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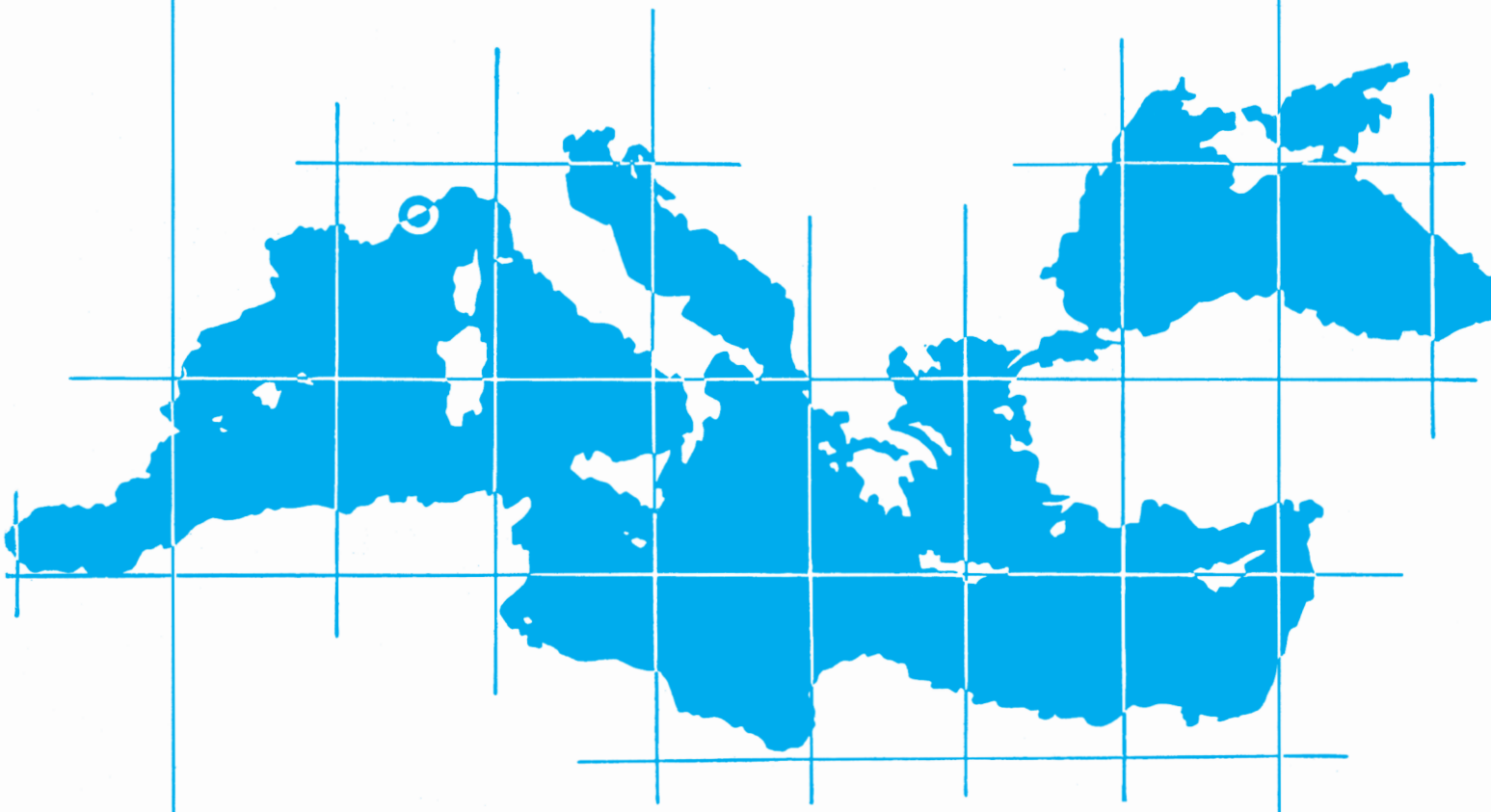

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36th CIESM CONGRESS PROCEEDINGS

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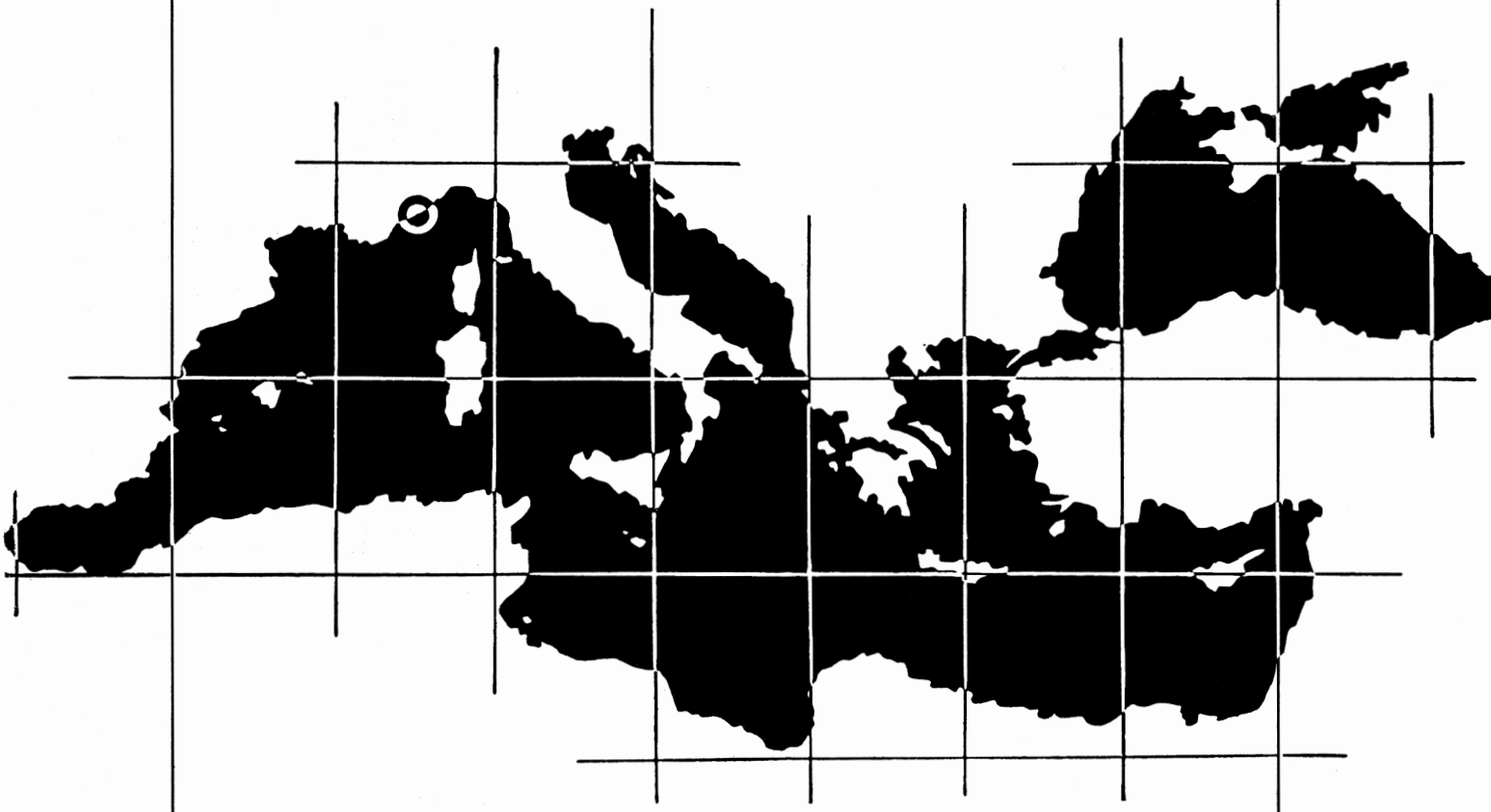

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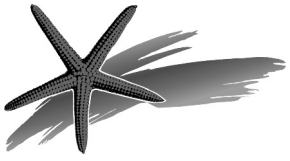

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Rapport du 36e Congrès de la Commission Internationale pour l'Exploration Scientifique de la mer Méditerranée

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Volume 36 2001

Sommaire

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GEOLOGICAL STRUCTURE OF THE MYRTOON BASIN (AEGEAN SEA) BASED ON SWATH BATHYMETRY

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Abstract

A novel structure of the sea-bed has been revealed in the junction point among the Myrtoon basin, Cretan basin, volcanic arc and the south-western border of the Cycladic plateau. The bathymetric map, resulted by recently acquired multibeam data permitted the distinction of: a) a deep basin at the west which represents an asymmetric tectonic graben with very steep slopes and with a maximum subsidence of –1080m; b) a canyon type feature at the north-east which runs through the western Cycladic plateau producing an arcuate depression of about 300m deep, for a length of approximately 20 Km; c) a rough area with an irregular small scale relief at the south-east which is interpreted as the submarine prolongation of the Antimilos volcano. The tectonic regime is outlined by two major fault zones: one of WNW-ESE, direction which constitutes the southern marginal fault of the Myrtoon basin separating it from the Cretan basin by the Falkonera-Antimilos tectonic horst and the second of WNW-ESE direction which represents the northern margin of the Myrtoon basin but with much less subsidence. A secondary fault set of NNW-SSE direction subdivides the regional structure in smaller neotectonic blocks.

Keywords: Swath mapping, tectonics, Aegean Sea, Cretan Sea

Swath bathymetry

SEABEAM 2120 is a new swath system that has been specifically designed to accommodate users with survey requirements exceeding 6000m water depth accomplishing a satisfactory resolution without mounting a very large array. The first installation of this type with 1.80 beam width, has been completed during 2000 on the Hellenic vessel R/V *Aegaio*. It has an angular coverage sector of 150 degrees with 149 beams, covering a swath width from 7.5 to 1.15 times the water depth for depths 1000m to 5000m respectively, with a maximum swath coverage of about 9 Km, operating with vessel's speed up to 11 Knots. The above system was used during November 2000 with an average ship's speed of 6 Knots in order to achieve better along track resolution. A total track length of 495 Km have been surveyed resulting to a coverage of about 1084 Km^2, between the small islets Falkonera and Antimilos. The processed detailed bathymetric map is presented on Figure 1, as gray-tone coded bathymetry with a contour interval of 10m, in reduction from the colored original map of 1:25000 scale. The maximum depth 1180m coincides with the deep basin at the western edge of the map to the north of Falkonera islet, while the shallowest depth 83m stands on the top of the southern side of this basin east of Falkonera. The maximum slopes (30-50%) are observed to the south, close to Falkonera and delineate the southern border of the basin. The seabottom relief presents a high heterogeneity at various scales of topographical variations which permit the distinction of discrete physiographic units that may represent different geological basement.

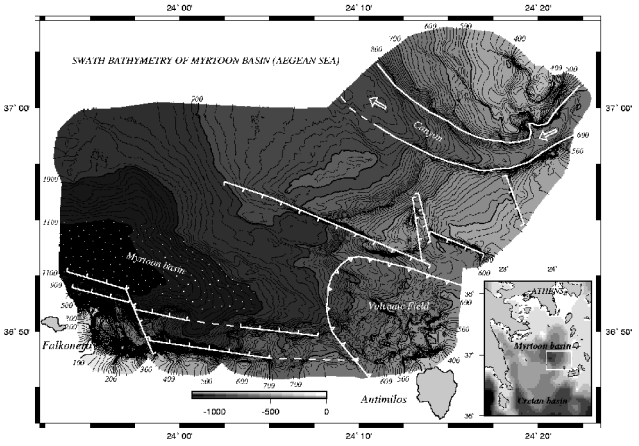

Figure 1. Bathymetric map

Interpretation of geological structures

The surveyed area, as can be seen in the inset map of Figure 1, is located in Myrtoon sea, at the junction between the Myrtoon basin, Cretan basin, volcanic arc and the south-western border of the Cycladic plateau. The overall neotectonic structure of the studied area is defined by three prominent features: a deep basin at the west, a canyon type feature at the north-east and an area of rough relief at the south-east north of Antimilos. The basin is developed in an approximately WNW-ESE direction as an elongated asymmetric tectonic graben with a length more than 8.5 Km and a width less that 3.5 Km (Fig. 2a1). It exhibits very steep slopes to the north of Falkonera and abruptly passes to a planar morphology slightly plunging to the south with slopes of 1-2% (Fig. 2a2). The submarine canyon is a semicircular channel that flows from the NE through the southern margin

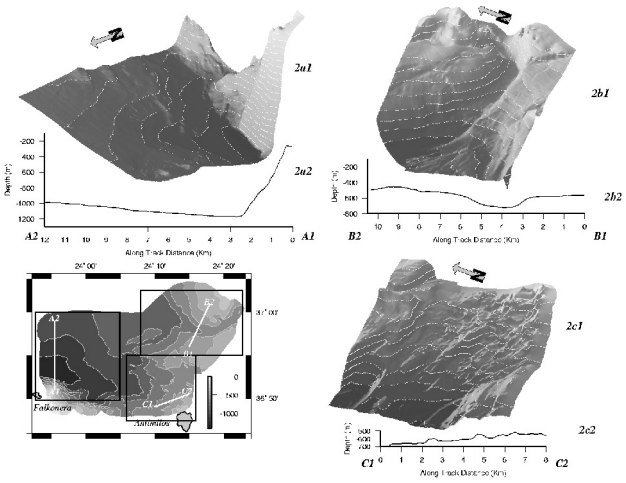

Figure 2. Perspectives images and bathymetric profiles of Myrtoon basin (a), Canyon (b), volcanic field. (c)

of the Cycladic plateau and discharges at almost right angle (Fig. 2b2). It is 200-300m deep, with a length of approximately 20 Km and a width from 1Km to 3Km (Fig. 2b2). The morphology of this canyon is most lightly inherited from older geological period when the Cycladic plateau was emerged and the present-day Cycladic islands were the summits of the mountain ranges. The peculiar rough relief exposed NW of Antimilos is presented by small undulations circular and oblong with a diameter of about 200-400m and highs of the order of 50m (Fig. 2c1, 2c2). This special relief has a distinctive signature also on the amplitude of the backscattered signal. The above signature may reflect a volcanic field in the northern prolongation of Antimilos volcano. The special morphological features may represent submarine volcanic debris, flows, submarine domes, necks and dikes. It is worth noted that, based on the dip of the volcanic formations on the northern part of Antimilos, Marinos (1) has suggested the existence of another volcanic center north of Antimilos.

The morphostructural regime revealed by the detailed analysis of the bathymetry pointed out the existence of two major fault zones of WNW-ESE direction, which form an asymmetric tectonic graben. The planar part of Myrtoon basin, previously described, occupies the central part of this tectonic graben and is developed, mainly, along the southern marginal fault zone which exhibits a vertical fault throw of more than 1 Km, in contrast to the fault throw of the northern margin which is only a few hundred meters. This general tectonic trend follows the regional trend of the Aegean volcanic arc and indicates a horizontal extension in NNE-SSW direction (2). The Falkonera-Antimilos ridge developed to the south of the southern marginal fault constitutes a WNW-ESE tectonic horst that separates the tectonic graben of Myrtoon basin from the major structure of the Cretan back-arc basin. A secondary fault system of NNW-SSE direction intersects the previous major fault structure creating smaller neotectonic blocks, as the blocks between the canyon and the volcanic field.

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SEDIMENT PATTERN DISTRIBUTION AND MORPHOLOGY OF THE ALBORAN RIDGE AND ITS RELATION WITH THE ANTICYCLONIC GYRE

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Abstract

The Alboran ridge is a linear seamount that divides the Alboran basin in two sectors and interferes in the general circulation pattern. The northeastern segment of this ridge has been studied by means of high resolution seismic, side scan sonar data and dredges. The sediment pattern shows a transition southwards from sands to biogenic sands or biogenic carbonates and muds. This particular distribution has been related to the interaction between the Atlantic inflow and the ridge generating a high pelagic and benthic productivity as well as mud sediments domination southwards the ridge.

Keywords: Western Mediterranean, Alboran Ridge, sediment transport.

Introduction

The Alboran Sea is a narrow (~200 km wide and 350 km long) basin located in the westernmost Mediterranean Sea. It is connected to the Atlantic Ocean through the Straits of Gibraltar and is characterized by narrow shelves, an irregular slope and several sub-basins, ridges and seamounts. The Alboran Ridge is a linear NE-SW and strong bathymetric high that extends 180 km and rises locally in the Alboran island. The Alboran Sea is a key location to understanding the influence on the Mediterranean paleoceanography of the Atlantic-Mediterranean gateways. The Atlantic surficial waters pass through the Straits of Gibraltar, shows a wide anticyclonic gyre in the western Alboran basin and takes a WNW-ESE direction on the Alboran Ridge before moving eastwards (1). The Quaternary evolution has been controlled mainly by the interplay of tectonics, sea level, climate changes, and ocean circulation (2, 3). The goal of this paper is to study the relation between sediment distribution and ocean circulation as well as the influence of the Alboran ridge.

Material and methods

Bathymetric (echosounder Furuno FUG 11), high resolution seismic reflection (ORE 3.5 kHz) and side scan sonar (EG&G, 500 kHz) data and dredges ranging from 0 to 500 m depth were used to study de northeastern segment of the Alboran ridge along two oceanographic cruises (Coral 8209 and Alboran 9409). A microphysiographic study has been performed based on a side scan sonar mosaic (4).

Bathymetric characteristics

The ridge in this area can be divided in three sectors (Fig 1). The northeastern one shows two mains relieves at 50 meters depth and the shelf gently deep to 130 meters. In the Central Sector, the shelf is constituted by some irregular relieves which the main is the Alboran Island. From 0 to 50 m depth, the bathymetric contours, rhomboedric and concentric, rounds the island. Between 50 and 100 m depth, the bathymetric lines are elliptic with a NW-SE major axis. The southern face is abrupt with a high slope from 100 meters depth, meanwhile, a flat zone, without relief, emphasizes the northern face between 110 and 120 meters depth. The southwestern sector is a very narrow shelf with two highs at 85 and 80 m depth respectively. Two submarine canyons (Piedra Escuela and Al Borani) have been differentiated in the southern slope, the second one is related to a well-developed submarine fan (5).

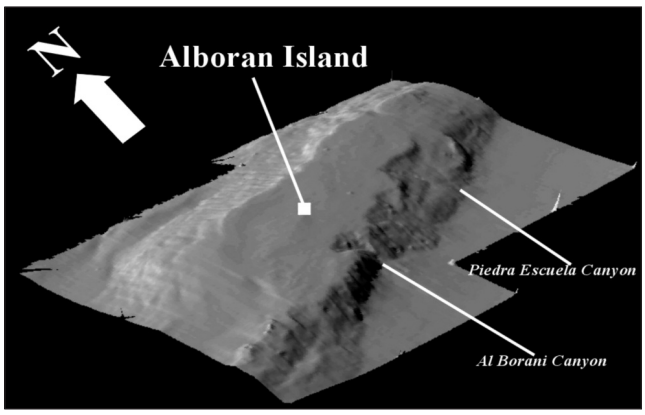

Figure 1. Digital terrain model of the Alboran ridge northeastern segment.

Sediment distribution

The sedimentary pattern on the Alboran ridge shows two main characteristics: 1) the textural distribution is sandy in the northern area and muddy in the southern area of the ridge, both areas are separated by a central elevation with several volcanic outcrops, and 2) the carbonate character of sediments especially in the central area (Fig. 2).

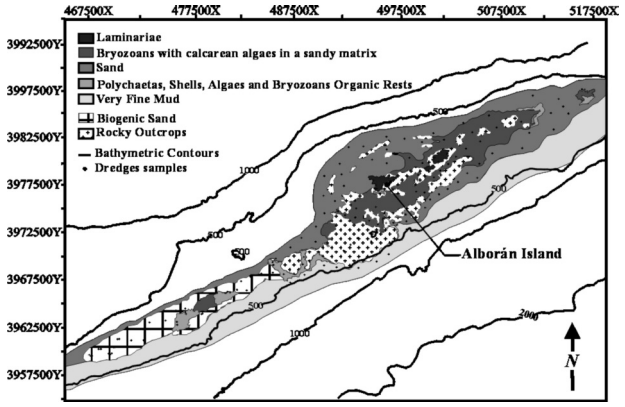

Fig. 2. Surficial sedimentary pattern on the Alboran ridge northeastern segment

There are a clear transition southwards from sands to carbonate sediments and to fine muds. Although it can be appreciated small rock outcrops in the northeastern sector and several volcanic outcrops around the Alboran island in the central sector of the studied area. Carbonates are constituted by bryozoans and calcarean algaes mixed with sands located in an elliptic area SW-NE directed and placed 100 m depth, however in the southwestern sector they are biogenic sands (polychaetas, algaes and bryozoans rests) and rodoliths containing the same organic rests. The origin of this sedimentary pattern have to be related with the interaction between the Alboran ridge as a barrier against the Atlantic surficial water masses controlling its flow. The southern flank remains leeward of this hydrodinamic regime and should develop an "island effect" that should favour a highly productive pelagic and benthic ecosystem, as well as a cascade contribution of biogenic and mud sediments on the southern area.

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SEDIMENTARY COVER STRUCTURING AND GEODYNAMIC MECHANISMS OF THE NORTH-AFRICAN EASTERN MARGIN OF TUNISIA

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Abstract

The Eastern margin of Tunisia constitutes a transition area between the most western and eastern Mediterranean active margins. Subsurface geophysical studies based on petroleum well, reflection seismic and gravimetric data had highlighted the deep tectonic structuring and the related Meso-Cenozoïc sedimentary cover basin evolution. The geodynamic reconstructions show an inherited deep tectonic mosaic of assimilated micro-plates blocks and ramified fault corridors acting as a continue space-time differential transform mechanisms. Related space-time basin migration mechanisms constitutes an original phenomena that merits to be presented here.

Tectonic cover structuring

Fault corridors

The eastern margin of Tunisia is affected by tectonic corridors represented by first order kilometric deep-seated strike-slip master flower fault trending north-south and east-west to west-north-west-east-south-east (1,2,3) and second order and third order ramified faults oriented northeast-southwest and/or northwest-southeast (Fig.1).These faults are marked by deep gravimetric and seismic discontinuities (2,3,4,5). The Meso-Cenozoic alkaline magmatic rocks (6) and the Hydro-geothermic gradient anomalies (7) follow the fault system.

Outside and inside fault corridor basins

Platform blocks

The fault corridors separate deca-kilometric quadratic rigid blocks of superposed deviated and tilted Mesozoic and Cenozoic platforms (1,2). The platform blocks have a differential subsidence rates that are marked by the sedimentary unconformities, sequence deposit distribution, environment and thickness variations highlighted in the petroleum well log correlations and in the seismic horizons (1,2).

Graben structures

Graben and half-graben Mesozoic and Cenozoic basin structures took place inside the fault corridors by a space-time superposition (1,2). The opening system of the grabens is induced by transtensive fault movements along east-west and north-south corridors (1,2). They are marked by the inversion subsidence mechanisms and the space-time sealing by platform structures.

Fold and syncline structures

They affect the sedimentary cover with low or high amplitude angles and are placed inside and/or outside the fault corridors. Their formation start at the Upper Cretaceous Alpine compressions and are accentuated by the successively Pyrrenean and Atlassic orogenies (1,2). These folds are disposed according a strike-slip en echelon drag folds.

