, 452
Koutsodimou M. 183
Koutsoubas D 347, 377
Kovač N. 390
Kovačić M. 480, 481
Kozarac Z. 198
Kršinić F. 180
Kraljević M. 373, 399, 442
Krasakopoulou E. 110
Kraus R. 382
Kremenetskiy S. 102
Kress N. 137, 214, 243
Krom M. 207
Krstulović J. 392
Krstulović N. 289, 290
Ktari M.H. 404
Ktari Rim 320
Kušpilić G. 216, 222, 409
Kucuksezgin F. 186, 215
Kulhanek E. 471
Kurgansky M. 113
Kuzmic M. 108, 114
Kwokal Z. 195

L, M

La Ferla R. 169, 263
Labraimi M. 3, 25, 50
Ladakis M. 187, 217
Lahbib Y. 218
Lakhal F. 272
Lakkis S. 383, 384
Lancini L. 336
Landini P. 265
Langar H. 492
Lapierre H. 42
Larcher M. 274
Lardner R. 155
Lario J. 68
Lascaratos A. 94, 115, 123, 141, 142, 143, 146
Lastras G. 4, 43, 71
Latasa M. 288, 313
Lavado R. 385, 533
Le Bras S. 135
Le Pennec M. 218, 448
Le Roy P. 21
Lebaron P. 274
Lebreiro S. 73
Leder N. 130, 151
Lee C. 204, 219
Lee Craig M. 116, 131
Lefkaditou E. 386
Leonardos I. 400
Leontarakis P.K. 387, 453
Lericolais G. 44
Leynaud D. 71
Licandro P. 532
Limam A. 538
Lipej L. 349
Liquete C. 45
Littardi V. 388
Llave E. 51
Lloret Josep 389
Lo Iacono C. 46
Loaec G. 161
Logan A. 510
Lojen S. 390
Lombarte A. 391, 423
Loncke L. 24, 47, 48, 54
López J. 117
López-Jurado J. 103, 118, 148
Loubrieu B. 49
Louzao M. 307
Lovrić J. 338
Lučić D. 392, 410
Lucu Č. 284
Lugliè A. 358, 455
Luque L. 68
Lykousis V. 15, 39, 66
Lyons D.M. 119
Maalej S. 278
Maamouri F. 447
Maanan M. 25, 50, 74
Machias A. 363, 443
Macic V. 393
Maestro A. 51
Maffucci M. 536
Magaletti E. 279
Maggi C. 507
Mahfoudhi M. 271
Maillard C. 120
Maiorano P. 424
Malacic V. 121
Maldonado A. 72
Malej A. 390
Malits A. 264, 313
Mallol S. 394, 406
Manca B.B. 111, 120, 122, 137, 241
Mancuso M. 269
Mandic S. 393
Mannini A. 425
Manoukian S. 52, 552
Mantziafou A. 123
Manzella G. 126, 155
Maršić-Lučić J. 395
Maran C. 233
Marasović I. 409, 440
Marcoux J. 42
Marín M.A. 35
Marini M. 116, 138, 220
Marinović S. 409
Mariottini M. 336
Marki A. 130
Marrasé C. 264
Marrasé C. 313
Martín J. 53, 63, 102
Martín P. 310, 396
Martín R. 533
Martinez F. 177
Martínez-Benjamín J.J. 117
Martínez-Gomez C. 172
Martín-Serrano A. 51
Mas Xavier 397, 426
Mascle G. H. 11, 42, 59
Mascle J. 13, 24, 29, 37, 38, 47, 48, 49, 54
Masiero L. 551
Masmoudi W. 221
Masó M. 358, 455
Masqué P. 55, 75, 181, 199, 200, 219, 245, 246
Massana R. 264
Massari F. 355
Massi D. 398
Massuti E. 367
Mateu G. 56, 57
Mateu-Vicens G. 56, 57
Matić F. 105, 125, 126, 130
Matić Skoko S. 373, 399, 442
Matijevic S. 222
Maudire G. 120
Maugeri T.L. 280
Mauri E. 124
Maury R.C. 42
Mavidis M. 400, 529
Mazza S. 329
Mazzocchi M.G. 325
Mazzoldi A. 153
McGenity T.J. 275
Medhioub K. 446