Geodynamics mechanisms

The reactivation of the inherited fault system since the Triassic extensive Tethyan rifting until the Neogene Atlassic compressions (1,2,3) had been characterized by a differential and space-time transtensive and transpressive movements accompanied by Mesozoic and Cenozoic magmatic basaltic rocks (6), Triassic evaporites and salts halokinesis and Neogene claykinesis (1,2). This kinematics had induced block platform and basin migration and inversion marked by the sedimentary and stratigraphic unconformities and the superposition of Mesozoic and Cenozoic paleoenvironments and paleogeographies (1,2). These records are shown by sequence deposit configurations of Downlap prograding and onlap/toplap aggrading and retrograding sequences along the fault corridors border basins and platforms. Time-space rotational clockwise and anti-clockwise migration and blockage characterize the basin subsidence (1,2,3). The tectonic deep structuring and the geodynamic mechanisms of the sedimentary cover can reveal a deep crustal organization of the lithosphere discontinuities witch can be recorded by the transfer fault ramified corridors bounded by lithosphere micro-plate platform blocks (1).

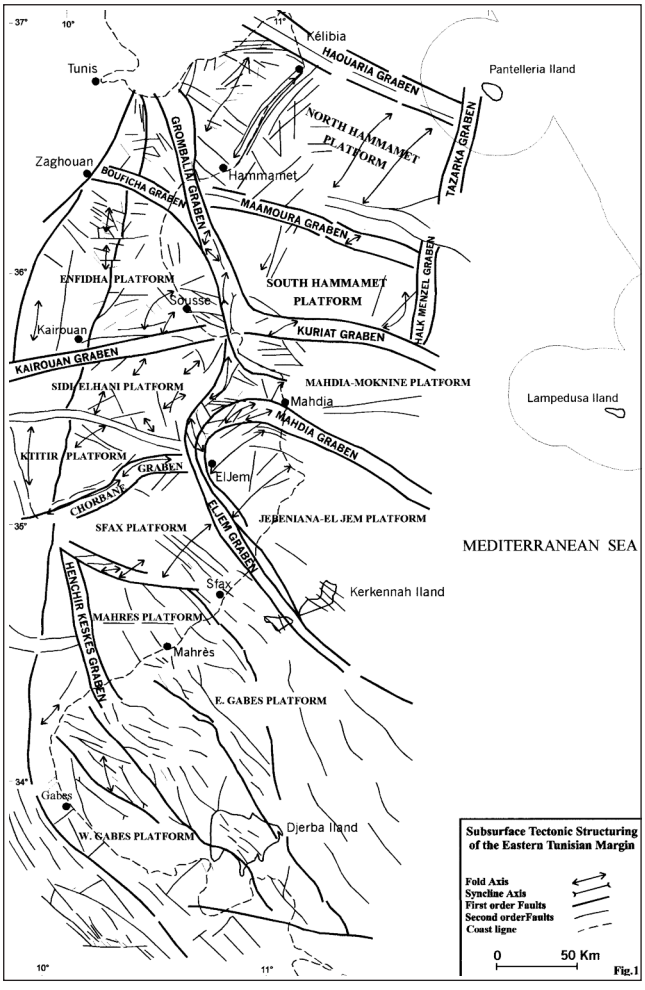

Fig. 1. Subsurface Tectonic Structuring of the Eastern Tunisian margins

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LE DEEP-SEA FAN DU NIL : PRINCIPAUX RÉSULTATS DE LA CAMPAGNE "FANIL" (N/O *LE SUROIT*, OCTOBRE-NOVEMBRE 2000)

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Résumé

La campagne Fanil a permis de distinguer dans le deep-sea fan du Nil les principaux domaines suivants: un secteur occidental, siège de failles de croissances et de volcans de boue; le système canyons-chenaux-lobes de dépôt y a été entièrement cartographié; un secteur central, siège de débris flows associés à des remontées de fluides; un secteur oriental, fortement accidenté (tectonique crustale et salifère) au sein duquel des volcans de boue sont associés à des remontées de fluides; enfin, un secteur "levantin", où chenaux nilotiques et d'origine levantine s'anastomosent avant de se jeter dans le bassin sud chypriote.

Mots clés : Nil- Deep-sea fan- Failles de croissances- Chenaux - Volcans de boue- Fluides.

L'objectif principal de la campagne "FaniI" (N/O *Le Suroit*, Octobre-Novembre 2000) était de compléter la connaissance du deep-sea fan du Nil, en étendant vers l'Est et vers l'Ouest la zone explorée précédemment par la campagne "Prismed II" (N/O *L'Atalante*, 1998). Les méthodes géophysiques mises en oeuvre étaient globalement les mêmes, à savoir bathymétrie multifaisceaux, imagerie acoustique, et sismique multitraces (6 et 24 traces). Environ 8 000 kilomètres de profils ont ainsi été réalisés. En outre, sept carottes à piston ont été prélevées. Cette étude a permis de définir clairement quatre principaux domaines :

a) Un secteur occidental correspondant aux morphologies et structures liées au prolongement de la branche Rosetta du Nil. Il a été reconnu, de l'amont vers l'aval, depuis le canyon vecteur, jusqu'aux parties les plus distales du deep-sea fan marqué par ses lobes de dépôt.

Au sein du réseau chenalisé, le chenal situé dans la partie la plus occidentale apparaît comme le mieux marqué topographiquement et est par conséquent le plus récent (1). C'est ici que les phénomènes de migration peuvent être les mieux analysés. Les différents profils sismiques multitraces réalisés perpendiculairement à l'ensemble du réseau chenalisé ont permis de mettre en évidence pour la première fois la structure sédimentaire de cet appareil détritique profond. Chacun de ces chenaux principaux dévoile une structure sédimentaire en corps acoustiques de forme lenticulaire. L'épaisseur de ces lentilles est de l'ordre 200 à 300 m et chacune d'elle est composée d'un faciès axial acoustiquement chaotique, témoignant de dépôts turbiditiques chenalisés de granulométrie grossière, et de faciès latéraux acoustiquement stratifiés, correspondant à des matériaux turbiditiques de débordement, de granulométrie plus fine (dépôts argilo-silteux). Une telle structure est comparable à celle d'autres deep-sea fans tels que celui de l'Amazone, du Rhône, de l'Indus ou du Congo. D'autre part, les chenaux principaux ont subi des phénomènes de migration que l'on peut suivre à travers la couverture sédimentaire jusqu'à près d'une seconde d'épaisseur. Certains chenaux ont connu de multiples étapes de migration (jusqu'à une dizaine), tantôt vers l'Est, et tantôt vers l'Ouest. Enfin l'imagerie acoustique a permis de cartographier nettement, dans les régions les plus distales, les lobes de dépôt du deep-sea fan, qui se manifestent par de très fortes réféctivités, caractérisant des sédiments grossiers (sables), qui ont pu être prélevés.

Un des caractères les plus frappants de cette couverture sédimentaire est l'existence et la présence généralisée de couches, acoustiquement transparentes ou chaotiques, que l'on peut interpréter comme des coulées de débris ("debris flows"). Certaines de ces couches peuvent atteindre une épaisseur de 700 ms td. Dans ce cas, il n'est pas certain qu'il s'agisse d'une seule et même coulée. On dénombre plusieurs épisodes de mise en place, la dernière étant d'âge très récent, puisqu'elle affleure directement sur le fond marin.

Le secteur sud-ouest de ce domaine chenalisé occidental offre deux types de fonds révélant des structures observées pour la première fois dans ce deep-sea fan : 1) dans le secteur amont, à partir de 1800m, la pente continentale est affectée par d'importants phénomènes d'instabilité sédimentaire, qui se manifestent par une série de failles de croissance, enracinées sur la couche de sel messinien, et générant des glissements de la couverture sédimentaire; 2) Plus en aval, entre ce secteur et les chenaux du deep-sea fan, le fond sous-marin est parsemé de très nombreux cratères de dimensions très variables (de 1 km à une vingtaine de km), résultant probablement de remontées de boue ou de fluides, associées aux phénomènes de surcharges sédimentaires crées par l'activité des failles de croissance plus en amont.

b) Un domaine central, caractérisé par la relative rareté des chenaux profonds, avec, dans sa partie occidentale, des fonds présentant un aspect fortement irrégulier et chaotique, comportant des blocs volumineux. Il s'agit très certainement de dépôts mis en place par des phénomènes gravitaires de type débris flows, s'étendant en direction du NNW-SSE, sur une longueur d'une cinquantaine de kilomètres et occupant une surface estimée à 3000 km^2.

L'imagerie correspondante montre qu'à ces zones chaotiques sont associées des taches fortement réflectives pouvant être interprétées comme des évents d'émission de fluides de type pock marks. Il est probable que les phénomènes locaux de surpression liés à l'épandage de ces débris flows sont à l'origine de ces remontées de fluide à travers un sédiment fortement désorganisé. Quant à l'origine de ces débris flow, on pourrait y voir la conséquence de très importantes déstabilisations gravitaires de la partie supérieure de la pente sous les effets de la surcharge sédimentaire mais et de l'activité sismique. Il est également possible d'invoquer, comme facteur de déstabilisation de la marge, des éruptions gazeuses dans ce secteur particulièrement riche en réservoirs gazeux activement explorés et exploités par l'industrie pétrolière. Rappelons que plus à l'est, la campagne "Prismed II" avait permis de mettre en évidence, dans la région amont, de nombreuses failles de croissance de 100 à 150 m de rejet, qui s'étendent sur un front de près de 200 km de large. Plus en aval, des rides de sel orientées approximativement N-S, isolent des bassins probablement remplis de sédiments de nature pélagique, hémi-pélagique, ou de parties distales de turbidites.

c) Un secteur oriental, qui contraste nettement avec les deux secteurs précédents car il est le siège d'une importante activité tectonique qui se manifeste en surface par de grands accidents linéaires (décrochements dextres) de direction NNW-SSE associés à des grabens transverses (résultats de la campagne Prismed II)(2). Ce réseau d'accidents résulte des effets combinés d'une tectonique crustale et d'une tectonique salifère liée à la présence d'une épaisse couche salifère sous-jacente. C'est dans ce secteur que la couverture salifère post-messinienne est la plus importante. Cette zone accidentée représente très probablement le prolongement en mer du rift de Suez, individualisant une micro-plaque Sinaï. Au sud, de ce secteur la campagne "FaniI" a pu mettre en évidence d'importants volcans de boue associés à une intense fracturation permettant des remontées de fluides. Les images acoustiques de certaines dépressions, localisées à l'intersection des accidents NNW-SSE et des grabens transverses, semblent indiquer la présence de lacs de saumure.

d) Enfin, le domaine situé le plus à l'Est, est caractérisé par la présence de très longs chenaux, fortement sinueux originaires de la branche Damietta du Nil. Ces chenaux, d'apparence récente car très bien préservés, cheminent vers le nord à travers une zone affectée de plis de direction tansverse, témoignant probablement des effets compressifs des glissements de la couverture sédimentaire, à l'approche de la limite d'extension du sel messinien. A l'est du Mont Erathostène, ce réseau de chenaux nilotiques fusionne avec un autre système de chenaux méandriformes, plus larges, qui semble provenir des côtes du Levant. L'ensemble de ce réseau débouche, en y déposant ses sédiments, dans le bassin sédimentaire situé au large de Chypre.

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LA MOBILITÉ DES RIDES D'AVANT-CÔTE ET LEURS RELATIONS AVEC LES VARIATIONS DE LA MORPHOLOGIE DE LA PLAGE AÉRIENNE EN BAIE DE ZEMMOURI EL-BAHRI, EST-ALGÉROIS

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Résumé

Les oscillations du niveau marin engendrent des variations de la morphologie de la plage aérienne et sous-marine ainsi que le changement du tracé du trait de côte. On assiste tantôt à un engraissement, tantôt à une érosion de la plage, selon le cycle saisonnier et la mobilité des rides d'avant côte.

Mots clés : Plage aérienne, ride, océanologie, trait de côte.

L'étude a porté sur un secteur de la baie, depuis la région de Boumerdès jusqu'au Cap-Djinet, entre les longitudes 003° 29' et 003° 43' Est et sous les latitudes 36° 45' à 36° 53' Nord. La baie de Zemmouri se situe à l'Est immédiat de la baie d'Alger. Elle est très ouverte aux conditions météo-océanologiques. (Fig. 1).

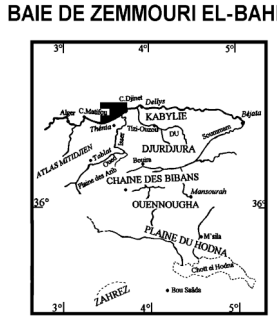

Figure 1. Localisation du secteur d'étude.

De ce fait, on assiste à des variations du niveau moyen de la mer et des déplacements des lignes du rivage. Les phénomènes majeurs pouvant façonner le littoral sont la marée et le déferlement des vagues. La marée est pratiquement nulle sur les côtes algériennes, ce qui permet de déterminer le niveau moyen de la mer.

Selon Paskoff [1], ce niveau moyen peut être perturbé par des oscillations limitées dans le temps, telles ≤ les vagues et de légères fluctuations dues à des phénomènes saisonniers (variations du débit des courants océaniques, de la pression atmosphérique, des vents dominants et de la densité de l'eau de mer). Dans notre cas ces fluctuations s'expliquent par de faibles oscillations : les seiches. Afin d'appréhender le système des rides d'avant-côte, deux levés bathymétriques ont été effectués en deux périodes différentes : hivernale (mars 1983) et estivale (juin 1983).

La pente de la plage sous-marine entre 0 et 20 mètres de fond est de l'ordre de 2% toutefois perturbée par une remontée du fond visible sur les profils bathymétriques. (Fig. 2). L'étroite relation existant entre les différents paramètres océanologiques et dynamiques a montré que les vents de secteur ENE et WSW ont engendré des directions de propagation de houle. En période hivernale, les directions dominantes sont relevées dans les secteurs Nord-Ouest, en été les houles de directions Est et Nord - Est sont les plus fréquentes.

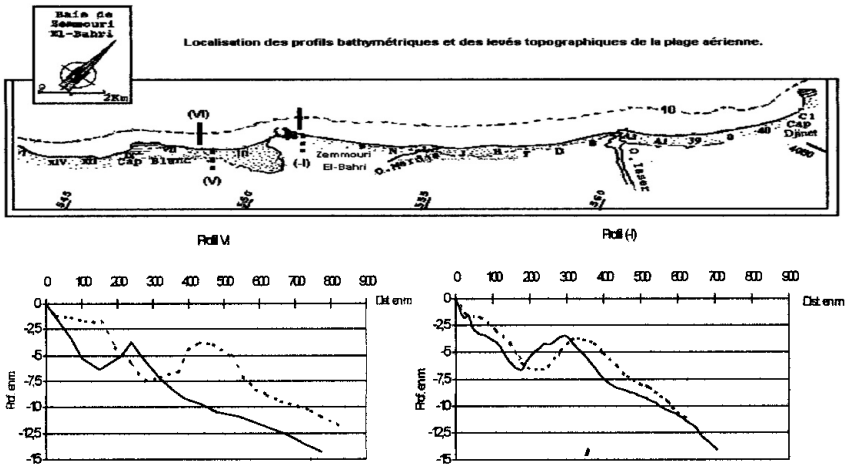

Figure 2. Profils bathymétriques (_____ mars 83 ; ------ juin 83).

Les courants de dérive littorale montrent une prédominance vers l'Ouest dans la partie orientale de la baie et permettent un transit d'est en ouest et une distribution du matériel grossier. On arrive ainsi à enregistrer la mobilité de la ride suivant le changement saisonnier.

Sur les profils bathymétriques de la figure 2 (–I et VI), s'observe une nette migration de la ride vers la côte en période hivernale, la pente du profil VI par exemple se fait ressentir à environ 300 mètres de la côte. En période estivale, la mobilité de la ride est plutôt vers le large, et la pente débute à 600 mètres de la côte.

Le sommet de ces rides est occupé par du matériel grossier; le plus fin se situe au niveau des sillons, le même constat a été observé dans le delta de l'Ebre [2].

Les profils de plages aériennes (fig, 3) montrent des largeurs de plage très importantes en été, témoins d'un engraissement des plages et d'une érosion de celles-ci en période hivernale.

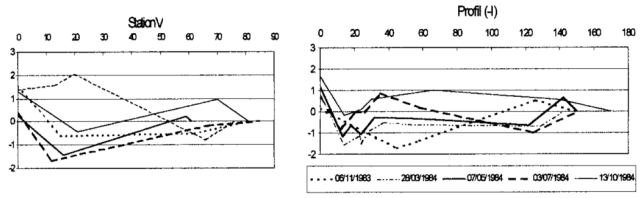

Figure 3. Profils topographiques de la plage aérienne à différentes dates.

Cette érosion se traduit par le phénomène de haute énergie, d'où le déplacement de la ride d'avant côte vers la côte en hiver. Il semblerait qu'il existe une véritable relation entre la mobilité de la ride vers le large et L'engraissement de la plage et inversement.

Conclusion

Les changements morphologiques du littoral et la mobilité des rides d'avant côte les plus importants s'observent pendant les périodes de grandes tempêtes. La mer envahie la plage, qui se rétrécie en hiver. Pendant la saison estivale, ces plages tendent à la reconstitution, d'où un rééquilibre saisonnier. Le déplacement des rides et l'occupation de leur sommet par du matériel grossier sont une conséquence des courants de retour, responsables de leur édifice et de la sélection de la granulométrie de leur composants.

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CARACTERES DU MES EN MILIEU ESTUARIEN SOUS CLIMAT MEDITERRANEEN MERIDIONAL : EXEMPLE DE L'OUED SOUMMAM, BEJAÏA (ALGERIE).

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Résumé

Le golfe de Béjaïa est un talus d'accumulations détritiques [1]. Les dépôts superficiels sont largement tributaires des apports continentaux issus essentiellement de l'oued Soummam. Le volume et la nature des apports sont soumis aux précipitations et à l'écoulement de l'oued. Le régime d'écoulement se manifeste par un comportement chaotique de crues momentanées lors desquelles l'essentiel des apports solides est émis [2]. Les apports en suspensions sont marqués par le facteur saisonnier. L'étiage est le plus souvent prolongée du mois d'avril au mois d'octobre En période de crues, la charge solide est élevée: elle est de l'ordre de 2 g/l. La nature argilo-détritiques des particules y est prédominante. En période d'étiage, la charge solide en suspension est supérieure à 10 mg/l; elle est riche en matière organique.

Mots clés : MES, Carbone organiques, Apports, Embouchure,

Introduction

La contribution détritique du continent à la mer transite par les fleuves avant d'alimenter le plateau, la marge et le bassin adjacent. Le milieu estuarien et la zone marine qui lui est soumise se caractérisent par la présence de forts gradients dynamiques, physicochimiques et sédimentologiques[3]. Leurs interactions, dans le cadre géomorphologique local, définissent les conditions de sédimentation au débouché du fleuve [4]. Dans l'estuaire de

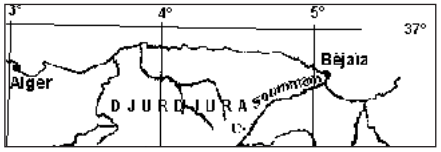

Fig. 1. Localisation.

l'oued Soummam, plusieurs campagnes de prélèvement ont eu lieu dont nous extrayons une synthèse (Fig. 1).

Prélèvements et méthodologie

La station de prélèvement dénommée «Station Pont», est située sur le pont de la R.N. 36 dans l'axe du fleuve à 500 mètres environ de l'embouchure; quand les conditions hydrologiques le permettaient une autre station, dénommée «Station Embouchure», située à 100m. de l'estuaire a fait l'objet de prélèvement (Fig. 2). Chaque station, exécutée sur une verticale dans l'axe de l'oued, comprend un échantillon prélevé à chaque demi mètre depuis la surface jusqu'au fond. La tranche d'eau échantillonnée, à l'aide d'une bouteille lestée dont l'ouverture et la fermeture commandées depuis la surface, est épaisse de 10 cm. Les échantillons d'eau ainsi recueillis ont fait l'objet de filtrations sur filtres Nuclépore de 0,4 μm de porosité pour la concentration du matériel en suspension (mg/l) et des filtres en microfibres de verre Whatmann GF/C pour le pourcentage de carbone organique de ces matériaux par combustion à l'analyseur de carbone [5].

Les charges solides en suspensions

La plus grande partie du matériel fin provient des affluents qui drainent les régions à flyschs et les formations marneuses de l'arrière pays. Les différentes situations échantillonnées montrent un écart très élevé entre les valeurs des charges mesurées en période d'étiage et celles relevées lors des crues (Fig. 3). Le maximum de turbidité est observé au début des premières pluies d'automne. Ceci correspond au «lavement» des bassins versants après une longue période sèche. Ainsi la charge solide en suspension à l'embouchure de l'oued Soummam, mesurée près du fond lors de la crue du 11/10/1987, est égale à 209,38 g/l. La majeure partie du matériel en suspension est émise pendant les crues.

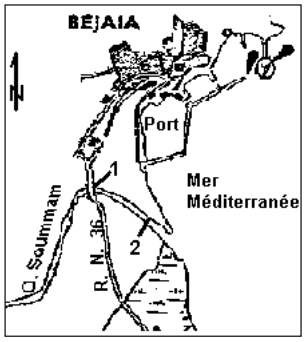

Fig.2. Localisation des stations de prélèvements.
1 Station Pont;
2 Station Embouchure

Le carbone organique particulaire (COP)

Les pourcentages en carbone organique particulaire (COP) varient entre des valeurs maximales à plus de 17% et des valeurs minimales de l'ordre de quelques dixièmes du pour-cent (Fig.3). Comme pour les teneurs en suspensions, les taux de COP montrent un écart important entre les plus fortes et les plus faibles valeurs. Toutefois ces taux montrent une variation inverse des teneurs en suspensions: aux forts pourcentages de COP correspondent de faibles teneurs en suspensions.

Les relations COP/suspensions

Le caractère saisonnier prononcé, bien marqué par la variation des teneurs en COP et en charge détritique, incite à considérer plusieurs types de suspensions.

* la suspension de crue se traduit par une charge élevée en matériel détritique (de l'ordre du g/l à plusieurs dizaines de g/l) et par un faible taux de COP (de l'ordre de 0,1% à 0,01%); cette suspension est essentiellement minérale;
* la suspension de fin de crue montre quant à elle une charge du matériel en suspension de l'ordre de 0,1 à 1 g/l et un taux de COP de l'ordre de 1 à 2%;
* la suspension du début de l'étiage s'enrichit quelque peu en COP (teneurs de 2 à 5%) mais la charge du matériel en suspension devient plus faible (inférieure à 0,1 g/l);
* la suspension d'étiage se caractérise par les taux les plus élevés en COP (supérieurs à 10 %) tandis que la teneur du matériel en suspension reste faible (inférieure à 0,01 g/l).

Conclusion

La dynamique du matériel en suspension obéit donc au facteur climatique auquel est soumis l'oued Soummam. Lors des crues, le matériel en suspension est dominé par des particules presque exclusivement de nature minérale. Pendant les décrues la quantité d'apports diminue ; la suspension est marquée par une réduction du matériel terrigène. Pendant le début de l'étiage et lors de l'étiage, les apports terrigènes se raréfient, l'écoulement devient faible et l'ensoleillement est intense ; il y a là autant de facteurs qui favorisent le développement de l'activité biologique génératrice de carbone

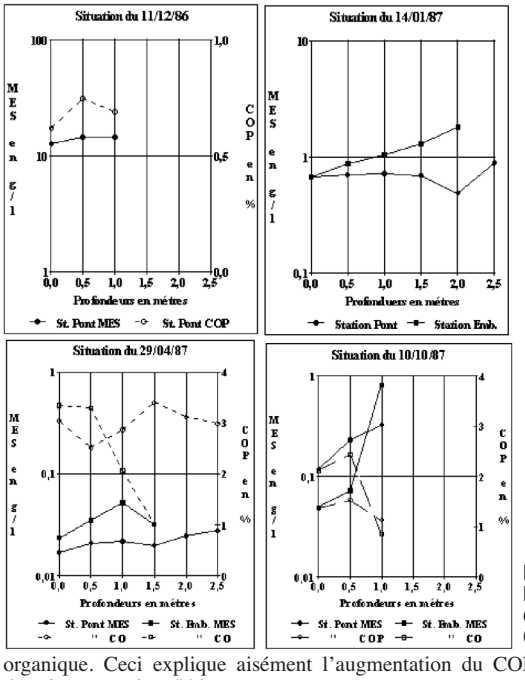

Fig. 3. Répartition du MES et du COP

organique. Ceci explique aisément l'augmentation du COP% observée dans la suspension d'étiage.

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GEOCHEMISTRY AND MINERAL ASSEMBLAGES OF THE MEDITERRANEAN EVAPORITE DEPOSITS. 3. SOME TEXTURAL CHARACTERISTICS OF EVAPORITE SEDIMENTS IN TUZLA SALT DEPOSIT

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Keywords: basin formation, diagenesis, evaporites, mineralogy

Introduction

Evaporites in the Mediterranean region occur in a variety of environmental settings. Depositional milieus range from coastal intertidal and supratidal zones (sebkhas), over small costal or atoll-type lagoons, deeper marine basins and sub-sealevel basins with marine inflow, to non-marine interior freshwater and saline lakes. The paleogeographic and tectonic settings include continental margins and shelves, interior cratonic basins and rifted continental slopes. The passage from one evaporitic sub-environment to another is often not quite obvious, as in the case of the simpler and regular behaviour of carbonate formative zones or sedimentary facies in less dynamic regions. The inherent diversity of the evaporitic series is further complicated by active diagenetic processes. Moreover, some of the products of late diagenesis exhibit outward similarities to textures actually developed during sedimentation, including diagenetic features which developed from and may be superposed on any characteristic facies of the depositional environment. The evaporite deposite of Tuzla in Bosnia-Hercegovina is the largest rock salt deposit in the Balkans. Salts were deposited on tertiary dolomites and marls during the Styrian orogenetic phase (1). The geochemistry of coexisting brines and their saturation states imply that the formation environment may be interpreted in terms of the mixing-zone model, or the end-member type salt lake deposits (2,3). The mineral association of the Tuzla rock-salt series consists of halite, thenardite, tuzlaite, searlesite, northupite, glauberite, and anhydrite. The mineral assemblage have been studied in detail (2,4). In the paragenesis, a new mineral - named tuzlaite to honour the occurrence - with a pentaborate sheet structure has been discovered (5). However, up to now no systematic investigations of the sedimentary textures developed during the formation of the deposit have been done. In this study only the sediments from the IIIB salt series were investigated. These sediments contains varying amounts of dolomite, and may be classified as clay-calcitic dolomite to dolomitized limestones, and marls (6). All sediments are devoid of entrained fossil fragments, and are gray, grayish-brown or greenish-gray in colour A characteristic feature of the sediments is their fine lamination and interchanged with layers of homogeneous carbonate sediment or (more seldom) tuff up to a few centimeters in thickness. The laminae are parallel to each other and discontinuated. Usually light laminae replace darker ones marked with bituminous film. Both are built of micritic carbonate. Some thicker laminae show a vertical size fractionation. Secondary minerals in the assemblage - northupite, halite, searlesite, and pyrite crystallized as thin layers or lenses, but they can also be dispersed within the sediment. Fine mineral grains underline primary lamination sequences, while lenses and large crystals produce deformations of the laminae. Cracks filled with diagenetic calcite may be occasionaly found.

Experimental methods and results

Minerals were identified by X-ray powder diffraction. Sedimentary textures, appearance and shape of diagenetic minerals were investigated within polished and thin sections (including acetate folia pills). Carbonate minerals were distinguished by the staining method (7).

Northupite. Northupit is found to be developed within parallel layers up to 1-2 mm thick. Crystals vary from 0.07 to 0.45 mm in size and they can be closely packed or separated. Carbonate or clay mud is always placed between the crystals. Sometimes northupite crystals have rounded edges. Very often pyrite crystals are dispersed within northupite. Neighboring primary lamination is never disturbed.Bigger crystals up to 3 cm in size are usually developed alone. Sediment is deformed around them and there are cracks around the crystals which are filled with secondary calcite. Near these big hooper crystals organic matter is common. There are carbonate solid inclusions within the crystals of northupite. Such inclusions mark growth sectors. Near the rim of the crystals and around them very fine pyrite grains form the opaque zone (Fig. 1). There are also solid inclusions within the small crystals of northupite (up to 1 mm in size) which are determined just within thin sections to be a searlesite.

Halite. Halite is found to be crystallized as single crystals of hexahedral habit, sometimes with high concentration of micritic sedimentary inclusions and colored with dark organic material. There are also transparent, colorless halite crystals, often of tabular habit. Such tabular habit exhibit also hoopers. Halite is found within compact thick layers of coarse grains, within lenses, and as separate crystals forming more or less continous layers.

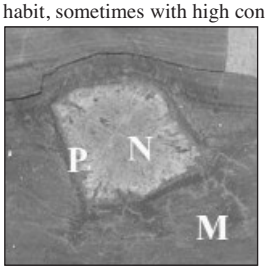

Fig.1. Big crystal of northupite, surrounded by hematite, after pyrite with in the marl with bended laminated texture

Pyrite. Pyrite is found as separate hexahedral crystals or as agglomerate. It is always connected with elevated concentration of organic matter. Within northupite it is found as solid inclusions and around giant northupite crystals it is found as cover. Sometimes it is oxidized to hematite and than northupite crystals are macroscopically red. These crystals are disintegrated to mixture of halite and magnesite (Fig. 1).

Searlesite. Searlesite is first boron mineral found in Tuzla salt deposit. It is found as small individual platy crystals dispersed within some layers, usually up to 2 mm thick. Sometimes it forms small sphaerulites, up to 1 mm in diameter, and sometimes it is found in big nests growing over the green (iron rich) northupite and before halite (Fig. 2). It is also found in Lopare near Tuzla in mixture with opal. Both of these minerals form sphaerical grains (8).

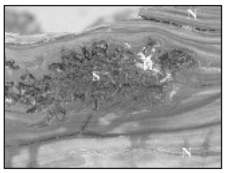

Fig. 2. Nodule of halite (H), searlesite (S), and northupite (N) which disturbed laminated sediment (it has about 3 cm in diameter).

Diagenesis

Occurrence of the dolomite is general characteristic of sediments developed in high salinity environment. Calcite-dolomite muds are typical for lake sediments and aragonite and Mg-calcite muds are typical for lagoons with permanent or temporary conection with the open sea (9). Very fine laminated textures typical for sediments in Tuzla deposit is similar to protodolomite developed in recent lakes where Mg-calcite (high-magnesian calcite) crystallize (10). During dolomitization grain size usually increase, but high Mg/Ca ratio prevent this process (6), what could be the explanation for such a fine lamination in this case. Pyrite is probably among the earliest diagenetic minerals growing in reductive conditions with the help of bacteria. It does not disturb sediments, because it is developed on the surface of the sediment or very early in very soft sediment. Northupite grew during few stages. Partly it crystallized within soft sediment and it included some carbonate grains and not disturbed sediments between small crystals. Some crystals with rounded edges, probably result of partial solving, also support early formation of this mineral. Later on bigger crystals grew and they bend the sediments around them. This sediments were still soft. At the end partly consolidated sediments were not so elastic to be banded, but small cracks around big crystals exist. The cracks were later on, filled with calcite cement. Northupite crystals grew very fast, because of high saturation of the brines. It is evident from the shape of the crystals (hoopers) and from growth sectors within most of the crystals. Such fast growth produced also many solid inclusions within the crystals. Halite also crystallized during few stages of consolidation of the sediment. Colorless hexahedral crystals were developed within the water on the surface of the sediment. The second type of crystals is full of inclusions, grew within the soft sediment. At the end halite grew within consolidated sediment which is highly disturbed by this process (halite together with searlesite and northupite remove the sediment and formed lenses or nodules). Organic matter colored such sediments and diagenetic minerals in brown or even black.

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SUIVI SEDIMENTOLOGIQUE ET MINERALOGIQUE DE LA FRACTION FINE DU BASSIN VERSANT DE L'ISSER A LA BAIE DE ZEMMOURI (ALGERIE)

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Résumé

Cette étude a surtout permis de suivre l'évolution quantitative et qualitative dans le temps et dans l'espace des apports fluviatiles depuis le domaine continental jusqu'à sa distribution dans le domaine marin en considérant les facteurs naturels ayant participé à cette évolution.

Mots clés : environnement ; géologie ; sédimentologie, argiles ; minéralogie ; faciès ; bassin versant ; plateau continental.

Introduction

Ce travail a été fait dans le but d'établir un lien existant entre le milieu continental et le milieu marin du point de vue sédimentologique et hydrodynamique et de connaître ainsi les différentes fluctuations subies par un sédiment fin depuis sa position originelle jusqu'à son dépôt final.

Conditions d'environnement

Le bassin versant de l'oued Isser (Fig. 1) localisé à 60 km à l'est d'Alger se présente sous une forme allongée grossièrement SW/NE et occupe une superficie de 4149 km^2 s'ouvrant sur la méditerranée entre Zemmouri et Cap Djinet. Le relief est assez accentué puisque l'altitude atteint des valeurs allant jusqu'à 1810m (djebel Dira ; chaîne des Bibans). La morphologie sous-marine [1] montre un relief plutôt monotone avec des pentes douces, dépourvues de perturbations. On notera toutefois une extension du plateau continental face à l'Isser (12.9km) ; alors que de part et d'autre de ce dernier le plateau est réduit (7.7km).

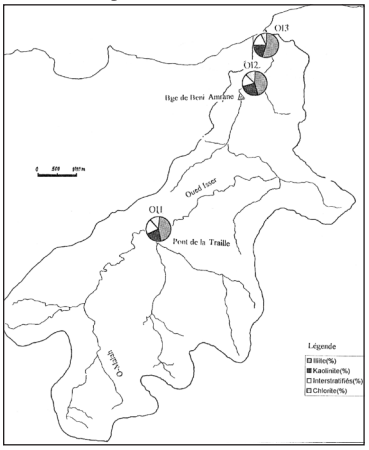

Fig. 1 : Distribution des minéraux argileux dans le bassin de l'Isser

Conditions climato-océanologiques

En règle générale, la région de l'Algérie du Nord appartient à un climat méditerranéen chaud et sec en été et doux en hiver avec des précipitations accentuées en octobre et en mars. Deux directions majeures de houles ont été déterminées statistiquement annuellement [2] : un semestre hivernal (nov-avr.) avec des houles du secteur ouest à sud-ouest (42.65%) ; un semestre estival (mai-oct.) avec des houles de secteur est à nord-est (49%).

Hydrologie

Les travaux effectués statistiquement sur les débits solides et liquides ont permis de constater l'importante diminution des apports fluviatiles de cet oued au cours de dernières années : on suppose que cette diminution des apports fluviatiles est probablement due au fait que la période 1982-1988 est plus "sèche"» que la période (1972-1978). La charge solide transportée est beaucoup moins importante pendant cette deuxième période ce qui nous emmènerait à supposer qu'en plus des conditions climatiques, les effets érosifs aient du provoquer l'épuisement des terrains sédimentaires superficiels du bassin versant du fait que dans une série stratigraphique la compaction augmente avec la profondeur; il deviendrait donc difficile de l'éroder. Cette comparaison montre que l'Isser connaît une régression en apports fluviatiles vers la mer. Ceci est encore plus accentué actuellement avec la "fermeture" de l'Isser par le barrage de Beni-Amran.

Cadre géologique

Le bassin de l'Isser présente des formations géologiques complexes et très variées comprenant : la chaîne calcaire, la chaîne des Bibans et les nappes telliennes. Ces formations sont triasiques (schisteuses et marno-calcaires, remontant jusqu'au plio-quaternaire (marneux conglomératique et gréseux). Le quaternaire est composé par un emboîtement de terrasses alluviales argilo-limoneuses ainsi que des sables plus ou moins consolidés [3].

Sédimentologie : répartition de la fraction fine

Milieu continental : dans le lit de l'Oued Isser la fraction lutitique des dépôts superficiels suit un gradient croissant depuis le pont de «la traille » jusqu'à l'embouchure où elle atteint 99.25%

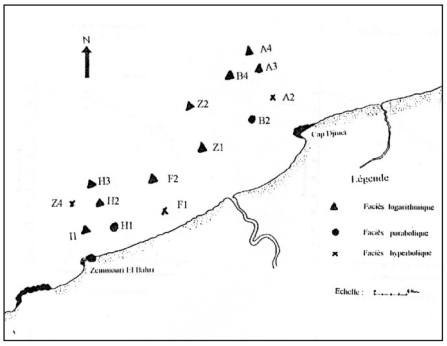

Fig. 2 : Distribution des faciès granulométriques dans la baie de Zemmouri.

Milieu marin : cette répartition montre plusieurs plages d'envasement. A l'est de l'Oued et au-delà de –50m, la fraction fine occupe une aire centrale avec des teneurs de 50 à 75%. Face à l'Oued ces teneurs dépassent les 90%.A l'ouest de l'oued, la répartition montre un gradient croissant jusqu'au-delà du talus, montrant un noyau lutitique à forte concentration(sup. A 90%) dans le canyon de Zemmouri.

Interprétation des courbes granulométriques fines en fonction de l'indice d'évolution de Rivière

Domaine marin : Les faciès paraboliques et hyperboliques s'intercalent suivant une ligne est-ouest de l'échantillon A2 (Fig. 2) à l'échantillon Z4 positionné dans le canyon de Zemmouri. Dans ce dernier ce faciès témoigne d'un milieu limnique à suspension uniforme au sens de Passega due à une élimination préférentielle des particules les moins fines abandonnées les premières lors du transport. Les faciès logarithmiques sont observés à des profondeurs comprises entre –40 et –70m. Ils représentent le terme extrême d'une évolution liée à un mode défini de transport et de sédimentation. Dans le domaine continental deux faciès ont été identifiés : un faciès sublogarithmique observé à l'amont de l'embouchure correspondant à une suspension dégradée au sens de Passega. A l'embouchure nous avons noté un faciès hyperbolique typique des dépôts vaseux d'embouchure [4]

Minéralogie

La détermination des argiles a montré les minéraux argileux suivants :

domaine continental : L'illite prédomine à 48%, la Kaolinite à 22%, la chlorite moins représentative est à 11% et les interstratifiés à 18%.

domaine marin : l'illite prédomine toujours à 43% avec une bonne cristallinité avec les plus forts taux face au cap Djinet; la kaolinite avec deux zones de forte concentration provenant probablement du démantèlement des volcanites côtières ; la chlorite à 18% minéral typique du métamorphisme existant dans le bassin de l'Isser et les interstratifiés à 15% [2], [3].

Conclusion

Nous avons retenu des proportions analogues pour les deux domaines avec toutefois quelques fluctuations subsistantes. Celles-ci sont certainement dues au démantèlement des formations littorales.La cristallinité médiocre des minéraux démontre une origine pédologique et le rôle primordial de l'érosion des sols dans l'alluvionnement fluviatile. L'existence d'un envasement précoce face à l'oued Isser pourrait être développée par les trois arguments suivants : fortes teneurs en lutites à des faibles profondeurs au voisinage de l'Isser; fort taux de silts fin en face de l'Isser et un faciès hyperbolique proche de l'embouchure à –20m de profondeur.

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CHRONOLOGY OF THE GEODYNAMIC EVOLUTION OF THE SARDINIA CHANNEL

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Abstract

Two stages of crustal extension account for the structure of the Sardinia Channel. The first, during the Upper Oligocene - Lower Miocene is related to the creation of the Algerian back-arc basin to the north of the Maghrebide Chain. The second stage, during the Tortonian, is related to the opening of the Tyrrhenian Sea behind the Calabrian-Peloritan arc.

Key-words Basin formation, Back Arcs, Tyrrhenian Basin, Algerian Basin

The Maghrebide chain extends from Gibraltar to Calabria. Between the Peloritani Mounts of Sicily and the Lesser Kabylia, a part of the internal zone of the chain as been deeply submerged in the Sardinia Channel.

The rocks sampled in the Channel are similar to those which outcrop in Kabylia, Peloritani Mounts and Calabria (CPK). Observations in submersible, samples and sismic profiles allow to reconstitute the same structural setting both in the channel and CPK, with an hercynian basement overlain by Oligocene and Miocene sediments.

The rocks sampled in the Sardinia Channel are less intensively deformed than those of the alpine shear-zones known in CPK. Samples were studied using the $^{40}Ar/^{39}Ar$ method in order to characterize the alpine reworking of the hercynian basement. Most of them partially preserved $^{40}Ar/^{39}Ar$ Hercynian ages. Alpine re-opening of the minerals increases southeastwards, from the scarps of the Sardinian Valley to the southern slope of the Cornaglia Basin where Cenozoic ages were measured in the first degassing fractions.

Isotopic data may be interpreted in the framework of a progressive transition from the hercynian Sardinian basement, not affected by the alpine deformations, to the CPK basement involved in the Maghrebide Chain.

Furthermore the hypothesis of an eo-alpine suture which would have separated Sardinia from the CPK massifs is not supported by any one of the numerous samples collected in the Channel nor by any observation on the sea-floor.

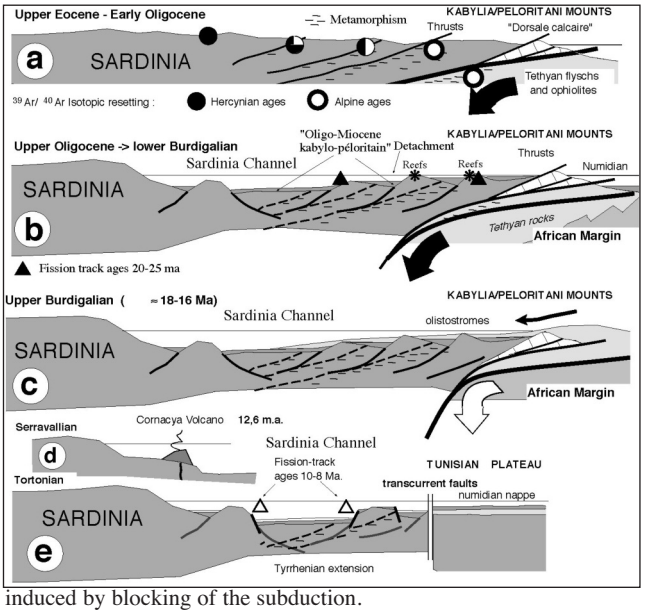
Thus, we can reconstitute the following stages of the channel evolution :

1) before upper Oligocene, the CPK massifs were connected to Sardinia and belonged to the Europe. They were fringed southward by a continental margin which became later the "Dorsale calcaire" unit. Further south, the Maghrebian basin of the Tethys separated this european margin from the african one.

2) during Oligocene, the CPK basement overthrusted the Maghrebian basin, due to the subduction of the Tethys below the european margin (fig; 1a).The CPK basement was cut itself by low-dipping thrusts. Seismic sections of the Sardinia Channel present reflectors gently dipping to the northwest which have been interpreted as such Eo-Oligocene thrusts (1). The major part of the alpine metamorphic recrystallization dates from this period of time.

3) during upper Oligocene and lower Miocene (fig; 1b), the internal areas of the CPK massifs, previously emerged and eroded, were flooded and overlain by the "Oligo-Miocène kabylo-péloritain" formation. Tilted blocks are associated to this distensive stage of collapse. The denudation of areas of the CPK and Sardinia channel basement during this time is dated using the fission-track method (2). The extensional shear zones in the Aspromonte basement, dated at 20-25 Ma (3), are related to this stage of distension. We assume that some low-dipping reflectors visible on the seismic cross-section of the Sardinia Channel may be interpreted as upper Oligocene - lower Miocene detachments. Thus the CPK massifs would have been separated from Sardinia since Upper Oligocene, by the opening of the eastern end of the North Algerian basin. The Oligo-Miocene basin, acting as back-arc basin, deepened and enlarged up to the lower Burdigalian. Its southern border was made by islands of "Dorsale calcaire" which separated it from the coeval Numidian trough, probably partially inherited of the Maghrebian basin.

4) during the upper Burdigalian, olistostromes and gravity-driven nappes glided northward into the Oligo-Miocene Basin cfig; 1c). They are made of flyschs and marls coming from the Maghrebian basin, the Numidian trough and the African margin. This movement requires a large uplift at the front of the internal zones, which was possibly induced by blocking of the subduction.



5) andesites of the Cornacya Seamount, including xenoliths of lamprophyres, were dated at 12.6 Ma using the $^{40}Ar/^{39}Ar$ method (fig; 1d). They correspond to the earlier stage of opening of the back-arc Tyrrhenian Sea.

6) this opening dislocated the eastern part of the Maghrebide Chain, carrying the Calabrian-Peloritan block far away from Sardinia and Kabylia. The basement of the Sardinia channel remained connected to the Sardinia block, but it suffered a new extension (fig; 1e). Datations using fission-tracks in apatite prove that the scarps of the Sardinian Valley and of the Cornaglia basin were formed between 10 and 8 Ma.

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MORPHOLOGY, STRUCTURE AND EVOLUTION OF THE SARDINIAN CHANNEL

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Abstract
The Sardinian Channel is located in a 400 km-long submerged section of the maghrebian branch of the Alpine chain. This 2000m deep trough connects the Algerian-Ligurian and Tyrrhenian Oceanic Basins. Sixteen dives were conducted on the channel scarps using CYANA submersible during two cruises in 1994 and 1995. A structural and morphological study involving film, seismic profile, relief map and sample analyses allowed recognition of the basement and its sedimentary cover. The oligo-miocene crustal thickening is followed by an early oligo-miocene extension and a latter tortonian rifting. A quaternary compressive event eventually inverts inherited extensive structures.

Keywords : Geomorphology, Basin formation, Tyrrhenian basin, Algerian Basin

SARCYA and SARTUCYA dives

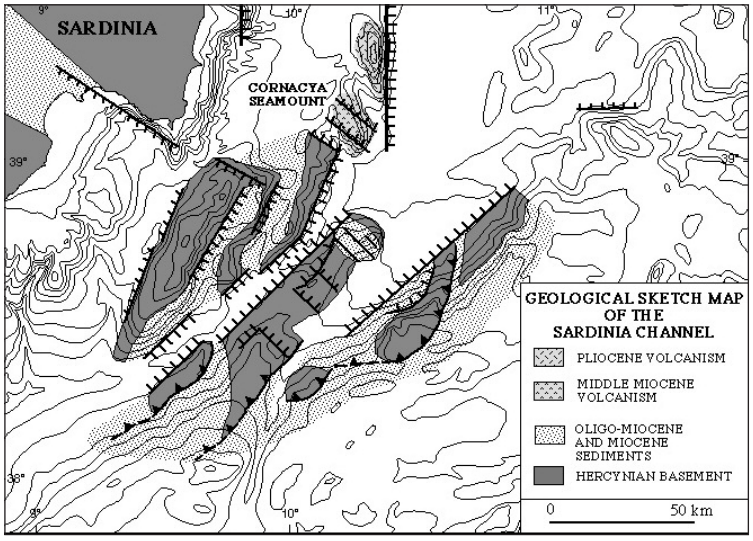
Early stages of the European margin outer blocks break-off that led to separation of Calabria and Peloritan terranes from Sardinia achieved elsewhere in the Tyrrhenian Sea. Slope steepness and deep sea water currents prevented burial of the channel margins under pelagic sediments thus allowing visual investigations. Dives data include 112 rock samples and a 78 hours film record.