Medialdea T. 51
Megalofonou P. 401
Méjri H. 523
Melgarejo J.C. 41
Mercado J. 238
Mercier de Lépinay B. 21
Merello S. 543
Merle P. L. 499
Metian M. 223
Mezali K. 534, 535
Micheli C. 536
Micic M. 193
Migeon S. 24, 47, 58
Migon C. 224, 225
Mihanovic H. 130
Mikac I. 249
Mikac N. 195
Mikhailov N. 120
Milazzo A. 311, 458
Milazzo M. 326
Miller J. 98
Millot C. 82, 106, 145
Milun V. 226
Minisini D. 16
Miquel J.C. 181, 196, 219, 227, 246
Miralto A. 324, 329, 487
Mishonov A.V. 110
Missaoui H. 320
Mitwally H. 537, 550
Mladineo I. 402
Mlakar M. 228
Mo G. 538
Molinari A. 539, 547
Molinero J.C. 403
Montagna P. 537
Monticelli L. S. 298
Montori C. 67
Morales A. 96
Morán X.A.G. 281
Moreiro M. 56, 57
Morel F. 275
Moreno A. 30
Moriceau B. 204
Morović M. 105, 125, 126, 216
Morri C. 510
Mosetti V. 184
Mostafa H.M 550
Mouine N. 404
Moulin C. 190
Mousseau L. 460
Mozetic P. 405
Mraouna R. 262, 272
Muceku B. 42, 59
Mulder T. 24
Müller C. 24
Muñoz M. 394, 406, 431, 456
Murashkovsky A. 127
Murat A. 24
Mutlu E. 407
Mytilineou Ch. 375, 408

N, O, P

Nachite L.D. 538
Nadal G. 56, 57
Najdek M. 265
Nakbi A. 282
Nannicini L. 241
Nascetti G. 536
Naud Jean 50
Neifar L. 319
Niessen S. 195
Nikolaidou A. 165, 183
Ninčević Ž. 290
Ninčević-Gladan Ž. 409, 440
Nittis K. 92
Nival P. 403
Njire J. 392, 410
Nomikou P. 60, 66
Nonnis O. 507
Nouacer S. 411
Nouar A. 412
Nour El-Din N.M. 413
Occhipinti-Ambrogi A. 414, 548
Ochi I. 272
Oddo P. 159
Odžak N. 213
Oguz T. 128, 229
Ojeda E. 61
Olivar M.P. 305, 330, 432
Ölmez E. 250
Ondréas H. 38
Onofri V. 348, 466
Oral Ersel Z. 33
Oral M. 380
Orellana J.G. 73
Orlic M. 116, 129, 130, 131, 151
Oro D. 307
Orsi Relini L. 367, 415, 424
Ortona A. 101
Ouannes Ghorbel A. 416, 417
Ouertani N. 205, 230
Ozel E. 64, 70
Özgür E. 378
Öztürk B. 378, 554
Öztürk H. 62
Packard T.T. 231
Paganin P. 536
Pagou K. 237
Palanques A. 53, 55, 63, 102, 191, 192
Palinkaš L.A. 41
Pallaoro A. 348, 349, 373, 418, 442
Pallàs R. 73
Palomera I. 305, 330, 334, 335, 432
Panfili M. 552
Panin N. 44
Panou E. 176
Pansini M. 510
Pantazidou A. 217
Panza M. 424
Paoli A. 277
Papaconstantinou C. 379

Papadopoulou K.N. 377, 443
Papaharisis L. 452
Papanikolaou D. 60
Parada V. 283
Paraskevopoulou V. 187
Paricio S; 104
Pasaric M. 129, 130, 132
Pasaric Z. 114, 116, 129, 130, 131
Paschini E. 85, 138
Pascual M. 328
Passalacqua C. 514
Pastres R. 299
Pauc H. 21
Pauly D. 428
Pavičić J. 189
Pavičić-Hamer D. 284
Pavic M. 130
Pavlidou A. 197, 232
Pavoni B. 233, 540
Pazı I. 133
Pečar O. 234
Pedrós-Alió C. 264
Peharda M. 338, 472, 497
Peirano A. 510
Pekcetinoz B. 64
Pelegrí J.L. 102, 134
Pellizzato F. 233
Peneva E. 94
Penna M. 343
Peralba À. 325
Perez B. 100
Perkins H. 85, 138
Pesci P. 357
Pete R. 204
Peters H. 116
Peterson M.L. 204, 219, 246
Petit de la Villéon L. 161
Petrakis G. 333, 386, 419
Petrillo M. 532
Piano T. 425
Piazza R. 27
Picco P. 87, 139
Picotti V. 14
Pierre C. 34
Pinardi N. 155, 159, 160
Pinhassi J 285, 287
Planquette H. 190
Plavšić M. 235
Polymenakou P.N. 286
Popescu I. 44
Porcu C. 356
Porte C. 385, 533
Poulain P.-M. 116, 124, 135, 147
Pouliquen S. 161
Pozo M. 426
Precali R. 234, 236, 392
Price N.B. 75
Profeta A. 495
Psarra S. 237
Psyllidou-Giouranovits R. 197, 232
Puig B. 455
Puig P. 53, 55, 63, 102,191, 192