Basement and sedimentary cover oligo-miocene evolution

Sardinian channel basement is made of metamorphic panafrican to hercynian rocks weakly metamorphised during alpine orogenesis. Like the on-shore Calabrian-Peloritan-Kabylian (CPK) basement, it records a oligo-miocene crustal thickening and erosion, here increasing toward the CPK front (as suggested by ^{40}Ar /^{39}Ar and apatite fission track datings).

The channel basement is overlain by the oligo-miocene detrital cover of peloritan or kabylian type. The dives led to the discovery of shoshonitic tortonian volcanism on both the sardinian and tunisian margins.

The South Cornaglia Scarp is characterized by lower slopes developed on the basement. They display a succession of scree-covered triangular facets and deep narrow canyons fringed with high cliffs. Above the lower slopes, the tertiary sedimentary cover is buried under more than 100m plio-pleistocene pelagic sediments deposited on a subdued relief in large valleys. Thus the tertiary sediments only outcrop in the canyon heads. A wide span of CPK sedimentary formations were sampled, however, as loose blocks on the lower slopes. The morphologic signature of the tertiary cover was used to draw a geological scheme of the channel (see figure). The south scarp exhibits several aprons, oblique to the main scarp direction. They could result from differential erosion around basement rocks or mezosoic limestones. As the Teulada Apron stands above a shallow dipping crustal reflector, they could be basement units thrusted over the sedimentary cover, or alternatively they could result from the intersection of the Late Miocene channel fault scarps with older rifted structures. Tertiary sediments were also found as pebbles along the sardinian slopes. They could lie on top of the tilted blocks along the Sardinian Margin and on the Median Ridge.



Indices of an early inversion

In some places, differential erosion has stripped off the basement topography drawned under the first oligo-miocene sediments. The interface is quite flat, broken by numerous fault scarps like in the Peloritan Mountains. This surface could account for the flat topped Teulada Apron and Median Ridge.

This buried faulted topography documents a regionally known early stage of extension during the ligurian-algerian rifting. This first tectonic inversion directly follows the stage of crustal thickening.

Tortonian evolution: the second period of faulting

Incipient tyrrhenian rifting propagated into the channel area during tortonian times and created the present trough. Whereas opening of neighbouring Tyrrhenian Sea is still an active process, it stopped abruptly before Messinian in the channel, and did not reached oceanization. Fractures orientations show that almost all the older structures were reactivated and that tyrrhenian strike-slip and normal faults directions prevail.

The Sardinian Margin exhibits a classical structure with 3 main steps of tilted crustal blocks and faulted relief at all scales. The Sicilian-Tunisian Margin formation could involve larger strike-slip components. It has been argued that the present slopes are detachment surfaces inverting older oligo-miocene thrusts. They would connect in the crust to shallow-dipping reflectors detected on deep seismic records. The slopes investigated here did not show evidence of the strong deformations that could be expected on pristine denudation slopes. However, those are not representative of the south margin as a whole.

Messinian evolution

The channel bottom is filled with several hundred meters of messinian evaporites. They grade into detrital formations at the foot of surrounding canyons. This suggest a continental evolution of the scarps consistent with a sea level drop.

Some conglomerates were found scattered on the Median Ridge and the Sicilian Margin slopes . They stand for possible remnants of continental or fluvial erosion. However, the other features observed on dive sites can be explained by post-miocene submarine gravitational processes: rock slide, rock fall, rock avalanches.

Quaternary evolution

Scree deposits several tens of meter thick blanket the lower slopes of the South Cornaglia Scarp. They are filled with a quaternary pelagic micrite and breached in some places by recent faults bringing the basement to the surface. Those dislocations are located on topographic flexures well visible on bathymetric maps. The flexures are linked to recent reverse activity on former normal faults, as it can be noticed at the foot of the Cornaglia Scarp where a ridge is growing into the sediments and dams the canyon outlets. This strain regime is also responsible for a wide bulge drawning canyons of the Sentinelle Apron. Other fold-like structures postdating erosion features surround the Median Ridge and the Sentinelle Apron. The influence of gravity driven instabilities cannot be excluded in their growth.

A CRUSTAL SECTION ACROSS THE CENTRAL TYRRHENIAN SEA (SARDINIA MARGIN, VAVILOV PLAIN, CAMPANIA MARGIN)

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Abstract

The reprocessing of a deep penetration MCS line shot across the whole central Tyrrhenian Basin, tied to available geophysical and geological data collected in its vicinity, allows an interpretation of the crustal characters and structures of the area. The main results are:a) a marked asymmetry between the two continental margins facing the Vavilov plain; b) a very wide COT across the lower Sardinia margin, characterized by widespread occurerence of magmatic and ultramafic bodies.

Key Words: Tyrrhenian Sea, crustal evolution, reflection seismics

Introduction

According to ODP Leg 107 results and to previous data (1), in the Vavilov plain oceanic crust was emplaced during Pliocene after two rifting events that affected the upper and lower Sardinian margin respectively. We analyse here a MCS reflection line running W to E across the whole Basin (Line ST08, shot in 1985 by IFREMER-CNRS-IFP and reprocessed in 2000 at IGM-CNR in Bologna), adding available geophysical and geological data collected in the vicinity of the line. The aim is to better constrain the transition from continental to oceanic crust and to elucidate the Neogene extensional processes that affected the area.

Results

Figure 1 reports the location and the line drawing of the reprocessed ST08 MCS line, together with heath flow and refraction data projected on the line (geophysical data, including magnetic anomalies, from 2, 3, 4, 5). The line and its characters will be described from W to E.

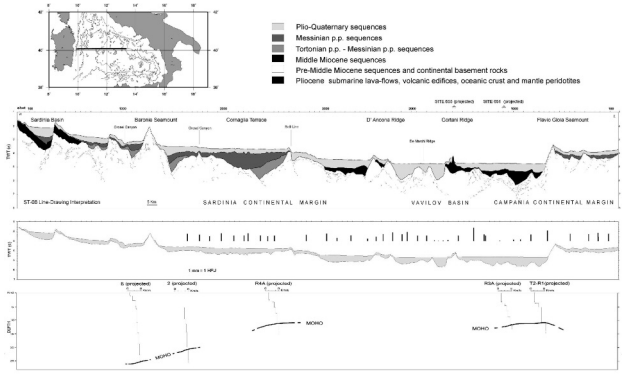

Fig. 1 MCS line ST08. Location, line drawing, Heat Flow (from 2) and refraction data (from 4,5).

Upper Sardinia margin

In this sector the line intersects at low angles a major lineament trending roughly W-E along the Orosei Canyon. As reported by Sartori *et al*. (6), this lineament separates two crustal sectors that experienced different structural evolution prior to Late Tortonian. Across the whole upper Sardinia margin (as far E as the R. Selli or Central Fault), the line shows extensional listric faults generating half grabens filled by sedimentary wedges of Late Tortonian to intra-Messinian age (1), while the Pliocene-Quaternary sequence drapes the previous units. Heath flow values are rather high and constant. Magnetic anomalies are weak. Refraction data indicate that the Moho depth is about 10 kms quite W of the R. Selli Fault, that is already under the upper Sardinia margin, and that it deepens from that area beneath Sardinia (down to 30 kms).

R. Selli Fault.

This marked feature separates the upper from the lower Sardinia margin. Along the seismic line the structure appears as pre-Messinian in age, since it separates different upper Messinian deposits and seismic facies (1). Heath flow values are markedly low in this region.

Lower Sardinia margin

From the R. Selli Fault to the Vavilov plain, crustal blocks rotated by extensional listric faults are observed, active from intra-Messinian to intra-Pliocene times (1). In several places, however, faults appear associated to magmatic bodies of Pliocene age. Magnetic anomalies are high though variable, as are the heath flow values.

Vavilov plain

Between the lower Sardinia margin and the Vavilov plain a wide Continent-Ocean Transition (COT) can be observed, spanning from the last tilted continental block (De Marchi Smt), to the W of the peridotite ridge drilled at ODP site 651 (1). Along most of the line, under a blanket of Pliocene-Quaternary sequences, a rough topography is observed that recalls an oceanic layer 2 (pillow basalts of Pliocene age have been drilled). At places, dipping reflectors occur inside the acoustic basement; they may represent either volcaniclastic bodies or faults linked to the tectonic uplift of the mantle peridotites. Heath flow values are irregular, though quite low across the sector floored by alleged oceanic crust and near the major volcanic bodies (such as the Vavilov Smt). Magnetic anomalies are high though irregular, the Moho depth is still observed at less than 10 km depth.

The Campania margin

The line does not run across the whole margin, imaging it only for some tens of kms. Contrary to the Sardinia margin, in this sector the COB is extremely narrow, because just a few kms E of the pillow lavas recovered at Site DSDP 373 (1), the F. Gioia Smt already contains continental rock units similar to those making up Calabria (7). In addition, no clear extensional listric faults are observed on Line ST08 across the Campania continental margin.

Discussion and conclusion

A very marked asymmetry is observed between the two continental margins facing the Vavilov plain. The Sardinia margin is wide, has been generated by at least two rifting events (1) and displays a complex COT, marked by Pliocene magmatism interplaying with extensional deformations. On the contrary the COB across the Campania margin is very sharp. While the domain with Moho depth of less than 10 km is quite wide, the area floored by laterally continuous layer 2 basalts is quite narrow and is limited to a small portion of the Vavilov plain.

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SUBSURFACE HYDRO-GEOTHERMICS GRADIENT DISTRIBUTION ON THE NORTHEASTERN AFRICAN MEDITERRANEAN MARGIN (TUNISIA)

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Abstract

The geographical area which concerned by the geothermal map is comprised between the parallels 33° and 37° and the meridians 8° and 12°, it covers the entire Eastern Tunisia domain (on-shore and off-shore). The region corresponds the eastern margin of the Sahel and the Pelagian sea that is characterized by many sebkhas and a wide plains where appear on the out crops Miocene, Pliocene and Quaternary deposits. This margin is indeed structured according to deep strike-slip faults corridors, bounding a grabens basins and Mesozoic and Cenozoic platforms blocks. The values of the geothermal degree map derive from treatment, according to an appropriate methodology, data's of temperature taken from oil well which cover the region.

Keywords : Geothermics. Tectonics. Hydrodynamism. Magmatism. Hydrocarbon.

Introduction

The establishment of the geothermal degree map reveals, for all region, a cardinal importance in measure that allows the spot of zones which have a positive geothermics anomalies (high degree until the average value is about 3°C/100m) (1, 2) and the other which have a negative geothermics anomalies (degree less than 3°C/100m). The knowledge of these zones constitutes a good guide for the petroleum engineering by the following the organic matter maturation, and for the hot water research.

Tectonic framework

At the surface, the eastern Tunisia is characterized by the flat light physiography and sebkhas. In subsurface, the structures of eastern Tunisia had been detected by many seismic and gravity geophysical studies (3, 4, 5). These authors highlight the deep structuring by reaching the Triassic horizons affected specially by transfer faults oriented N90-110 ; N130-140 and 160-170 injected by Mesozoic magmatic rocks (6). The structure organisation associated to the fault corridors is marked by (3) (Fig.1) :

- en echelon flolded structures along E-W and N-S corridors.
- platform structures, located between the tectonic corridors
- grabens structures located in side some fault corridors
- triassic dome structures existing along the faults of the western domain of the region.

Geothermal degree map

We note that the major area are characterized by a geothermal degree average higher than 4°C . Only four zones show a lower degrees with a negative anomaly :

- SW sector of the gulf of Gabes
- N-S Axis band laying out
- NW sector of Hammamet Gulf
- NE-SW bands of the tectonic corridors of Zeramdine-El Jem-Kerkennah

For these zones, the hydrodynamism is the important factor of reducing the geothermal degree (1), obviously, these zones correspond of recharging zones from surface water, so cold, of deep acquifers. At Jebéniana block, we measure in the side of the fault corridor of Mahdia-Ksour Essaf geothermal degrees upper than 5°C/1000m (2). This corridor is injected by Cretaceous basic rocks and constitutes a drain of the underground heat.

Conclusions

We retain that the distribution of hydro-geothermal degrees on the eastern margin of Tunisia is double influenced by the deep structuring of transfer fault corridors, the magmatisms of sedimentary basins, and by the hydrodynamism of aquifers across these basins. We remark a relationship between the oil field sites of this margin and the distribution of the geothermal gradient. These results can help to guide petroleum exploration and hot water research.

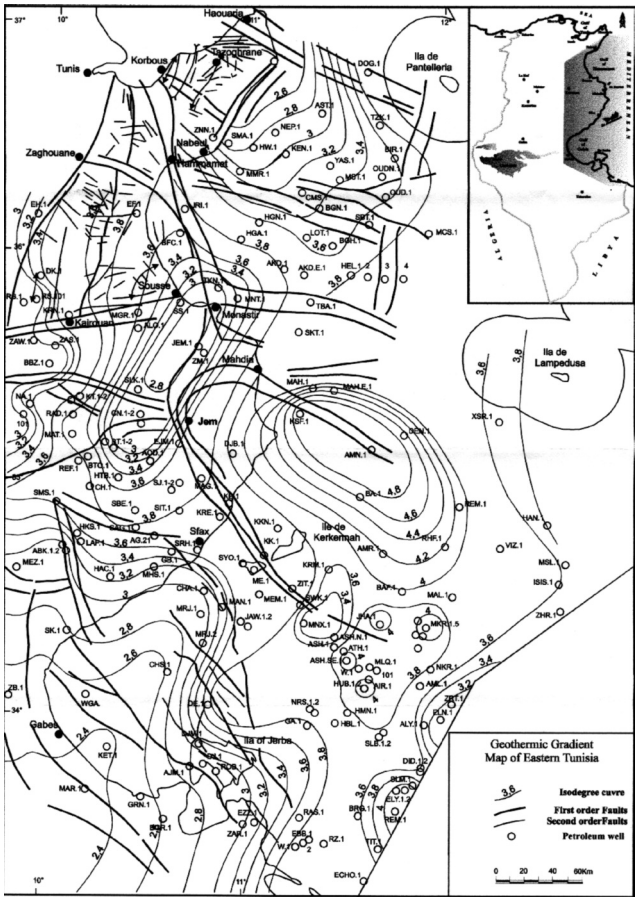

Figure 1. Geothermic gradient map of Eastern Tunisia

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LE MAGMATISME LITTORAL TELLIEN DANS SON CADRE GEODYNAMIQUE

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Résumé

Le magmatisme littoral tellien résulte, en large partie, de la fusion du manteau lithosphérique africain modifié par une subduction. Cet état semble résulter : 1/ d'une subduction, à l'Eocène, du fond océanique, ou aminci, d'un sillon de flyschs maghrébins développé sur la bordure nord de la plaque africaine et, 2/ de l'isolement et du positionnement sous la lithosphère tellienne de la partie profonde de la plaque subduite, par glissement vers le N de la plaque africaine au Burdigalien.

Mots-clés: tectonics, volcanology, Western Mediterranean

Introduction

Le magmatisme littoral tellien est interprété soit comme une manifestation post-tectonique, soit comme un phénomène syn-tectonique, contemporain de la formation de la chaîne alpine et des bassins méditerranéens. Notre proposition essaye de sortir de ces contradictions.

Le magmatisme tellien n'est pas un magmatisme d'arc (fig.1)

Si l'on admet que volcanisme tellien est un magmatisme d'arc, que la chaîne alpine tellienne est un prisme d'accrétion et les bassins de la Méditerranée occidentale des bassins arrière-arc, l'origine du magma se situe nécessairement, dans le manteau d'une plaque supérieure dont les massifs anciens kabyles constituent la partie affleurante. Or, tous les levers géologiques montrent que les massifs kabyles ne sont que des lames charriées de faible épaisseur, voire totalement déracinées (fig. 1, selon ref.1). Les volcans telliens n'ont donc pu être alimentés

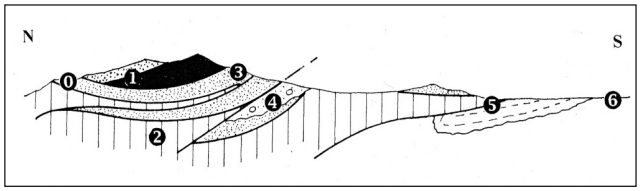

Fig. 1 – Le magmatisme tellien dans son cadre structural.

Légende de la coupe: en **blanc** = autochtone africain; **hachures** verticales = unités allochtones africaines; **pointillé** = unités de flyschs; **noir** = socle kabyle et sa couverture; **marnes** = Miocène de l'avant-fosse sud-tellienne; **conglomérat** = Miocène intra-montagneux de la Soummam.

Localisation du magmatisme: **0** = Cap Djinet; **1** = E Algérois, N de la Grande et de la Petite Kabylie, Cap de Fer; **2** = Oued Amizour, Djebel Filfila; **3** = El Aouana; **4** = Soummam; **5** = SW Oranais; **6** = frontière algéro-marocaine.

en magma "orogénique" qu'à partir d'une source mantellique située dans le plaque inférieure, africaine.

Le magmatisme tellien replacé dans son cadre géodynamique alpin (fig. 2)

La présence passée d'un sillon de flyschs externes maghrébins à fond aminci (au moins) en bordure nord du continent africain est largement admise. Celui-ci, est actif du Crétacé inférieur à l'Eocène supérieur, date très probable de son écrasement. L'existence d'une phase tectonique de cet âge, en effet, est suggérée dans le Tell central, par l'interruption générale des séries externes à l'Eocène supérieur, et démontrée sur arguments positifs en Oranie et dans le Constantinois (2,3). La disparition de ce bassin de flysch peut-être attribuée - soit à une subduction à plongement africain, avec des déformations superficielles à vergences septentrionales (hypoth. 2, fig. 2), - soit à une subduction à plongement européen (4) et donc avec des chevauchements superficiels à vergences méridionales (hypoth. 1, fig. 2).

La phase majeure est Burdigalienne

Cette date, correspond à la tectonisation générale de l'orogène et à la disparition définitive du sillon des flyschs internes alpins, actif depuis le Jurassique moyen. Nous admettons que cette disparition, amorcée par une subduction reconnue dès le Sénonien, a pu s'effectuer par un décollement généralisé de la lithosphère africaine qui aurait eu

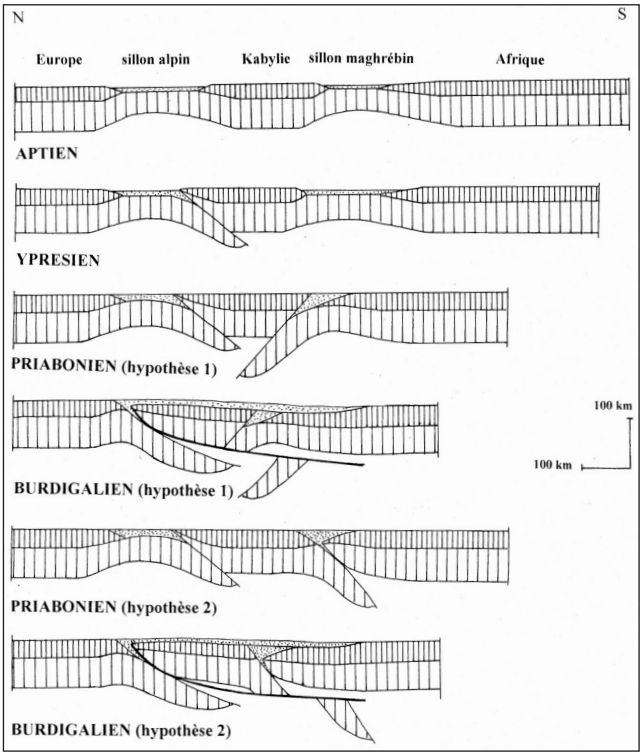

Fig. 2 – Géodynamique schématique de l'orogène tellien de l'Aptien au Burdigalien.

Légende des figurés: en **blanc** = asthénosphère; **hachures lâches** = manteau lithosphérique; **hachures serrées** = croûte continentale; *pointillé* = matériel sédimentaire plus ou moins tectonisé (échelle très dilatée).

pour conséquence d'amener cette lithosphère à venir surmonter le résidu décroché de l'ancien fond des flyschs maghrébins. Des données tomographiques (5) confirment cette hypothèse.

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HYPERSALINE EASTERN MEDITERANEAN BRINES: COMPOSITION AND ORIGIN (*)

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Keywords: Eastern Mediterranean, brines, hydrothermal, geochemistry

During the last few years an increasing number of deep brine lakes has been discovered in the eastern Mediterranean and characterized in successful EU projects such as PALAEOFLUX, MEDRIFF, SAP, and BIODEEP, and the French-Dutch MEDINAUT programme.

These anoxic hypersaline deep basins are amongst the most extreme environments found in the deep Mediterranean, with one of the highest dissolved sulphide concentrations ever reported for the 'open marine' environment (upto more than 12 mM), and demonstrating large compositional differences between different brine pools: going from a nearly 5 M MgCl2 solution and below seawater Na content (Discovery Basin) to a nearly saturated 5.3 M NaCl solution (Tyro Basin). The recently discovered Nadir brine has a high conductivity, is high in NaCl, methane, and possibly sulphide, is relatively shallow (2088 dbar compared to > 3200 dbar for al other brines) and seems rather 'recent'.

One of the most extreme environments thusfar discovered is Urania Basin which contains the highest radiogenic supersaturations ever observed for the marine environment (^{3}He / ^{4}He of 1.10^{-7} and ^{40}Ar / ^{36}Ar of 470; ref. 1), the most extreme d11B (28‰; ref. 2), the highest methane content (> 260 ul/ml), and the highest bottomwater temperature (> 48°C). Irregular methane-driven (?) mud-eruptions appear to occur from the latter bottom at least upto 600 m above the basin-floor, i.e. to a waterdepth of 2900 m.

The composition of most of the brines seems to relate to a 'relict brine' or the dissolution of evaporites both originating from the Messinian period during which the Mediterranean is thought to have been dessicated (Bannock, Atalante and Tyro Basins). On the basis of various isotopes for most of these basins the 'relic brine' option seems the most plausible. In addition, the compositions of relevant major and minor elements appear to be in near coincidence with the theoretical seawater evaporation path.

Urania brine is the most extreme exception to this picture, its major and minor element composition, but in particular its isotopic signature clearly relates to a source area that must be much deeper than that of the Messinian evaporites, and which is clearly influenced by high-temperature interactions with old sediment and volcanic (ash layers ?) units.

In addition to their individual compositional characteristics, each brine demonstrates a typical and for most of them rather stable internal brine structure of various different brine levels. Subtle as well as outspoken temperature and compositional differences occur between the different brine levels in individual basins. The transition between different brine levels, and between brine and seawater may be relatively gradual but usually is extremely abrupt (Fig. 1; see also ref. 3). In particular the seawater/brine transition is dramatically changing from seawater to 10x seawater concentration within a depth interval of 100 cm. The interface is further characterized by a strong dip in Transmission (= high suspended matter content, but possibly partly related to reflections while waters of different densities are mixed; Fig. 2). Not only redox-related changes occur at these abrupt interfaces (ref. 3,4), but also the distinct presence of specialized bacterial communities are hypothesized, resulting in bacterial mats. These latter have thus far been encountered in the underlying brine sediments only, usually at the base of a slump deposit, suggesting their entrainment upon entering the brine.

(*) Results have been obtained during EU projects MEDRIFF, PAELEOFLUX, SAP, BIODEEP, during French/Dutch bilateral project MEDINAUT, during MEDMUD and PASS2 projects, and are ongoing during BIODEEP.

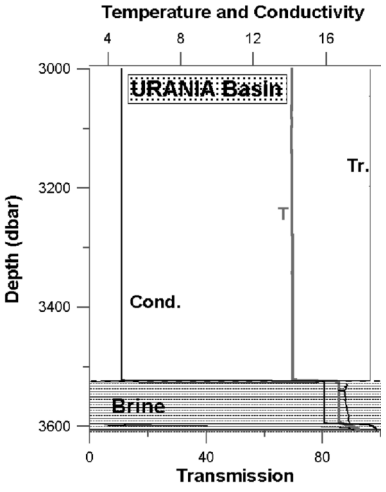

Fig. 1 -Temperature, conductivity and transmission *versus* depth below 3000 dbar for Urania basin. Note the low transmission at seawater/brine and brine I /brinne II interface.

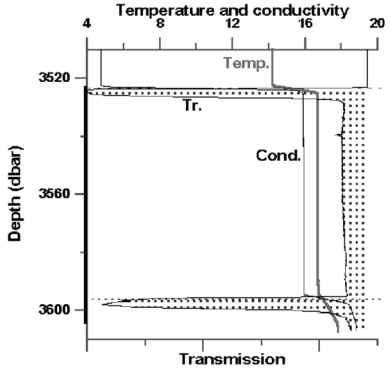

Fig. 2 - Detailed graph of temperature, conductivity and transmission *versus* depth below 3510 dbar for Urania basin. Transmission values below normal seawater values are indicated in grey; total brine interval by thick line on left.

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NEW INSIGHTS ON THE LIGURIAN SEA STRUCTURE AND EVOLUTION FROM A SYNTHESIS OF GEOPHYSICAL DATA

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Abstract
Using new multichannel seismic data (MALIS cruise, 1995), sampling and magnetic anomalies, we analyze the deep structures of the Oligocene-Miocene Ligurian basin and conjugate margins and describe the tectonic style of opening. We map the acoustic basement and propose new extents for the oceanic, transitional and continental domains. We find from seismic facies analysis that the previous Alpine crustal thickening likely contributed to spread the extension across NW Corsica, whereas farther south strain is localized at the foot of both margins. We identify probable tholeitic volcanics in the ocean and calc-alkaline volcanism becoming younger eastwards. Therefore, Apulian slab roll-back and inherited lithospheric inhomogeneities have strongly controlled the Ligurian basin evolution.

Key-words : Tectonics, Passive margins, Ligurian sea, Western Mediterranean

The Ligurian domain has received much less attention than other Mediterranean basins since the studies of the 80's which have provided the evolutionary scheme for Neogene basins [1, 2, 3]. This domain has undergone extension from Late Oligocene to lower Miocene within heterogeneous lithosphere, behind the Apulian subduction zone and at least partly within the Alpine orogen. Rifting occurred between -30 et -20 Ma and drifting until -15 Ma. The relative importance of tectonic forces acting during the evolution of the Liguria basin is unclear, since they depend on poorly controlled and complex, deep processes [4, 5, 6, 7, 8], as well as tectonic inheritance within the heterogeneous upper plate [9]. Furthermore, the age, nature and distribution of Neogene volcanic rocks, which have accompanied and postdated back-arc extension, are poorly constrained, and are not easily related to the various phases of back-arc evolution [10, 6, 11, 12]. In order to better identify the deep structures of this basin, its assymmetry, and the origin and importance of plutonism and volcanism which occurred before, during and after rifting, we have led a cruise (MALIS, 1995, N/O *NADIR,* IFREMER) which allowed us to collect a new set of 3300 km multichannel (96) seismic reflection lines and wide angle data recorded by land seismographs. After data processing, we have been able to recover acoustic energy from reflectors as deep 20 km below margins and 15 km in the deep basin [4]. Furthermore, dredging (MARCO cruise, 1995) et diving data (CYLICE cruise, 1997) have brought important constraints on the nature and age of rocks on the margins and the basin. We combine these data together with a new map of magnetic anomalies reduced to the pole, complementing another map recently published westwards [13]. To minimize problems arising from the salt layer and long-period multiple energy, we have used a tuned air-gun array ("single bubble" pulse method), and we have taken particular care during the processing phases with Geovecteur software™ (*Compagnie Générale de Géophysique, France*).

We propose an updated map of the acoustic basement by using all profiles available in the region. Offshore, we identify the Hercynian basement and its sedimentary cover located in the Maures-Esterel Massif and in the western part of the Corsican margin, and the Alpine nappes on the NE parts of the Ligurian and Corsican margins. The correlation between the changes in syn-rift structural trends of the pre-rift acoustic basement with the change in the geology of the outcrops observed along the coast suggests that the pre-existing structures have influenced the mode of deformation of the acoustic basement during rifting. The morphology of the top of the acoustic basement and the deeper reflectors give insights on the width of the margins after rifting and on their detailed structure: we observe that the Ligurian margin is about 40-50 km wide from northeast to southwest, whereas the Corsican margin is generally wider (about 70-80 km width on NW and SW Corsica margins). No clear axial ridge is present near the centre of the basin.

We also propose new boundaries for the three domains recognised in the acoustic basement in the Ligurian basin: (1) *the continental thinned margins*: they are limited oceanwards by the slope break of the basement acoustic facies, and is structured in grabens and several half-grabens; (2) *the transitional domain:* along the Provençal-Ligurian margin, it is characterized by strong reflectors at the top of the acoustic basement gently deepening towards the continent; on the Corsican margin, it depicts typical facies of volcanic flows associated with large, circular magnetic anomalies; and (3) *the central domain:* although it was never drilled, the basin is assumed to be an oceanic type domain by most authors [14, 1, 10, 2, 3, 4], but with varying characteristics and shapes, since the crust is abnormaly thin [15] and magnetic anomalies are ambiguous [16, 4]: we base our interpretation of the atypical oceanic domain on the presence of a particular acoustic facies similar to the one identified in the Tyrrhenian sea [17]. Compared to previous studies [1, 10, 14], we therefore propose a slightly narrower oceanic domain in the northeastern half of the Ligurian Basin, with a wider NW Corsican margin.

The crustal structure imaged on MCS lines depicts strong changes between conjugate margins, in good agreement with the morphological segmentation. On the Ligurian margin, offshore the Maures Massif, the top of the acoustic basement is underlined by a strong reflector which forms a nearly E-W trending fault sub-parallel to the structural pattern observed onshore in the Maures Massif, therefore suggesting that both onshore and offshore fault networks were inherited from the same tectonic history and would have been reactivated during the Oligocene opening of the Ligurian basin. This geometry is comparable to the one observed in the Gulf of Lions [10, 17] where it is interpreted as a décollement associated with the reactivated Pyrenean thrusts. On the Corsican margin, near the NW Cap Corse, the top of the acoustic basement is underlined by strong reflectors gently dipping towards the continent and sole into a group of strong reflectors, sub-horizontal and sub-parallel, between 6-7 s TWT. By analogy with onland features [18, 19], we interpret shallow reflectors as thrusted units related to the Alpine orogenesis and deeper reflectors as a shear zone within the Alpine nappes, reactivated as normal faults during Oligocene time.

Finally, we have performed a systematic identification of volcanic or volcanoclastic bodies in the basin and the margins. In the Gulf of Genova, we note high seismic velocities at the base of the crust, located under and around the Monte Doria volcano, and also along the Ligurian margin from the Gulf of Lions to the Gulf of Genova, and only locally on the Corsican margin. This layer 2-3 km is of controversial origin [14, 10, 20], and we have no way to answer. A new map of magnetic anomalies reduced to the pole shows that volcanism identified on seismic profiles correlates well with the largest positive magnetic anomalies. The two types of magnetic signatures are thought to represent : (1) volcanic flows sourced from nearby lava centers located in the deep basin, trending parallel to the basin axis: we can hypothesize that this volcanism has a tholeitic affinity and overlies mantle rocks, since both types of rocks have been identified in the Tyrrhenian sea [21]; and (2) magmatic fields on the margins and in the transitional domain, striking NW-SE or NE-SW, for which recent datings suggest different volcanic phases of 21-18 Ma, 16-15 Ma and 12-11 Ma which migrated from the the Ligurian margin to the Corsican margin. We propose that this space-time migration is driven by the roll-back of the Apulian subduction zone towards the E-SE [2, 3], in a way similar to what is described in the Tyrrhenian Sea [2, 5, 22], and that part of the Alpine (Apenninic) frontal wedge has collapsed during this process. Magmatic fields on the margins and in the transitional domains are therefore likely to be related to the subduction setting, whereas the spread volcanic signature in the deep basin is probably related to drifting.

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Introduction

La distribution bathymétrique des espèces d'ostracodes en Méditerranée occidentale et en mer d'Alboran était déjà entamée (1, 2, 3, 4, 5). Dans le but de compléter l'établissement de cette distribution, l'étude de l'ostracofaune des sédiments superficiels prélevés en plusieurs points de la marge méditerranéenne marocaine (partie occidentale) a été réalisée. Cette marge, située dans la partie méridionale de la mer d'Alboran, s'étend du détroit de Gibraltar à l'Ouest à 4°30' de longitude à l'Est (Fig. 1). Sur le plan hydrodynamique, les eaux superficielles, d'origine atlantique, circulent en permanence d'Ouest vers l'Est et donnent naissance à un ou deux gyres anticycloniques de part et d'autre du Cap des trois Fourches (6). Dans le sens inverse, les eaux méditerranéennes profondes longent la pente continentale marocaine en direction du détroit de Gibraltar (6).

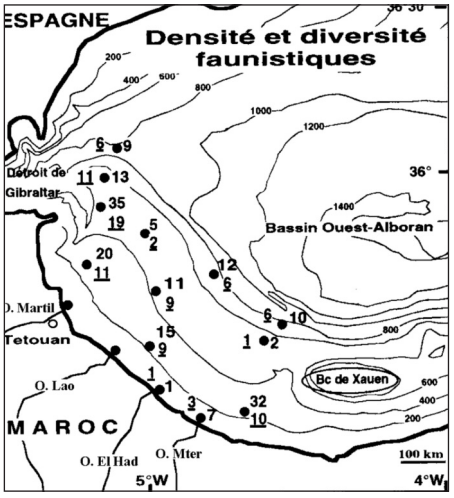

Fig. 1 Distribution de la densité et de la diversité (chiffres soulignés) faunistiques dans les dépôts superficiels.

Matériels et méthodes

Les échantillons étudiés proviennent de la partie supérieure (0 - 2 cm) de carottes de type "Kullenberg" prélevés lors de la campagne océanographique Albosed II-1986 (Fig. 1), à bord du *N/O Catherine Laurence* (CNRS - France). Les échantillons ont été traités sur 20 g de sédiment brut et tamisés sur 125 μm. Les paramètres analytiques de la microfaune d'ostracodes pris en compte sont d'ordre qualitatif et quantitatif.

Résultats et discussions

La microfaune autochtone d'ostracodes montre une densité et une diversité faunistiques relativement faibles avec environ 23 espèces et 19 genres (Fig. 1 et 2). Elle caractérise l'étage circalittoral sur le haut de la pente continentale et l'étage strictement épibathyal sur le plateau marginal et la pente qui lui est adjacente (Fig. 3 et 4). Au niveau des embouchures des Oueds, l'absence de cette microfaune serait due à l'instabilité du fond marin, à la forte turbidité du milieu soumis à l'importance des apports détritiques terrigènes par les différents émissaires continentaux, le développement d'un milieu réducteur et à l'importance des apports en métaux lourds due aux rejets industriels des villes côtières et surtout de la ville de Tétouan (1, 2, 4, 7).

REPARTITION ACTUELLE DE LA MICROFAUNE D'OSTRACODES DANS LA MARGE MEDITERRANEENNE MAROCAINE (PARTIE OCCIDENTALE)

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Résumé

L'étude de l'ostracofaune dans les sédiments de surface permet d'obtenir des informations sur les processus sédimentaires récents à actuels de la marge méditerranéenne marocaine. A l'exception des embouchures deltaïques, où les ostracodes sont très rares et d'origine continentale, les 43 espèces et 35 genres, récoltés et déterminés caractérisent les différents étages bathymétriques de la zone d'étude. La distribution quantitative et qualitative de la microfaune est principalement contrôlée par l'influence des apports par les oueds, le régime hydrodynamique (échange Atlantique - Méditerranée), la bathymétrie et le contexte morphologique.

Key words : Ostracodes, Superficial sediments, Hydrodynamic regime, Moroccan Mediterranean Margin.

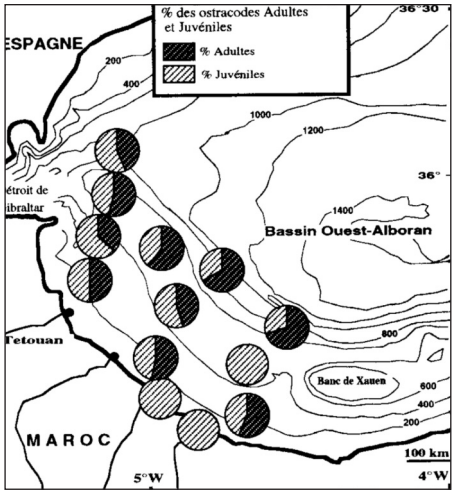

Fig. 2 Distribution des pourcentages d'ostracodes adultes et juvéniles dans les dépôts superficiels.

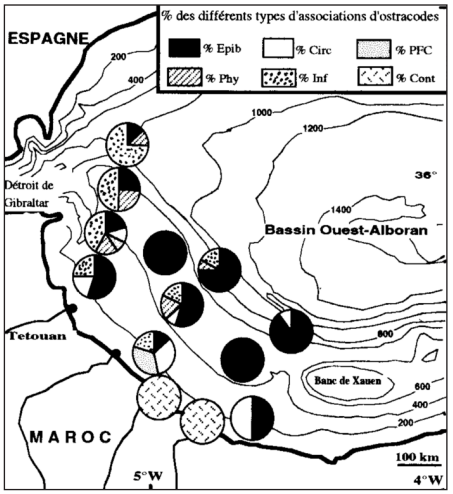

Fig. 4 Distribution des différentes associations d'ostracodes dans les dépôts superficiels (Epib : Epibathyal, Phy : Phytal, Circ : Circalittoral, Inf : Infralittoral, PFC : Plate forme continentale, Cont : Continental).

Dans la radiale de Oued Martil, la richesse quantitative et qualitative des ostracodes (Fig. 1 et 2) serait probablement en relation avec un apport considérable d'éléments nutritifs par l'entrée des eaux superficielles atlantiques et leurs mélanges avec les eaux méditerranéennes sortantes au niveau du détroit de Gibraltar (8). Dans la radiale de Oued Mter, la prédominance jusqu'à 100% des formes autochtones (Fig. 3 et 4) témoigne de la stabilité du fond marin et de la situation géographique à l'abri de l'influence continentale par les différents Oueds dont les apports sont transportés vers l'Ouest par la circulation générale des masses d'eaux (gyre anticyclonique d'ouest).

La microfaune allochtone d'ostracodes provient principalement de l'étage infralittoral (Fig. 3 et 4). Elle est rencontrée surtout entre 400 et 600 m de profondeur. Sa diversité faunistique reste relativement faible avec seulement 16 espèces et 12 genres (Fig. 3 et 4). La prédominance des formes allochtones dans la radiale de Oued Martil (>75%) indiquerait l'influence d'un plateau continental très peuplé en microfaune d'ostracodes, à côtes rocheuses et à situation très exposée aux agents d'érosion hydrodynamique. La diminution des proportions des formes allochtones depuis le détroit de Gibraltar à l'Ouest jusqu'à leur disparition vers la radiale de Oued Mter à l'Est, refléterait la circulation des masses d'eaux superficielles d'origine atlantique.

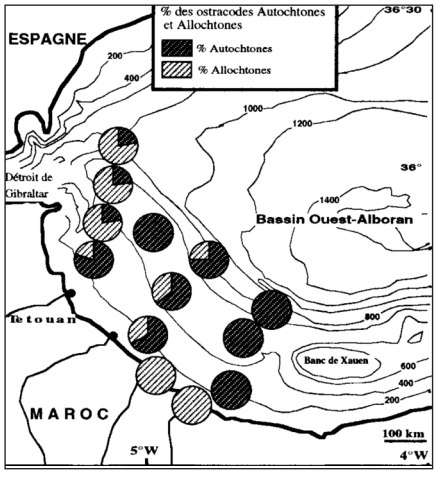

Fig. 3 Distribution des pourcentages d'ostracode autochtones et allochtones dans les dépôts superficiels.

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SURFACE BOTTOM SEDIMENTS OF THE MEDITERRANEAN AND BLACK SEAS (LARGE SCALE MAPS)

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Abstract

The international colour maps "Unconsolidated bottom sediments of the Mediterranean and Black seas" (scale 1 : 1 000 000; Black Sea – scale 1 : 2 000 000), total 10 sheets, were issued under leadership of the IOC UNESCO in the HLNO of RF [1]. Popov A.V. is a chief editor of the maps. Representatives of Spain, France, Italy, Greece, Turkey, Israel, United Kingdom, Germany and other countries are coauthors of separate sheets of the maps. Separate sheets of the Mediterranean map were compiled with assistance of scientists: A. Monaco, P.F. Burolett and G.M Bellaiche (France), S. Varnavas and C. Papavasillon (Greece), A. Brambatti (Italy), A. Maldonado (Spain), Y. Nir (Israel). They presented important data for the map. The small version of this map in the scale 1 : 5 000 000 (1 colour scheet) was reissued in 1998 in Israel with assistance of John Hall.

Keywords: Mediterranean, Black Seas, sediment map.

Material

Genetic and granulometric types of sediments were presented according to the new legend which was worked out during some international workshops. Folk's triangle was used for classification of sediments according to grain size composition for both basins (Mediterranean and Black Seas), for deep-sea and shallow water areas as well [2]. New legend eliminates diversity in deposits classification, existing up to date in numerous publications and published schemes and maps. By different shade of blue colour there were sjhwn areas with <10, 10-30, 50-70, 70-90 and >90% $CaCO_3$. More detail and more exact picture of spatial distribution of different types of recent sediments, more better knowledge on recent sedimentation have got both in the Mediterranean and Black Seas.

Composition of lithologically homogeneous upper-most layer 5-10 cm of thickness is reflected on the Black Sea sediment map. According to biostratigraphic data and absolute datings by 14C, its age is approximately up to 1-2 k.y.

Mostly Upper Holocene sediments (3-5 k.y.) were mapped in the Mediterranean Sea. An age of the studied layer was established by radiocarbon datings, biostratigraphically and using well dated lithological layer (sapropel S-1, pteropod ooze) in some hundreds of sediment cores.

Material-genetic and granulometric composition of recent sediments are unsteady in the main sedimentary basins of the Mediterranean Sea. Heterogenity of its tectonic and morphologic structure, as well as climatic situation and water regime are the main reasons of it. More humid watershed of Algerian-Provence Basin predetermine originating of terrigenous low carbonate muds here. Carbonate foram-nano oozes widespread in the Eastern Mediterranean Sea, primary, in its southern part, bordering with drainless Africa coast where rates of sedimentation are lowermost. Saturation of sea waters with calcite is the highest one in the Eastern Mediterranean. This stimulates participation of chemogenic carbonates and originating of large amounts of high magnesian calcite in sediments. They predominate here in comparison with common calcite. In the Western Mediterranean common calcite consist almost all carbonate material.

Intensive fracturing of sea floor lead to hydrothermal activity and originating of metal-bearing sediments on some volcanic seamounts of the Tyrrhenian Sea. As a result of neotectonic fracturing small anoxic hollows with salt brines are appeared in the Eastern Mediterranean on the Eastern Mediterranean Ridge (Bannock and Tyro anoxic basins). Besides tsunami induced homogenites are accumulating on abyssal plains of number small basins here. Relatively enrichment of terrigenous muds and clays by number metals (Fe, Mn, Ti, Cu, Zn, Pb, Cr, Ni) in the vast Pre-Nile area and around the Cyprus island is related to accumulation od the Nile sediments and riverine matter from Troodos, accordingly. Recent sediments of Mediterranean Sea are lacked of diatomic oozes and sapropelitic muds. Diatomic oozes cannot be originated because of dissolution of silicic sceletons of diatoms and silicoflagellates, already in-upper strata of water. Low biological productivity and intensive destruction of organic matter by oxygen prevents its intensive fossilization in the bottom sediments.

Black Sea recent deep and shallow water sediments highly differ from that of Mediterranean Sea. More humidity of climate, much more high ratio of catchment and surface water areas favour for high rates of terrigenous sedimentation and widespread of terrigenous muds on shelf areas and along Turkish and Caucasian continental rises modern sediment fans are originating.

Anoxic conditions and specific system of surface water circulation favour to sapropelitic nano oozes originating in some central and peripheral areas of the basin. They are enriched in U, Mo, W, Se and others. The areas underly centres of cyclonic gyres where rates of accumulation of terrigenous material are low but biological productivity is high, because of upwelling of deep waters, enriched in nutrients, into photic zone. For the Black Sea is characteristic originating of Fe-Mn nodules of specific composition on some areas of lower shelf. The elements for their formation are coming from land sources and anoxic zone, as well.

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Separate issue "Explanatory Notes" in English is in press (2001 y.). Maps are available in E .Emelyanov's office.

Acknowledgments

Authors would like to express their gratitude to all scientists who helped to compile the maps and IOC UNESCO and P.P. Shirshov Institute of Oceanology RAS for the financial support.

GAS HYDRATE STRUCTURES IN THE EASTERN BLACK SEA BASIN

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Abstract

Methane hydrate is a methane-bearing, ice-like material that occurs in marine sediments and in permafrost regions. They are normally formed under low temperature and high-pressure conditions. The amount of methane contained in hydrate deposits is enormous. Hydrate deposits are estimated to contain a much greater amount of natural gas than conventional accumulations. Since 1991, UNESCO/TREDMAR Training-Through-Research (TTR) studies have shown that the Black Sea has an important potential for the gas hydrates. Structures bearing gas hydrates are distinguished on the subbottom profiler records as strong acoustic reflections.

Key Words: The Black Sea, Seismics.

Intoduction

Oceanic hydrate system deposits, which include both methane hydrate and associated methane gas, are very large, but relatively low grade when compared with conventional hydrocarbon deposits. Near surface gas hydrate zones in several water depths can be predicted to some extent by side scan sonar, profiler, single, multichannel high resolution seismic, and exploration 3D seismic data. Gas hydrates could be formed by natural gas vents and other oil and gas seepages. They indicate a potential for shallow gas accumulations, and formations of hydrates could present geohazard problems at the offshore installations and operations. Methane hydrates are found in high pressure-moderate temperature in sediments of the Black Sea. Hydrate is now widely recognized on continental slopes, where they are well developed, because of their unique appearance on profiler and seismic reflection records. Structures which contain gas hydrates are present on the profiler records as strong acoustic reflections in the Black Sea basin. Hydrate formation can strengthen sediments through both pore filling and cementation and retard compaction. Hydrate provides a mechanism for concentrating methane both in hydrate itself and in associated trapped gas. These formations indicate gas charged layers covered by the gas hydrate shield, preventing the escape of gas where there is a contact between hydrate and gas, a strong impedance contrast termed the bottom simulating reflector (BSR) forms (1).

Gas hydrates and the potential in the Black Sea basin

Methane hydrate is a mixture of methane and water that is frozen into an ice. The crystalline structure of the frozen water molecules forms a cage-like lattice inside of which is trapped high concentrations of methane molecules. Methane hydrates form in generally two types of geologic environments, in permafrost regions (where cold temperatures dominate) and beneath the sea in sediments of the outer continental margins (where high pressures dominate). Methane hydrates can form at temperatures above the freezing point of water (2).