Q, R

Quignard J.-P. 312, 331, 367, 447
Quintanilla L. 360
Rabotin M. 341
Radic T. 382
Radin F. 540
Raffa F. 268, 483, 511, 512
Raicich F. 136
Raimbault P. 237
Rais C. 492, 538
Ramfos A. 420
Ramieri E. 321
Ramírez T. 238, 337, 360
Ramón M. 421
Ras J. 175
Raspor B. 189
Ravot G. 275
Rebzani-Zahaf C. 422, 541
Recasens L. 391, 423
Regner D. 542
Rehault J.-P. 36
Reicherter K. 65
Reinthaler T. 261
Relini G. 425, 543
Relini M. 424
Renieris P. 92
Reñones O. 426
Reseghetti F. 126
Retima A. 203
Revelles M. 327
Rey J. 342, 427
Rezig M. 312
Ribera d'Alcalà M. 122, 263
Richard S. 494, 540
Richardson C.A. 387
Rigas F. 244
Rinelli P. 365, 457
Rismondo A. 321, 536
Rixen M. 80, 81, 84, 120
Rizzi E. 491
Rizzo P. 458
Rizzo Y. 428
Roca E. 67
Rodríguez C. 172
Rodriguez y Baena A. 181, 227, 246
Roether W. 111, 137
Roldán C. 313, 330
Romagnoli C. 10
Romano E. 544
Romano G. 324
Romano J.-C. 259
Romdhane M.S. 221, 474, 555
Rorandelli R. 545
Rori N. 244
Rosen Dov S. 97
Rosentraub Z. 88
Rosoiu N. 485
Rossetti I. 436
Rossetto B. 364
Rosso M. 388
Rouchy J.M. 34
Rousakis G. 15, 66

Rudman W.B. 312, 557
Ružinski N. 338
Ruiz A. 61
Russo A. 85, 138, 220
Russo G.F. 493

S, T

Saad A. 383, 429, 430
Sàbat Maria 406, 431, 456
Sabatés A. 95, 313, 396, 432
Sabatini A. 357
Sabour W. 383
Sabourault C. 471
Sadki I. 538
Sage F. 13
Saidane H. 8
Saïdane-Mosbahi D. 212, 256
Saidi B. 433
Sairouni A. 90
Saiz E. 306, 441
Sakellari A. 211
Sakellariadou F. 239
Sakellariou D. 66
Sakka Hlaili A. 546
Sala M.M. 287, 295
Salat J. 95, 96, 313, 432
Salem S. 461
Salusti E. 91, 113
Salvati E. 538, 539, 547
Salviato S. 321
Sampedro N. 358, 455
San Felix M. 327, 328
Sánchez P. 423, 434
Sánchez-Arcilla A. 90, 104, 117
Sanchez–Cabeza J.A. 55, 75, 199, 200
Sanchez-Vidal A. 75, 240
Sanda S. 409
Sandroni V. 225
Sangrà P. 134
Sansone E. 101
Santinelli C. 241
Sanz J.L. 22, 28
Sardà F. 63, 334, 335
Sardou O. 58
Sartini M. 435
Sartoni G. 510
Sartor P. 351, 436
Sass A.M. 275
Sava D. 485
Savelli F. 173
Savini D. 548
Savoye B. 21, 32, 58
Saygın N. 250
Sayın E. 133
Sbrana M. 436
Scalisi M. 311
Scarcella G. 369
Scattolin M. 255
Scharek R. 288
Schembri P.J. 496
Schiano M.E. 87, 139
Schrimpf W. 94
Schulz M. 190
Sclavo M. 138, 150
Sconfietti R. 549
Scoullos M. 171, 176, 211
Scroccaro I. 140
Sebastián M. 238
Send U. 145
Seret B. 430
Seridji R. 370
Seritti A. 241
Serra J. 67
Sertorio T. 532
Šestanović S. 289, 290
Sfriso A. 518
Shabaka S.H. 550
Shafee M.S. 464, 465
Shelef G. 243
Shiganova T. 437
Shoam-Frider E. 243
Shtereva G. 242
Siapatis A. 379, 386
Sibuet M. 38
Sierra J.P. 104
Sierro ..... F. 30
Signell R. 85, 138, 220
Silva P.G. 68
Silvestri S. 321
Sime-Ngando T. 446, 516
Šimunović A. 345, 520
Sinovčić G. 438, 462
Sintes E. 261, 283, 291
Siokou-Frangou I. 437, 439
Sist P. 279
Sitran R. 512
Skaramuca B. 366, 381, 451
Skejić S. 440
Skliris N. 141, 143
Sklivagou E. 206, 244
Skovgaard A. 441
Smith C. 443
Smodlaka N. 119
Socal G. 487
Sofianos S. 94, 115, 141, 142, 143
Soldo A. 348, 349, 373, 442
Šolić M. 289, 290
Somarakis S. 363, 443
Somoza L. 51, 68
Soresi S. 551
Soriano S. 69
Soto Juan I. 35
Soufi-Kechaou E. 444
Souissi S. 339, 340, 403, 532
Spagnolo A. 52, 552
Spanier E. 390
Spanò N. 495
Sparnocchia S. 87, 139
Stamataki Ch. 443
Stamatis N. 210
Stemmann L. 460
Stephanou E.G. 286
Stergiou K.I. 376