Studying and the understanding of the gas hydrates in the slope areas and deep basins are important for several reasons. Sea floor stability and safety are two important issues related to gas hydrates. Sea floor stability refers to the susceptibility of the sea floor to collapse and slide as the result of gas hydrate disassociation. The safety issue refers to petroleum drilling and production hazards that may occur in association with gas hydrates in both offshore and onshore environments. Throughout the world, oil and gas drilling is moving into regions where safety problems related to gas hydrates may be anticipated. Oil and gas operators have recorded numerous drilling and production problems attributed to the presence of gas hydrates, including uncontrolled gas releases during drilling, collapse of well casings, and gas leakage to the surface. These problems are generally caused by the dissociation of gas hydrate due to heating by either warm drilling fluids or from the production of hot hydrocarbons from depth during conventional oil and gas production. Subsea pipelines may also be affected by loss of sea floor support from hydrates destabilized by warming. Hazards arise because gas hydrates are only quasi-stable; if the temperature is increased at a fixed pressure or the pressure decreased at fixed temperature, or both temperature increased and pressure decreased, it is easy to pass out of the stability regime of hydrates. The hydrate structure encases methane at very high concentrations. A single unit of hydrate, when heated and depressurized, can release 160 times its volume in gas. It is possible that both natural and human-induced changes can contribute to in-situ gas hydrate destabilization, which may convert an offshore hydrate-bearing sediment to a gassy water-rich fluid, triggering sea floor subsidence and catastrophic landslides. Evidence implicating gas hydrates in triggering sea floor landslides has been found along the Atlantic Ocean margin of the United States. These processes may release large volumes of methane to the Earth's oceans and atmosphere. Methane is a "greenhouse" gas, 10 times more effective than carbon dioxide in the process believed by many to cause climate warming. The hydrate accumulations in the world comprises of thousands of square kilometers. Therefore another importance of the gas hydrates is that they will probably become an energy source of the word in the future after running out of the existing oil and gas reservoirs (3).

The Black Sea is one of the most important areas having prospective geosources of the large gas hydrate accumulations. The most suitable geophysical methods used to investigate the large gas hydrate areas both in the seabed surface and near bottom sediments are sonar and high-resolution seismic methods. Hydrate formations can easily be determined on the subbottom profiler records, because the boundary between the hydrate formations and the underlying gas or water bearing sediments causes strong reflection packets (Fig. 1). Methane seeps are common features in the Black Sea Basin and they can also be defined by the mud volcanoes. The shelf and the continental slope regions are the areas in which high amount of methane accumulations occur.

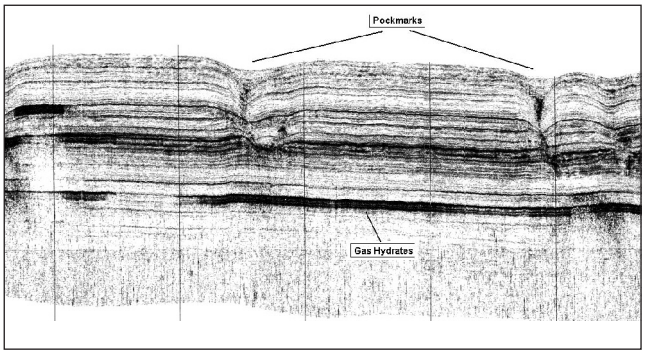

Fig. 1. Subbottom Profiler record example from Eastern Black Sea showing gas seeping zones (pockmarks) and gas hydrate layer as strongly acoustic reflectors.

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HIGH RESOLUTION SEISMIC AND SONAR CHARACTERISTICS OF THE EASTERN BLACK SEA TURKISH CONTINENTAL SLOPE

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Abstract

The Black Sea is one of the largest inland seas in the world. Off the shelf, the water depth quickly plunges to an average depth of 2 km making it unusually deep for what would normally be termed a marginal sea. The slope failures and sediment instability are serious problems that can lead to the failure of offshore installations. Some marine geophysical surveys have been carried out in the Eastern Black Sea basin and continental slope areas using state-of-art technology to produce sonar and high-resolution maps.

Key Words: The Black Sea, Continental Slope, Sediment Transport.

Introduction

The Black Sea, one of the largest inland seas in the world lying at the junction between Europe and Asia, is both oceanographically and geologically unique because of its to anoxic layer below 100-150 m. Although there is excessive supply of terrigenous sediment input in the Black Sea, pelagic sedimentation plays the major role in the deep (1).

Since 1991 the group formed around the UNESCO/TREDMAR Training-Through-Research (TTR) program has investigated the Black Sea with the works of other groups. During these surveys, SIMRAD EM 12S low frequency multibeam and SEABAT echosounders were used to obtain bathymetric charts and reflectivity maps of the sea floor. In addition, MAK-1 deep-tow side scan sonar and subbottom profiler system was used to get acoustic images of the seafloor and the shallow sediments. SIMRAD EM 12S multibeam echosounder operates at 13 kHz frequency and has an angular coverage of 1200 m. The MAK-1 combined side scan sonar and subbottom profiler system has a swath range of up to 500 m per side in long-range mode (30 kHz) and up to 200 m per side in high-resolution mode (100 kHz). The high-resolution subbottom profiler sections and the side scan sonar records shown in this study were compiled from several TTR researches.

Turkish continental slope

Turkish Continental Slope of the Eastern Black Sea Basin, which has a relatively smooth slope and deepens from 305 m to 1945 m. depth, comprises of rectilinear gullies and V-like channels (2). In contrast with the concave Russian continental slope, the Turkish continental slope has a convex morphology. The slope gradient becomes progressively steeper as it is traced downwards from the top, which is the result of either mass movement or structural control. Maximum slope angle detected is 12.6° (3). The slope is cut by only a small number of canyons and valleys, which are generally on a smaller scale than those found on the Russian Continental Slope. The lower section of the slope comprises relict slump structures overlain by a semi-continuous surficial unit of parallel-bedded sediments. The middle section of the slope exhibits a steeper gradient, and slump structures are observed at the seabed here. The upper slope shows a zone of syn-sedimentary thrust faults (the upslope side is down- thrown). The basin and the canyons are a continuation of the Yesilir-mak River across the shelf to the continental slope. The basin and the canyons deepen towards the northwest.

The sediments on the continental slope show slump and creep structures (Fig. 1). The seabed slumping and creep occurs mainly in areas with slope gradients over 2°. During slumping, a mass of superficial sediment becomes detached from a seabed slope along a slip plane and moves downslope. Creep is the imperceptible but continuous movement of sediment down a slope in response to gravity. It is a viscous type of flow in which there is internal and permanent deformation. The steep slope exhibits minor and major northward dipping listric faults as a result of slump and creep features. The depth of the shallow gas remains constant at 20 meters (4, 5).

This has been clearly identified by the slide faults on the sonar and especially the landslides on the subbottom profiler records. The channels can be identified clearly on the sonar mosaics, bathymetric charts and subbottom profiler records, the channels are the best visible on the cross-lines of subbottom profiles (Fig.2). The velocity and direction of the sliding and flowing down of the material is not constant along the slope, but also in time duration. The sediment transportation direction is controlled by the general direction of the slope and channel direction. These rivers have marked associated submarine canyon systems. Turbidity current activity is responsible for much of the movement of sediment into the canyons. Slumping or turbidity flows of sediment from steep side walls of canyons is also thought to be a possible cause of damming the main channel and delaying sediment transport.

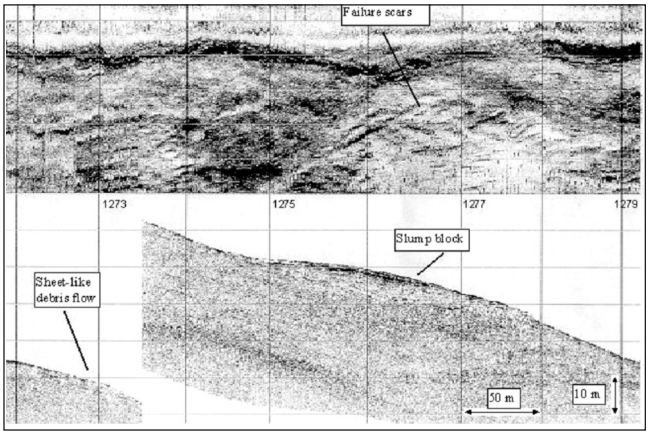

Fig. 1. Detailed Chirp Side Scan Sonar and Subbottom Profiler record example of a canyon wall. The subbottom record shows two slump blocks and a sheet-like debris flow. Failure scars are visible as high reflectivity lineations on the side scan sonar record.

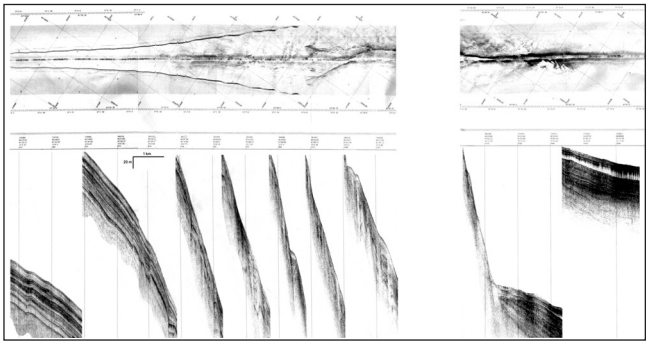

Fig. 2. Side scan sonar (top) and subbottom profiler (bottom) records from Turkish Continental Slope.

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CHEMOSYNTHESIS-BASED COMMUNITIES ASSOCIATED WITH FLUIDS IN DEEP MEDITERRANEAN MUD-VOLCANOES

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Abstract

Dense living chemosynthetic-based communities were for the first time observed at 1700m depth in Mediterranean southwestern to Turquia. These assemblages, mainly composed of bacterial mats, tube worms, small bivalve molluscs (Lucinidae, Mytilidae , Vesicomyidae) and an Echinidae sea urchin, occur usually at the top of mud volcanoes or along fault zone and are associated with methane seeps.Tube worms and bivalve molluscs are sustained, through bacterial symbiotic associations, either by sulfide present in the sediments or by both sediment- sulfide and methane abundant in the seeps.

Key Words: Eastern Mediterranean Sea, Mud-volcanoes,Chemosynthetic populations

Introduction

Following the discovery of dense chemosynthetic-based populations associated with hydrothermal vents in the deep rift system (1) submersible and remotely operated vehicle investigations discovered number of seep sites indicating that seeping is a general feature of the geohydrologic system of continental margins.

Since first discovery of communities in the Gulf of Mexico (2) and immediatly after in Japan trenches (3) number of sites were described in continental margins between 400 and 6000m in different geological contexts (reviewed in Sibuet and Olu - 4) and more recently even till 7326m (5). In all sites, Chemosynthetic-based communities are restricted to areas where hydrogen sulfide and/or methane rich seeps out along geological faults.

The food webs of hydrothermal vent and cold seep communities entirely rely on the production of organic matter via bacterial chemoautolithotrophy (6), the two main sources of energy in these zones appear to be sulfide or/and methane (7, 8)

Among these geological contexts, mud volcanoes has been identified as one of the contexts favorizing to the exploitation by chemosynthetic-based symbioses of cold seeps rich in methane (9).

Results and Discussion

The Anaximender area (southwester Turkey) was explored with the submersible *Nautile* during the French-Dutch MEDINAUTE expedition (1998).

Dense living chemosynthetic-based communities were for the first time observed at 1700m depth in Mediterranean southwestern to Turkey. These assemblages occur usually at the top of mud volcanoes or along fault zones and are associated with methane seeps. Living individuals were mainly sampled on the top of Kazan mud volcanoe at 1707m (35°25.983N ; 24°33.594E) , large site composed of a mixture of grey-dark sediment and pieces of calcareus crusts and densily populated. The main componant of the community is a lucinid bivalve, identified as *Myrtea sp*.. Others living symbiotic bivalves include a small vesicomyid, *Vesycomya sp*. and an unknown small mytilid settled on carbonated crusts. Few vestimentiferan tubes with living worms were also collected on this site. Lying on the heavily reduced sediment, white-grey bacterial mats were observed as well as many unknow sea urchins and number of undetermined crabs.

Transversal sections of *Myrtea sp*. gill filaments observed by TEM demonstrated them mainly composed by bacteriocytes housing sulfur-oxidizing type bacteria. This type of symbionts was also observed in gill cells of *Vesicomya sp*. as well as in the trophosome of the undetermined vestimentiferan worm . The undetermined mytilid appeared as an additionnal exemple of symbiosis using both reduced sulfide components and possibly methane as potential source of energy. TEM observations show that the great majority of the gill cells contains two distinct morphological types of symbionts. The first type is small (mean diameter: 0.35 μm) coccoids or short rods and similar to the sulfide-oxidizing symbionts observed in *B. thermophilus*. The second type are large (mean diameter: 1.25 μm) coccoid-shaped bacteria resembling type I methylotrophs with stacked intracytoplasmic membranes.

13C/12C isotopic ratios clearly enhanced the hypothesis of chemosynthetic based organic material with values ranging from –27.7‰ to – 30.5‰ for *Myrtea sp*, from –29.3‰ to –30.1‰ for *Vesicomya sp*. and from –23.6‰ to –26.6‰ for the vestimentiferan worm, values similar to others symbiotic chemosynthetic-based bivalves or vestimentiferan worms housing sulfur-oxydizing symbionts and found in different vent or cold seep sites .

The values obtained for the mytilid are more depleted : ranging from 44.2‰ to -44.6‰ they are in agreement with the presence of methylotrophic symbionts possibly using methane as energy source. The 15N/14N isotopic ratios are also in agreement with data obtained on other bivalves or vestimentiferan worms found in other vent or cold seep sites ranging from -1.0 to 1.4 ‰ for *Myrtea sp*., from 0.2 to 0.4‰ for the mytilid, to-1.6 to 1.9‰ for *Vesicomya sp*. and from -0.8 to 0.2‰ for the vestimentiferan worm.

Conclusion

The results demonstrated for the first time the presence of living chemosynthetic-based populations associated with fluids in deep Mediterranean mud volcanoes . These populations obviously got their energy either from sufide abundant in reduced sediments of these zones or from both sediment-sufide and of methane expelled in large amount in the cold seeps.

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RECENT COASTAL CHANGES IN THE NORTHERN LACONIC GULF, GREECE, BASED ON GEOMORPHOLOGICAL AND ARCHAEOLOGICAL EVIDENCE

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Abstract

The Laconic gulf is located in southeastern Peloponnesus and is characterized by intense seismicity with many strong disastrous earthquakes reported since ancient times. Moreover the gulf forms an asymmetric graben situated between the mountain masses of Parnonas in the east and Taygetos in the west, showing signs of active tectonics. On both sides of the Laconic gulf, submerged archaeological remains from Classical to Byzantine times have been observed in the sea as deep down to 5m. Detailed coastal geomorphological mapping was performed in relation to the location of archaeological sites, in order to determine whether eustatism or tectonism, is primarily responsible for their submergence.

Keywords: Tectonics, Geomorphology, Sea level, Coastal process, Aegean Sea

Introduction

The study area, located in southeastern Peloponnesus, extends along the shores of the northern Laconic gulf (Fig. 1). Geomorphologically the broader area of southeastern Peloponesus have been studied by several researchers (1,2,3). Morphotectonicaly, the gulf and its northern extension form an asymmetric graben situated between the mountain masses of Parnonas (1935m) in the east and Taygetos (2407m) in the west. Regarding the tectonics, step like normal faults having NW-SE directions and dipping to the NE are observed in the west, while in the eastern part the big normal fault of Molai with a NE-SW direction and a SE dip exists. The morphological and the archaeological observation suggest that these faults have been reactivated in historical times. Moreover the area is characterized by intense seismicity, as strong disastrous earthquakes have been reported since ancient times, indicating recent tectonic activity.

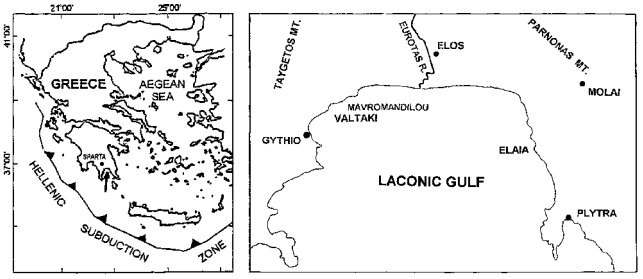

Figure 1. Location of the study area within Greece and main localities discussed in the text.

On both sides of the Laconic gulf and especially in the area of Plytra in the east and at Gythio, Valtaki and Mavromadilou in the west (4,5), submerged archaeological remains from Classical to Byzantine times have been observed in the sea as deep as 5m. Furthermore, 3km inland from the the mouth of Eurotas river at the head of the Laconic gulf, archaeological reports indicate the existence of the port (Elos) of the ancient city of Sparta (6). In the present study, detailed coastal geomorphological mapping was performed in relation to the location of archaeological sites (Fig. 2), in order to determine which of the two factors, eustatism or tectonism, is primarily responsible for their submergence.

Archaeo-geomorphological observations

Gythio, the harbor of ancient Sparta was in use since the Homeric times and served the hinterland till the Roman times. Although several earthquakes shook the town the worst one happened in 375 A.D. and the sea covered a considerable part of the town. Nowadays submerged ruins are observed down to 5m depth. Valtaki, In the Holocene, following the stabilization of sea level around 5000 BP, the E-W flow of the longshore drift formed a sand spit which extended westwards resulting to the formation of a small lagoon behind it. Eventually, the fluvio-torrential sediments filled most of the lagoon leaving a small marshy area. In the western part of the sand spit, near the springs (Glyfada), Roman and early Byzantine ruins extend into the sea down to a depth of about 2m. Over them, coastal dune fields have developed reaching to an elevation of about 4m. The most recent formation is the beachrock which covers the archaeological remains and is located in the present intertidal zone but eroding today.In Plytra, part of the classical city of Asopos, is submerged at depths of around 2m. The overlying Roman and early Byzantine ruins at above present sea level.

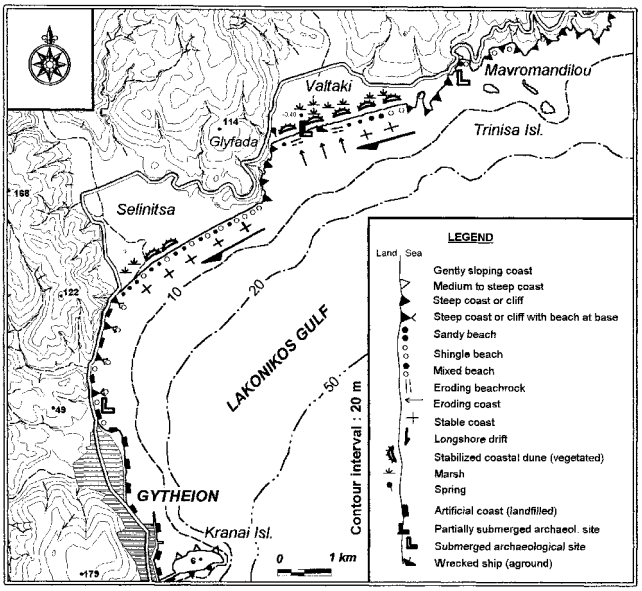

Figure 2. Coastal geomorphological map of the study area

Conclusion

It is evident that this area has been submerged in recent times, but is it is still difficult to distinguish the proportional contribution of eustatism and tectonism. However archaeological sites of the same age has not submerged with the same rate. Ruins of Classical time at Gytheio in the west are found much deeper (5m) than in Plytra in the east (2m), indicating tectonism is much more significant factor in the relative sea level change in the last 2000yrs. The reactivation of local normal faults has played the predominant role. The plane of Eurotas evolved differently because of the important sedimentation of the Eurotas river.

This study shows that geomorphological mapping combined with archeological observation could provide valuable conclusions concerning the recent geomorphological evolution of the area.

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GEOMORPHOLOGICAL STUDY IN THE LOKRIAN COAST OF N. EVOIKOS GULF (CENTRAL GREECE) AND EVIDENCE OF PALAEOSEISMIC DESTRUCTIONS

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Abstract

The broader area of Lokris (Central Greece) is one of active tectonism where large earthquakes have occurred in historical times that have significantly affected its coastal morphology. Along the eroding coastal strip south of the Kynos archaeological site, Late Holocene alluvial fan deposits are exposed in a 120 m long retreating coastal cliff, where detailed stratigraphic study revealed the existence of at least one archaeological destruction layer and a tsunami deposit. Radiocarbon ages of the tsunami deposit and the destruction layer correlate well with the earthquakes of 426 BC and 105 AD.

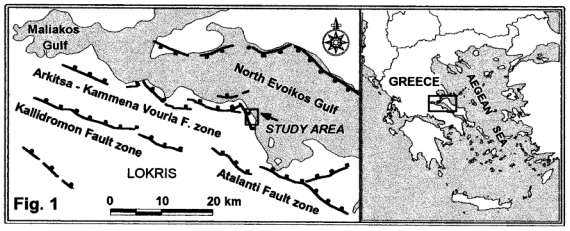
Keywords: Tectonics, Geomorphology, Coastal Processes, Aegean Sea

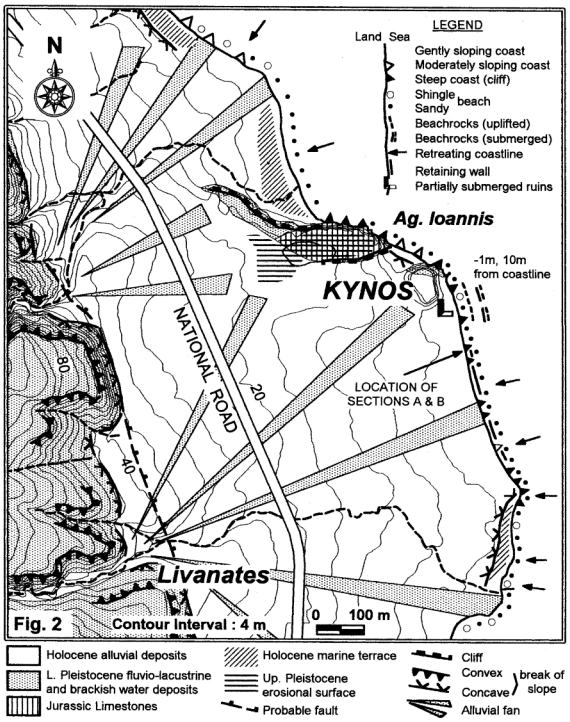
Introduction

Lokris (Fig. 1) is a tectonically active region located in the extensional province of Central Greece, which is characterised by a series of parallel WNW-ESE, north-dipping normal fault zones (1,2). The area has been affected by a number of catastrophic earthquakes since ancient times, like those of 426 BC, AD 105, 551 and 1894 (3). A detailed geomorphological study of the broader coastal area of Livanates (Fig. 2) was performed, together with stratigraphic observations in Holocene alluvial fan deposits, in order to find indications of past seismic destructions.

Geomorphological study - results

During detailed coastal geomorphological mapping, terraces, raised or submerged beachrocks, and uplifted marine notches were recognised (Fig. 2). The area is characterised by a series of parallel secondary faults extending into north Evoikos gulf, which result in vertical coastal movements (mainly uplift). The stretch of coast between Livanates and the Kynos archaeological site is characterised by shoreline retreat, and Late Holocene alluvial fan deposits are exposed in a 120m long coastal cliff, up to 3m high. In this natural section, two stratigraphic units including a large quantity of in situ archaeological sherds were identified (Fig. 3). Between these, a 20 to 30 cm thick lens of sand was observed, rich in marine shells.





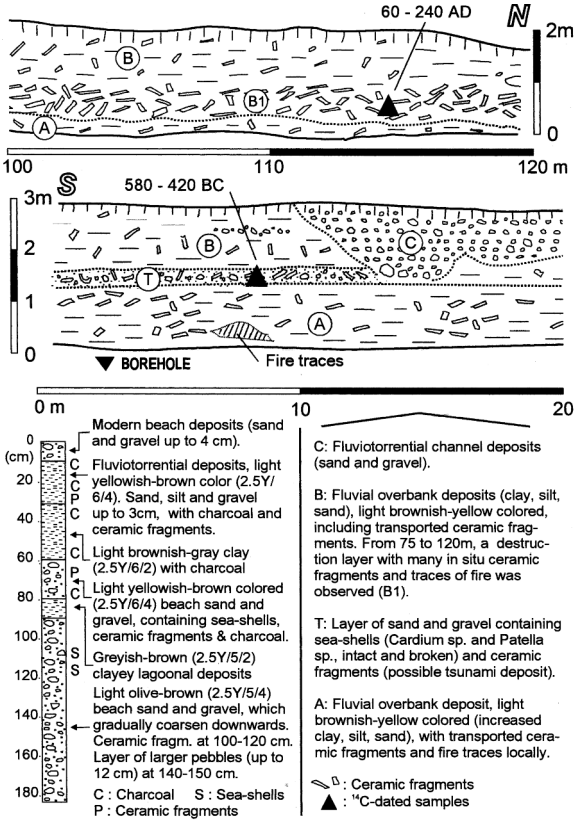


Fig. 3

Grain size analysis combined with microscopic examination suggest that this deposit is a result of a tsunami event, radiocarbon dated to 2450±80 yrs BP (13C corrected, ±1_), that correlated well with the earthquake of 426BC. The same tsunami deposits were also observed during the excavation of the coastal archaeological site of Alope, located a few km to the NW.

The unit of fine-grained overbank deposits overlying the tsunami sand contained a large amount of in situ archaeological sherds as well as remains of fire, suggesting it might be a destruction layer. Pieces of charcoal were dated to 1870±40 yrs BP (±1_, 95% probability) corresponding to a calendar age of 150±90 AD (±2_, 95%). This age suggests a possible correlation with the earthquake of 105 AD, which caused severe damage in the broader area, and especially the area of Atalanti, as reported by archaeologists. In order to gain further information about the stratigraphic sequence in depth, a shallow (2m) borehole was drilled. In the first meter alternating terrestrial and coastal deposits were encountered, followed by a continuous coastal environment (Fig. 3). These alternating deposits could be an indication of submergence due to seismic events prior to 2500 yrs BP.

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PORE WATER GEOCHEMISTRY OF CH4-RICH MUD VOLCANO SEDIMENTS IN THE EASTERN MEDITERRANEAN SEA: IMPLICATIONS FOR FLUID ORIGIN, THE PRESENCE OF GAS HYDRATE AND BIOGEOCHEMICAL REACTIONS

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Abstract

Pore water geochemical studies were carried out in surface sediments of eastern Mediterranean mud volcanoes to study the following issues:

1 - What is the impact of methane-rich fluid flow for microorganisms and macrobenthic fauna?
2 - What are differences in fluid composition within single mud volcanoes and in different areas?
3 - Is gas hydrate present and what are the conditions of formation?

Keywords: Anaerobic methane oxidation, macrofauna, gas hydrate, fluid flow

Submarine mud volcanoes are frequently found in active continental margins such as the Mediterranean Ridge. They are formed by overpressurized mud in the deep subsurface where methane-loaded fluid flow originates. High methane concentrations in the ascending fluid make gas hydrate formation possible given the required temperature and pressure conditions and create highly adapted forms of life depending on methane as a carbon source.

Mud volcanoes of the Olimpi mud volcanoe field (OMV) and of the Anaximander Mountains (AM) were the subject of a French-Dutch interdisciplinary project. In 1998 direct observations and sampling of sediment and biota were carried out from the French submersible 'Nautile' during 20 dives. In 1999 sampling was carried out by means of box, gravity, and piston coring on-bord of R/V Prof. Logachev. Direct observations revealed heterogeneously distributed occurrence of microbial mats and macrofauna such as clams, mussels, tube worms, sponges, urchins, crabs and fish. Often fields of empty (dead) shells were found. Apart from biota, up to decimeter thick carbonate crusts were found on top of the sediment. On Napoli Dome, a mud volcano located in the OMV, discrete brine water seepage induces creek-like downhill flow ending in brine ponds and lakes.

The most important process with respect to carbon turn-over is anaerobic methane oxidation ($SO_4^{2-} + CH_4 \rightarrow HS^- + HCO_3^- + H_2O$), which has been prooved in the studied sediments by means of organic compound identification (1) and which is also evident from pore water data. SO_4^{2-} typically becomes depleted in the upper meter, which coincides with depletion of upward ascending CH_4. As a result of anaerobic methane oxidation build-ups of HS^- and dissolved inorganic carbon are found in the pore water. The latter leads to supersaturation and precipitation of carbonate which explains the observation of abundant authigenic carbonate.

Pore water distribution of conservative constituents display significant differences for different mud volcanoes: On Napoli dome (OMV) Cl, Na and B always increase with depth in the uppermost sediment and stay constant below. This implies an ascend of brine water enriched in Na and B by a factor of ~10 versus normal sea water which is in agreement with brine water occurrences and composition west of the OMV, Urania and Bannock Brines. In contrast, in mud volcanoes of AM both conservative tracers show sea water concentrations in the uppermost decimeters. Below this zone Na is decreasing whereas B is increasing. Homogeneous sea water-like concentrations of Na, B can only be explained by intensive bioirrigation, presumably by macrofauna which live in symbiosis with CH_4 / HS^- oxidizing bacteria. B enrichment originates here from leaching of detrital sediment under high temperature conditions. The decrease of Na is traditionally explained by the in-situ presence of gas hydrate, which dissociate during core recovery and dilute ambient pore water.

To assess in situ methane concentrations required for the formation of gas hydrate we developed a coupled transport-reation model. In this model we predict the methane depth distribution by setting the methane flux equals to the sulfate flux which is justified by the net reaction of anaerobic methane oxidation (see above) and use the advection velocity derived from fitting conservative constituents (Na, B) with a transport equation accounting for diffusion and advection. Model results from two cores reveal that *in situ* methane concentrations are not high enough for the formation of gas hydrate despite the finding of reduced concentrations of conservative constituents. We interpret this by dehydration of smectite in the deep subsurface serving as fresh water source.

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TECTONIC CONTROL OF MUD VOLCANOES FROM THE CENTRAL MEDITERRANEAN RIDGE (SOUTH OF CRETE): A MULTISCALE ANALYSIS.

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Abstract

Recent marine investigations over mud volcanoes of the Central Mediterranean Ridge, based on multibeam echo-sounding (PRISMED II cruise, 1998), deep-tow side scan sonar (MEDINETH survey, 1999) and deep-dives (MEDINAUT cruise, 1998), illustrates obvious relationships between mud expulsions on the sea-floor and tectonic features. At a regional scale, swath-mapping data show evidences of close genetic relationships with structural trends cutting across the Crestal domain of the ridge. Complementary near-bottom observations, and sampling, over a few characteristic mud domes, provide new constraints of this tectonic control, and allow to precise some mechanisms of mud emplacement.

KeyWords: Mud volcanoes, tectonic control, swath-mapping, deep-tow side scan sonar, Central Mediterranean Ridge, Eastern Mediterranean.

The top of the Mediterranean Ridge (MR), in Eastern Mediterranean, is covered by abondant sub-circular bathymetric features (Fig. 1), made of heterogeneous and heterometric clasts in a clayey matrix (2) and commonly known as "mud volcanoes" according to their morphology. Over the Central MR, the distribution of these features is now relatively well know (3, 4) and their genetic relationships with backthrusting (1) as well as with thrusts and transcurent features (5) are well imaged, at a regional scale, by swath-mapping data.

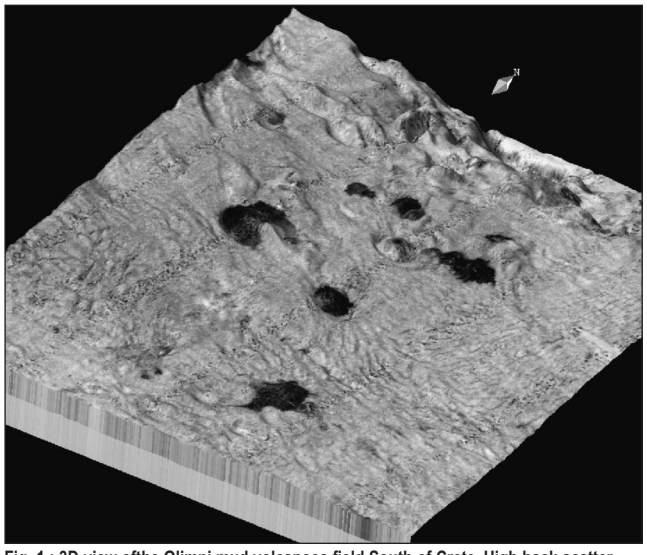

Fig. 1 : 3D-view ofthe Olimpi mud volcanoes field South of Crete. High back-scatter patches indicates recent mud breccia flows.

Integration of these data with ORE-Tech near-bottom side scan sonar records over some of these mud features (MEDINETH survey, 1999) allow to image in details these mud-generated constructions and their successive mud flows, as well as associated brines and carbonate crusts (Fig. 2). They also stress the contrast between small weakly reflective subcircular mud domes (1-2 Km in diameter) and large highly reflective "mud volcanoes" (5). Deep-tow complementary profiles provide new observations of the relationships between mud constructions and tectonics, particularly potential influence of strike-slip faulting. Several examples of mud domes connected with potential riedel-type secondary faults are evidenced.

The MEDINAUT survey (1998), has yielded new near-bottom in-situ observations and rock samples on a few characteristic mud domes, through 20 dives performed with the submersible Nautile. Analysis of videos provides additionnal images of successive mud flows, associated fluid seeps and close associations with active tectonic features; fault escarpments are clearly seen during these dives in connection with mud flows and mud volcanoes (Fig. 3a). Moreover, detail studies of clasts sampled during these dives, help to precise some characters of mud expulsion mechanisms, and subsequent evolution of mud volcanoes. For example, the composition and age gives data concerning paleoenvironmental conditions of deposition, detailled microstructural study shows close control of the clast shapes by early microfractures (Fig. 3b). Subsurface alterations seen on most of the samples are indicative of complex cold-seep context related to mud expulsion.

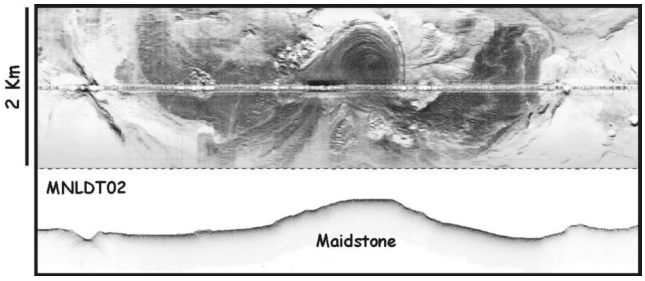

Fig. 2 : Ore-Tech deep-tow side can sonar profile recorded accross the Maidstone Mud Vulcano during the MEDINETH cruise (1999). Variable back-scatter strength indicate successive mud flows, and subcircular chaotic patches are typical of carbonated crusts.

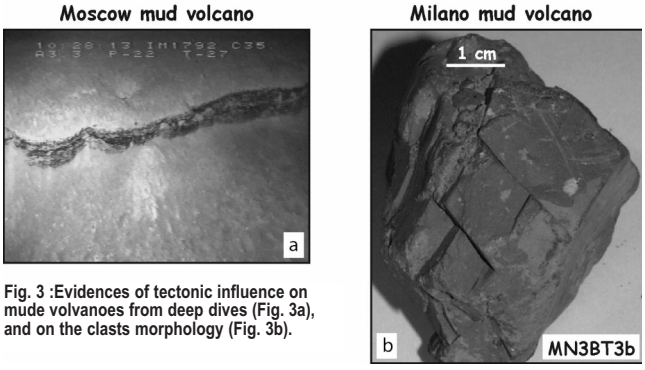

Fig. 3 :Evidences of tectonic influence on mude volvanoes from deep dives (Fig. 3a), and on the clasts morphology (Fig. 3b).

In summary, a clear tectonic control of mud volcanoes is well supported at a regional scale (the entire sedimentary prism), as well as at a local scale according to near-bottom side scan sonar records and deep dives observations.

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CRUSTAL STRUCTURE AND VELOCITY TOMOGRAPHY OF THE NISYROS VOLCANIC AREA-EAST AEGEAN SEA

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Abstract:
Within the frame of GEOWARN project active and passive seismic studies have been performed at the volcanic area of Nisyros. Our aim is to map the crustal and velocity structure of this volcanic area and the microseismicity in order to delineate the active fault systems. In the active experiment we involved 20 land and 40 bottom seismic stations and recorded 7000 shots in 3D geometry. We identify that the island of Nisyros is occupied by apophytic intrusion of much larger volcanic structure with a caldera of 30 km diameter extending between the southern coast of Kos and southern coast of Nisyros.

Keywords: Aegean Sea, crust structure, seismic, volcanology

Within the frame of the European Community supported GEOWARN (Geo-spatial warning system Nisyros volcano (Greece). An emergency case study) investigation of the volcanic area of Nisyros active and passive seismic and seismicity studies have been performed during the last two years. Our aim is to map the crustal and velocity structure of this volcanic area and to map the microseismicity in order to delineate the active fault systems. This project was initiated out of the necessity to better understand the volcanic behavior of Nisyros. By combining geodetic, geophysical, geochemical and geological observations it is intent to correlated magma movements and changes of physical and chemical parameters of the volcanism. The existence of overheated (300 C) aquifers at shallow depth (1500 m) below the volcano cause a permanent danger for the inhabitants and tourists who visit this island. A decrease of the lithostatic pressure triggered by seismic activity could cause an explosive reaction of the aquifers and distractions of the island as already occurred in 1871 and 1873 (1). In the active experiment we involved 40 ocean bottom seismographs and 20 standalone digital seismic stations and we recorded 7000 shots in 2D and 3D geometries (Fig. 1). The evaluation of these data are now in process and the crustal structure as is presently known and referred to by (2) shows that between Rhodes in the south-east and Patmos in northwest the continental crust of east Aegean sea does not exceed 23 km in thickness (Fig 2). We could identify through the geometry of the crust and the distribution of the sediments that the island of Nisyros is occupied by apophytic intrusion of a much larger volcanic structure have a caldera of 30 km diameter extending between the southern coast of Kos and southern coast of Nisyros. By tomographic inversion of the active seismic observation we could see that the islands of Yali and Strongili arte also occupied by apophytic intrusions in a similar fashion as that of Nisyros.

We observed the microseismicity by an on- and offshore seismic array for 3 mouths in 1997-98 and for 3 month in 2000. The epicentral distributions plotted in Fig.3 delineate the geometry of caldera and it associated with shallow distribution of foci mainly triggered by hydrothermal activity and magmatic processes. A series of active faults were identified between the islands of Tilos to Nisyros and between Nisyros and Yali by the linear distribution of the foci. Other active fault seems to be east northwest oriented and truncate the caldera at different azimuths. All these active faults can trigger vertical and horizontal movements and rupture the lithological overburden thus changing the physical parameter at depth. We are now in the process of computing by the active seismic experiment new crustal and tomographic models of the area and our next step will be to integrate these data to the chemical and geodetic observation the GEOWRN team has collected.

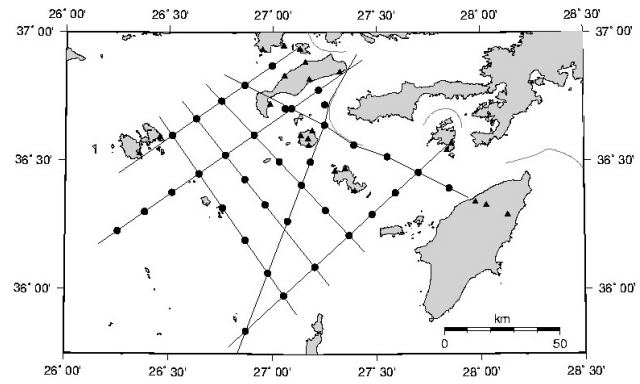

Figure 1. Locations of OBS (filled circles) and land stations (filled triangles) in Nisyros 2000 tomography project. Black lines are the airgun shooting profiles.

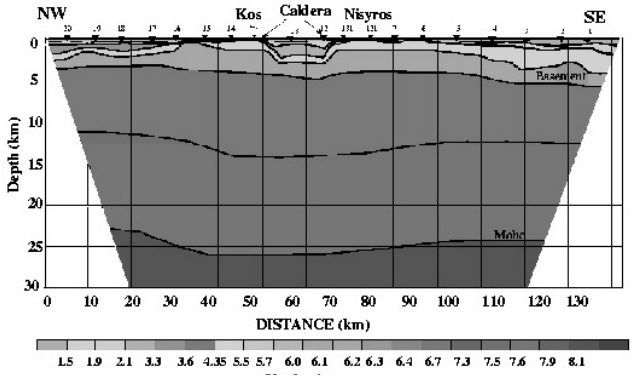

Figure 2. The P-wave velocity cross-section through Dodecanesos islands.

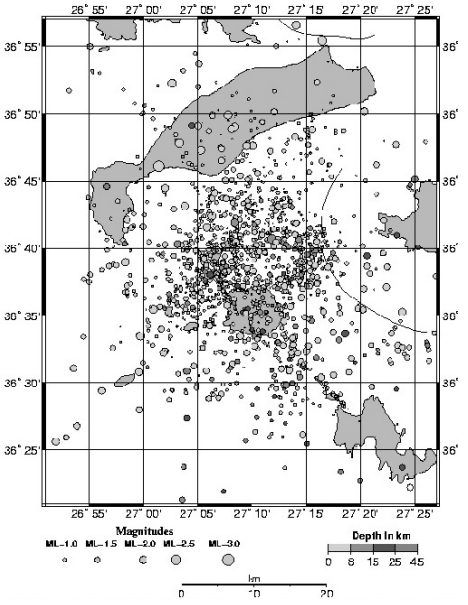

Figure 3. Microseismic observations in Nisyros area recorded in periods: 1) 11.10.97 – 02.01.98; 2) 15.07.00 – 14.09.00.

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ZONAGE SISMOTECTONIQUE ET EVALUATION DU RISQUE SISMIQUE DE LA MARGE MEDITERRANEENE DE LA TUNISIE.

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Résumé
Une carte de zonage sismotectonique a été élaborée pour la marge orientale méditerranéenne de la Tunisie pour des besoins d'aménagement et de développement durable. Ce zonage a été établi selon la séismicité historique, la néotectonique et la structuration profonde de la couverture sédimentaire néogène.

Mots clés : Tectonique. Zonage sismotectonique. Marge orientale. Risque sismique

Introduction

Dans le domaine intra-plaque, la séismicité est diffuse et les structures sont souvent cachées. Le zonage sismotectonique permet de traduire le degrés du risque sismique. Il est basé sur l'analyse des structures en surface et en subsurface. A l'intérieur de chacune de ces zones, on considère que l'activité sismique est homogène et ne dépassera pas une valeur donnée de l'intensité sismique maximale (I max).

Zonage sismotectonique

La marge orientale de la Tunisie, qui se prolonge à l'Est par la mer pélagienne, est caractérisée par des couloirs de failles E-W, NW-SE et N-S (1). Elle est bordée à l'Ouest par l'axe Nord-Sud qui limite le domaine atlasique à plis NE-SW. Au Sud, la chaîne nord des Chotts marque la transition entre la plate-forme saharienne non plissée et l'Atlas méridional plissé (2). Sur la marge orientale, la géologie de surface et la cartographie des structures néogènes enfouies en subsurface à travers les données de prospections sismiques montrent des couloirs de failles de décrochement pluri-kilométriques de direction N 90-120, N140-150 et N-S (1- 6). Ces failles délimitent des blocs rigides de plates-formes et de grabens de tailles décakilométriques. La croûte continentale s'amincit progressivement de l'Ouest (40 km) à la marge est (20 km). Les trois critères majeurs considérés sont : la géométrie des déformations (orientation des plis et des failles), l'intensité du plissement et la prédominance de certaines directions traduisent l'héritage structural. La carte structurale ainsi établie permet d'esquisser le zonage tectonique suivant (fig. 1).

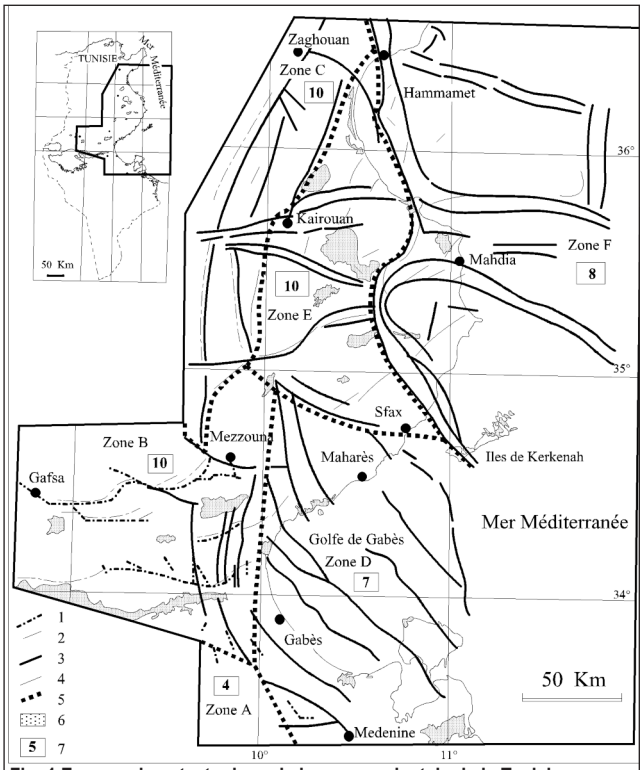

Fig. 1 Zonage sismotectonique de la marge orientale de la Tunisie.

1 : faille; 2 : pli; 3 :faille de subsurface; ; 4 : pli subsurface; 5 : limite de zone sismotectonique; 6 : Sebkha; 7 : Intensité maximale estimée pour une zone.

Zone A: *Plate-forme saharienne :* domaine stable caractérisé par la présence de séries mésozoïques et cénozoïques non plissées.

Zone B: *Atlas méridional :* marqué par la présence d'accidents E-W dominants, des accidents moins fréquentes NW-SE et NE-SW et des plis moulés sur ces accidents à jeux récents décrochants (1 et 6). L'état des contraintes néotectonique est en compression NNW-SSE.

Zone C: *l'Axe Nord-Sud ss*. marqué par la présence de plis dont la direction dominante est N-S à coeur crétacé ou jurassique, associés à des failles directionnelles et obliques. L'état des contraintes néotectonique local est en compression E-W.

Zone D: *le golfe de Gabès,* montre une structuration en Horsts et Grabens limitées par des failles normales NW-SE injectées de roches magmatiques mésozoïques. Les plissements sont moins intenses (3, 5). L'état des contraintes néotectonique est en distension NE-SW.

Zone E: *Domaine du Sahel central,* les plis sont sigmoïdes en échelon de directions E-W à NE-SW limités par des failles profondes E-W et N-S (1, 2), injectées de roches magmatiques mésozoïques et paléogènes. Les structures enfouies sous une couverture quaternaire sont à cœur néogène. L'état des contraintes néotectonique est en compression NW-SE.