Stewart G. 181, 245, 246
Stjepcevic B. 542
Stoica E. 292
Stojanoski L. 253
Stroganov O. 102
Sultan N. 58, 71
Sunlu F.S. 553
Sunlu U. 247, 553
Supić N. 119
Svetličić V. 265
Sylaios G. 210
Szlosek J. 181
Taktak A. 319
Tamburini C. 293
Tambutté E. 471
Tambutté S. 471
Tamvaki A. 531
Tardy M. 42
Tarkan A.N. 372
Tartar M. 190
Tashko A. 42, 59
Taupier-Letage I. 82, 106, 145
Teira E. 294
Tel E. 144
Tello O. 22, 28
Tepic N. 248
Terlizzi A. 493, 509
Terrats A. 408
Terzic S. 248, 249
Testor P. 145
Tetorou D. 401
Teyssié J.-L. 223
Thaler D. 116
Thanos G. 92
Thebault H. 168
Theocharis A. 146
Thibaut R. 533
Thiebot E. 36
Tičina V. 213
Tommasi P. 10
Topaloglu B. 378, 554
Topcuoglu S. 250
Tornero V. 316
Torrobella J. 109
Toumi N. 446
Touzri C. 555
Trabelsi M. 447
Trabucco B. 507
Trepat I. 306
Triantafyllaki S. 187
Tricart P. 11
Trigui El-Menif N. 218, 448
Trincardi F. 16
Trousselier M. 266
Tsapakis M. 390
Tselepides A. 237, 286, 332
Tsikliras A.C. 449, 450
Tsimenides N. 363
Tsirtsis G. 347, 531
Tudela Sergi 334, 335
Tunesi L. 538, 539, 547
Tursi A. 424
Tutman P. 338, 366, 381, 405
Twining B.S. 251
Tzanatos E. 452
Tziavos Ch. 92
Tzomos Th. 332

U, V, W

Ulug A. 64, 70
Uluturhan E. 215
Umgiesser G. 140
Unsal N. 380
Urbani R. 279
Urgeles R. 4, 45, 71
Ursella L. 147
Vafidis D. 453, 477
Vallerga S. 157
van den Berg Constant M.G. 235
van Lenning K. 455
Vandenbulke L. 81, 84
Vannini M. 326
Vantrepotte V. 267
Vaqué D. 295, 296
Vargas J.M. 100
Vargas-Yáñez M. 118, 238
Vassallo C. 355
Vassilopoulou V. 202, 454
Vatsos I.N. 297
Vázquez J.T. 7, 72
Vázquez-Domínguez E. 296
Vegas R. 72
Vélez-Belchi P. 103, 118, 148
Verdicchio G. 16
Vervatis V. 142
Vetrano A. 149
Vichi M. 150
Vidal M. 313
Vidoris P. 311
Vila M. 358, 455
Vila S. 406, 456
Vilaclara E. 104
Viličić D. 116, 180, 270, 498
Vilibic I. 130, 151, 152
Villari A. 457
Viñals M.J. 56, 57
Virno Lamberti C. 507
Vitale S. 311, 458
Viva C. 310
Vizcaino A. 35, 73
Vlatsiotis Y. 452
Voultsiadou E. 476, 477
Voutsinou-Taliadouri F. 252
Vukadin I. 253
Vukanić D. 459
Vukanić V. 459
Vuksanovic N. 542
Wakeham S.G. 204, 219
Warembourg C. 460
Warnau M. 223
Wittmann K.J. 479
Woodside J. 29, 38
Würtz M. 388
Wyse E. 196

Y, Z

Yelles K. 21
Yiagnisis M. 297
Yılmaz Y.Z. 250
Yokes B. 556, 557
Yurterin N. 553
Zaccone R. 298
Zaggia L. 153, 182
Zaki M.I. 461, 484, 558, 559
Zampino D. 298
Zangrando V. 173, 174
Zaouali J. 312
Zappalà G. 154
Zatsepin A. 102
Zaupa A. 182
Zazo C. 68
Zecchini F. 299
Zeidane R. 383, 374
Zeri C. 252
Zervakis V. 92
Žic V. 254
Zine N. 538
Zoccola D. 471
Zodiatis G. 155, 156
Zonta R. 182, 255
Zorica B. 438, 462
Zouari L. 463, 560
Zoubi A. 464, 465
Zourarah B. 3, 25, 50, 74
Zrafi I. 256
Žuljević A. 466, 475
Zuliani A. 182
Zúñiga D. 75
Zvonaric T. 213, 226