Zone F: *Domaine du Sahel oriental* où dominent les failles normales anciennes NW-SE à E-W. Les plis sont sub-affleurants et enfouis en subsurface (1, 3). Les accidents ont été remobilisés au cours de la période néotectonique selon une distension NE-SW.

Les données néotectoniques ont été intégrées pour l'évaluation des intensités sismiques maximales pour chacune de ces zones structurales (fig. 1). L'appréciation de I max repose sur les critères de présence de faille néotectonique, de faille de subsurface affectant les niveaux subaffleurants et enfin la valeur de l'I max enregistrée dans la zone en question. Ainsi ont été attribués les I max suivants : Zone A : I max : 4; Zone B,C et E : I max : 10 ; Zone D : I max : 7 ; Zone F : I max : 8.

Conclusion

Cette étude a permis de cartographier des zones sismotectoniques à comportement différencié et à degrés d'intensité de risque sismique basés sur les données de la seismicité historique et les données néotectoniques et géophysiques. Ainsi, le potentiel risque peut être évalué pour le développement durable et l'aménagement de cette marge.

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GEOCHEMISTRY AND MINERAL ASSEMBLAGES OF THE MEDITERRANEAN EVAPORITE DEPOSITS
2. BORON HYDROGEOCHEMISTRY IN THE TUZLA DEPOSIT, BOSNIA-HERCEGOVINA

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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. This study deals with some aspects of the hydrogeochemistry of boron in the deposit, making use of mineralogical and petrological evidence to define the formation conditions of the boron minerals and the deposit in general.

Keywords – basin formation, diapirs, evaporites, geochemical cycles, mineralogy

Introduction

The evaporite deposit of Tuzla is located in the north-eastern part of Bosnia-Hercegovina and is the largest rock salt reservoir in the Balkan peninsula, with estimated reserves of ca. 170 million tons of salt. Despite the rather well investigated geological setting of the area, there is still no unambiguous evidence as to the depositional environment in which these evaporites formed. The essentially stratified salt-dome type deposit is of mid-Miocene age, hosted in a sedimentary series of banded halite and anhydrite. Early investigations of the Tuzla salt basin have indicated that the halite crystallization process has followed a sequence of several cycles, as the basin became shallower during the Styrian orogenetic phase (1). Anhydrous and hydrated salts were deposited on tertiary dolomites and marls. The geochemistry of coexisting brines and their saturation states imply that the formation environment may be interpreted in terms of the mixing-zone model, rather than end-member type marine or salt lake deposits (2,3). On the other hand, the close relationship of the evaporite series with the associated dolomitic limestones as well as evidence of progressive dolomitization, may reflect their possible formation under evaporative, non-evaporative or seepage-reflux conditions (4). The described framework shows some similarities with the depositional environment of the Messinian deposits of Sicily which may serve as a sedimentary model for the extensive Messinian evaporite deposits throughout the Mediterranean basin (5). Several factors influence and determine the formation of evaporitic sediments in subaerial, intratidal and hypersaline basins. Of these, clearly the most significant ones are a) the rate of influx of water; b) the concentration and speciation of ionic and complexed forms in solution; c) the rate of evaporation and d) the physical environment in which precipitation takes place. The interrelationships of these factors, coupled with clearly discernible diagenetic processes resulted in the Tuzla basin in a diverse suite of lateral equivalents of the evaporite series. Several distinct facies can be observed in most of the proximal and distal lateral rock formations. A lack of marine and/or freshwater flora and fauna in all adjacent geological formations further complicates the investigation of prevailing sedimentary cycles and environmental conditions. Changes in the features of the original depositional forms are frequently caused by tectonics, burial and migrating waters and brines.

The mineral association of the Tuzla rock-salt series consists of halite, thenardite and anhydrite. The a(H_2O) indicator couple is thenardite-mirabilite. Several accessory minerals, including northupite, are present in varying amounts. The assemblage, as well as possible lithotype indicator minerals have been studied in detail (2,6). In the paragenesis, a new mineral - named tuzlaite to honour the occurrence - with a pentaborate sheet structure has been discovered (7). The conditions of its formations and thermodynamic stability are still unclear, but there are indications that diagenetic changes could have affected the nucleation kinetics of the normal succession of borate minerals in the sequence, resulting in the precipitation of tuzlaite. Searlesite is the other boron containg mineral in the deposit.

Hydrogeochemical behaviour of boron in the Tuzla deposit

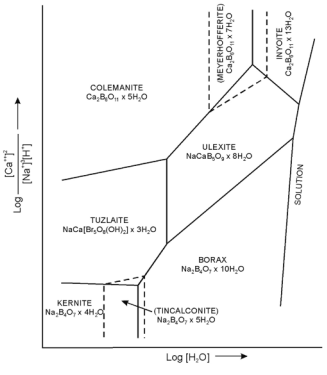

Fig. 1. Activity-activity diagram for the system $Na_2O.{}_2B_2O_{3.4}H_2O$-$_2CaO.{}_3B_2O_{3.5}H_2O$-H_2O

Boron is a highly dispersed element in nature, averaging 3 ppm in the earths crust and 4.6 ppm in seawater. The few occurences worldwide with economically significant concentrations of boron involve local volcanic activity as a source of B (8). Also involved is a standing body of water capable of accumulating boron salts leached from the volcanics. Associated evaporation processes are required to concentrate the solution to the point of precipitation of various boron containing minerals. Impervious evaporite salts (of possibly different origin) form a protective layer and a geochemical barrier that prevents subsequent redissolution. Thus, sodium and calcium borate salts present major economic minerals (borax, kernite, ulexite, colemanite) but also secondary or accessory minerals associated with evaporite salts (tuzlaite, probertite,searlesite).

In agreement with mineralogical and petrological evidence of the tuzlaite-bearing host rock, it can be assumed that this hydrated borate formed initially as a chemical deposit in a saline body of water. Essentially two distinct types of borates form by this mechanism – hydrated sodium borates from alkaline environments high in Na and low in Ca, and hydrated sodium-calcium borates from milieus relatively higher in Ca. These two situations correspond to the conditions for the stability fields of borax and ulexite respectively in activity-activity diagrams, taking into account that the primary borates would be the higher hydrates (10). The relative abundance of Mg^{2+} in a brine or groundwater, at any stage of the paragenetic sequence is a complicating factor, since the actual assemblage formed depends on the ratio $(Ca^{2+})/(Mg^{2+})$ and (H_2O). Consequently, a decrease in the activity of water due to concentration of solution after evaporation of water (or due to the possible influx of a more concentrated solution), or any increase in temperature, would cause the dehydration of the primary borate with the formation of a lower hydrate. Upon eventual burial of a saline water body (lake), the increase in pressure would thermodynamically favour the formation of lower hydrates since these have lower specific volumes. The water formed might be transferred to interstitial pore solutions. Parental fluids for the carbonate (and borate) evaporites may originally have been derived from the evaporation of surface waters fed by geothermal springs associated with local volcanic activity. However, a direct volcanogenic exhalative model for the Tuzla deposit appears unlikely, since borate minerals are too soluble to precipitate directly into a fresh, mixed lacustrine or marine water body associated with unevaporated hydrothermal fluids. In this respect, the Tuzla salt deposit seems to have a comparable formation history with Tertiary lacustrine borates of Bigadic in Turkey, which is the worlds largest sedimentary evaporite deposit (9). On the other hand, the major boron phases of Bigadic are the minerals colemanite and ulexite, deposited as nodules and veins within laminated and tuffaceous sediments of a perennial alkaline salt lake.

Conclusion

The occurrence of banded tuzlaite in the Tuzla salt deposit could indicate short periods of extreme dessication and subaerial exposure within the standing water bodies (lakes). The presence of searlesite implies periods of high Si concentrations. Thus, boron-containing minerals such as tuzlaite may have formed as secondary minerals either during burial and dewatering, or as reconversion products of other boron phases exposed to weathering and/or percolating groundwaters. The possible association of the Tuzla evaporite deposit - and its conspicuous suite of boron minerals – with local volcanic activity is still to be tested in terms of boron isotopic signature compatibilities.

Acknowledgements The authors thank the Ministry of Science and Technology of the Republic of Croatia for financial support of partial studies which have resulted in the present communication. Part of this work was facilitated by a research grant awarded to GK by the Alexander von Humboldt foundation, Bonn, Germany.

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THE LATE MIOCENE CORNACYA SHOSHONITIC ANDESITES: REMNANTS OF THE FIRST STAGE OF THE SOUTHERN TYRRHENIAN OPENING

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Abstract

Discovered on the Sardinian margin of the Tyrrhenian sea, the Cornacya shoshonitic lavas, dated at 12.6 Ma, could represent post-collisonnal suites emplaced during the first stage of the southern Tyrrhenian opening.

KeyWords : Tyrrhenian Basin, Basin formation, Back Arcs

The Sardinia Channel is located on the 400 km long submerged segment of the Apenninic-Maghrebides Alpine collisional Chain, at the junction of the Algero-Provençal and Tyrrhenian oceanic basins. The Cornacya submerged volcano is located at the northeastern end of the Sardinia Channel and on the western margin of the Cornaglia basin. It was discovered during dives with the Cyana submersible. This volcano consists of andesites which include amphibole and mica bearing lamprophyric xenoliths. Clots of plagioclase and biotite phenocrysts are ubiquitous in the andesites. The lamprophyric xenoliths are formed of olivine pseudomorphs, euhedral zoned amphibole and mica phenocrysts caught in a fine grained groundmass containing the same minerals and anhedral plagioclase. In the andesites, plagioclase shows intense normal zoning with Ca-rich cores and oligoclase to albite rims. In the lamprophyric inclusion, cores and rims of the phenocrysts are labradorite while the microlites are andesine and/or sanidine. Amphibole in the andesite and lamprophyre is a Fe-rich or not pargasite. Mica composition in the andesite depends heavily of its vicinity with the lamprophyric inclusion. Located far from the inclusion, the mica is a biotite whereas when the host rock and inclusion are in close contact, the mica is a phlogopite.

Cornacya andesites were dated at 12.6 ± 0.3 Ma using $^{39}Ar/^{40}Ar$ method with a laser microprobe on single mica grains.

Cornacya lavas are TiO_2-poor (< 0.8 %) and Al_2O_3-rich (17 <Al_2O_3% < 22). The Cornacya lavas plot in the shoshonitic field of the Ce/Yb and Th/Yb versus Ta/Yb diagrams. These lavas are enriched in LREE relative to HREE [18.6 < (La/Yb)N < 37.10] and have a marked Eu negative anomaly (0.62 ≤ Eu/Eu* ≤ 0.73) which is absent in the andesite with the lamprophyric xenolith (Fig. 1). The mantle normalized multi-element plots (Fig. 1) have overall similarities with shoshonitic rocks developed in continental arc settings.

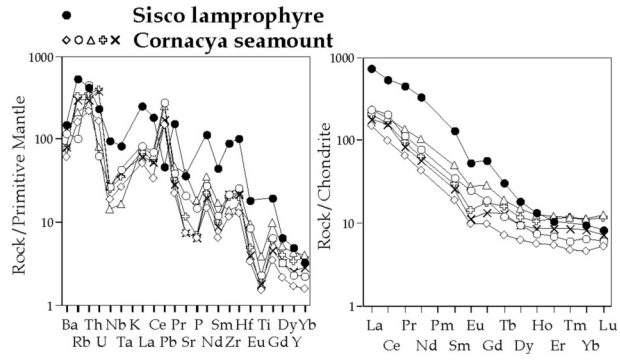

Figure 1.

The $\varepsilon Nd_{(i = 12\ Ma)}$ ratios of the Cornacya lavas are low and range from +0.39 to –10.71. The andesite with the lamprophyric xenolith has the highest ratio (+0.39) which is close to the Bulk Silica Earth composition (Fig. 2). All the these volcanic rocks have very homogeneous and high isotopic Pb ratios [18.791 < ($^{206}Pb/^{204}Pb$)i < 18.839, 15.660 < ($^{207}Pb/^{204}Pb$)i < 15.676; 38.941 < $^{208}Pb/^{204}Pb$)i < 958]. The Nd and Pb isotopic compositions suggest that all these rocks show crustal affinities and likely derive from the melting of a mantle source which suffered contamination and/or assimilation of continental crust.

The age of the Cornacya shoshonitic suite is similar to that of the Sisco lamprophyre from Corsica which similarly is located on the western margin of the Tyrrhenian sea. The Cornacya K-rich andesites and their lamprophyric inclusions share with the Sisco lamprophyre similar geochemical features. However, new geochemical data show that the Sisco lamprophyre differs from the Cornacya andesites by a higher LREE enrichment and a signifcantly lower εNd (-11.2; Fig. 2).

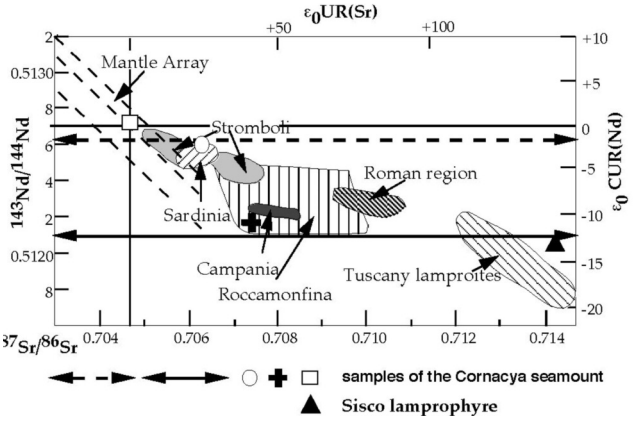

Figure 2.

The geochemical characteristics of this lamprophyre-shoshonitic suite are similar to those of K-rich and Ti-poor magmatic rocks emplaced in post-collisionnel settings.

Both igneous suites are 500 km apart but have similar structural location on the Western Tyrrhenian margin. They emplaced during the post-collisional lithospheric extension of the Corsica-Sardinia block, just after its rotation and before the Tyrrhenian sea opening. This means that lithospheric thinning began in northern and southern Tyrrhenian at the same time, during the Serravallian. The differences between the geodynamic evolution of northern and southern Tyrrhenian basins occurred later due to the southward retreat of the Tyrrhenian subduction.

3-D EVOLUTION OF SEDIMENT LOBES ABOVE PRE-EXISTING DORMANT OR ACTIVE RELIEF. IMPLICATIONS FOR THE NILE DEEP-SEA FAN, EASTERN MEDITERRANEAN

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Abstract

We conducted a series of physical experiments to better understand the complex structural pattern in the Nile deep-sea fan, where thin-skinned tectonics due to sediment loading of Messinian evaporites and deep-seated tectonics interact. Experiments tested the influence of active or dormant subsalt relief during progradation of sediment lobes. Results from models where the subsalt graben was dormant show the best fit with the structural pattern observed in the Nile-deep-sea fan.

Key-words: experimental modelling, Nile deep-sea fan, thin-skinned tectonics, thick-skinned tectonics, salt tectonics.

Deformation in the Mediterranean area involves both thick-skinned, crustal-scale tectonics and thin-skinned, gravity-driven deformation of the Messinian evaporites and their sediment overburden (5). This is particularly true in the Nile deep-sea fan (Figure 1), recently surveyed during the Prismed II and Fanil surveys (1998, 2000) using multibeam swath bathymetry and acoustic imagery, seismic reflection data and HR seismics. These surveys have evidenced different structural features that have formed in response to either gravity-driven salt tectonics due to loading of the Messinian evaporites by the Nile's sediments (3) or to transtensional, deep-seated tectonics (1,2,4). In this area, it is particularly difficult to distinguish structures that are truly related to large-scale tectonics from those that are solely the result of salt tectonics and, therefore, cannot be used as regional tectonic indicators (Figure 2). We consequently used experimental modelling to test the structural patterns produced by gravity spreading above salt where residual or active deep-seated relief is present.

3D spreading above active subsalt relief

In this experiment, we simulated radial spreading of a sediment lobe above an active graben beneath the evaporites. Model results show that an active subsalt graben influences spreading of the lobe only after significant graben subsidence has taken place, and that only a few structures formed with a trend parallel to the graben orientation. In this experiment, flow pattern in distal area of the greatly differed from what is observed in the Nile deep-sea fan.

To assess the contribution of a spreading lobe on the final deformation pattern, we also run an experiment where syntectonic sediments aggraded only, rather than prograded. In this model, some overburden structures formed parallel to the graben direction, but did not link with the basement faults.

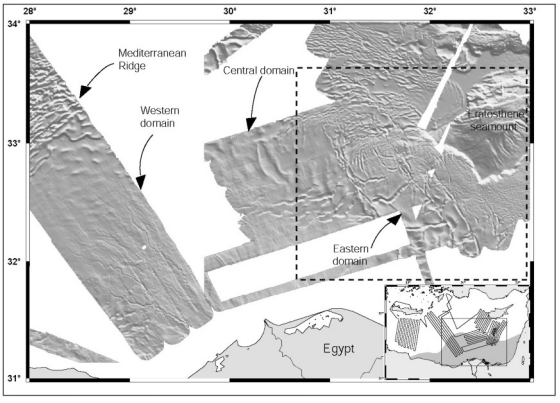

Figure1: Shaded bathymetry of the Nile deep-sea fan, acquired during the Prismed II cruise. This fan has been divided in 3 main morphostructural provinces: a Western, a Central and an Eastern province. The dotted frame indicate the area that has been compared with physical models.

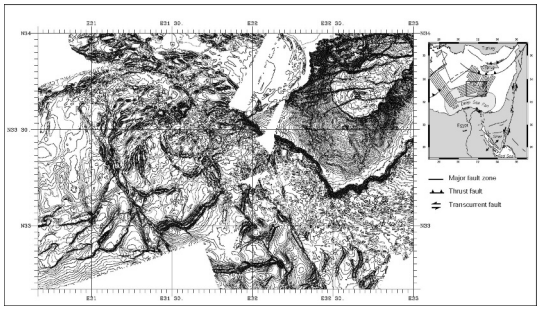

Figure 2: Eastern domain of the Nile deep-sea fan showing a complex structural pattern corresponding to both thin-skinned tectonics due to sediment loading of Messinian evaporites and deep-seated tectonics. This morphostructural domain was compared to experiments that tested the influence of active or dormant subsalt relief during progradation of sediment lobes.

Furthermore, the absence of polygonal depocentres or buckle folds makes this model unable to explain the deformation pattern of the Nile deep-sea fan.

3D spreading above residual subsalt relief

We also studied the influence of a dormant subsalt graben, no longer active, during progradation, and tested that set-up using lobes having various shapes.

Even during the early stages of deformation, a dormant subsalt graben influenced the spreading of the lobe by acting as an underlying corridor that channelled the movements of salt and overburden. The overburden located above the dormant graben extended and subsided faster, which caused depocentres there to be thicker. In addition, salt flow in the distal part of the models caused trains of arcuate folds, a pattern exactly identical to that observed in the Nile deep-sea fan. Experiments also indicate that formation of well-defined graben-parallel faults or salt-ridges depends essentially on the planform geometry of the sedimentary lobe: spreading of a circular lobe forms polygonal basins, having no specific preferred fault orientation, rather than graben-parallel structures. By contrast, when the lobe was elongate, numerous graben-parallel faults and ridges formed throughout the model history. Wrench structures, grabens and salt-ridges successively accommodated the overburden's movements. These lineaments can be reactivated in compression by spreading of other nearby lobes.

The following conclusions emerge from these experiments:

1. The main difference between radial spreading above dormant or active subsalt relief occurs during the early stages of overburden. Spreading is highly channelled when the underlying subsalt graben is dormant, but is not when the graben is active.
2. During the early stages of deformation, the evaporitic layer commonly decoupled the overburden from the subsalt basement. Basement faults did not propagate through the salt layer. The connection between subsalt and suprasal structures took place only during the later stages of lobe spreading, during which ponded basins became anchored onto the basement.
3. As long as the lobe had not subsided significantly, the basement's influence remained limited to causing variations in the rate of salt flow and overburden movement, both of which essentially depend on the salt layer's thickness. Lateral variations in spreading rate induced apparent strike-slip movements within the spreading overburden.
4. Spreading of an initially circular sediment lobe did not create a set of elongate, graben-parallel features but mostly radially-oriented structures.
5. By contrast, spreading of an elongate lobe parallel to the subsalt graben induced formation of different graben-parallel structures including wrench zones, grabens or salt-ridges. These faulted structures widened during the late stages of spreading, forming structural drains and pathways that can guide and funnel the sediment transport. A nearby second spreading lobe can reactivate some of these structures in compression.

Clearly, the structural pattern that developed in our experiments of progradation above dormant subsalt relief fits best the Nile deep-sea fan natural example:For example, thin-skinned contraction, expressed by arcuate buckle folds in the models, is extremely-well identified in the distal parts of the Nile deep-sea fan. Furthermore, a huge NW-SE deformed belt in the Eastern Nile deep-sea fan is associated, with transverse salt ridges, crestal grabens and polygonal depocentres. A similar association of tectonic trends and structural styles is also observed in models of lobes spreading above dormant basement relief.

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POCK-MARKS, GAS CHIMNEYS AND MUD-VOLCANOES: EVIDENCES FROM THE NILE DEEP-SEA FAN

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Abstract
Recent geophysical surveys on the Nile deep-sea fan (PRISMED II, Fanil) have revealed the existence of numerous pock-marks, mud-volcanoes or gas chimneys, all indicating fluid ascensions such as gas or mud-flows. Fluid releasing processes are observed in different settings, associated to large scale destabilizated sedimentary masses, growth-fault footwalls, or deep-seated tectonics. Fluid escapes might be trigerred by high sedimentary influxes generating overpressure processes in deep reservoir-layers by sedimentary overloading.

Key-words : Nile deep-sea fan, fluids, gas chimneys, pock-marks, mud-volcanoes, sedimentary overloading.

The Nile deep-sea fan's physiography, and shallow structure, have recently been imaged in detail during two recent scientific surveys (PRISMED II in 1998, and FANIL in 2000), Figure 1. Multibeam swath bathymetry and acoustic imagery, seismic reflection data, HR seismic profiling and a few piston-cores have allowed to discover numerous probable gas and fluid sea-bottom escapes, and mud volcanoes.

- Pock-marks have been well-imaged by backscatter data (highly reflective patches) in two domains: Firstly, within the Central deep-sea fan's province, between the Rosetta and Damietta onshore areas. There, they chiefly characterize the upper slope, between 1000 and 2500 meters where they seem to be related to slope destabilization processes and huge debris flows. Pock-marks have also been detected along the upper slope of the Eastern Nile deep-sea fan, at water depth ranging from 750 to 1000 meters.

- Numerous sub-marine conlets similar to mud volcanoes (300 to 1000 meters in diameter on average) have been discovered along the lower slope, within the Western Nile deep-sea fan's province. These features are not randomly distributed, but appear clearly located at the foot of growth fault systems that characterize most of the middle slope domain in this area. Within this sub-domain, huge sub-circular depressions, 5 to 10 kilometers in diameter, where several mud cones are emplaced, look like "calderas". Some of them are bounded by circular rims indicating probable collapse processes. We suspect that these features reflect areas of intense fluid and mud escapes (mud volcanoes), due to sedimentary overload above overpressured reservoirs. This overload may results from the activity of growth faults rooting within underlying Messinian salt layers. A thining of the sealing salt layer at the growth faults footwalls might be responsible for ascension of overpressured fluids and gas-saturated clay through the overburden. The conlets show often more reflective centers, or even flows, that might be associated with sedimentary dispersal by mud-flows. This may be an alternative explanation for their depressed morphology.

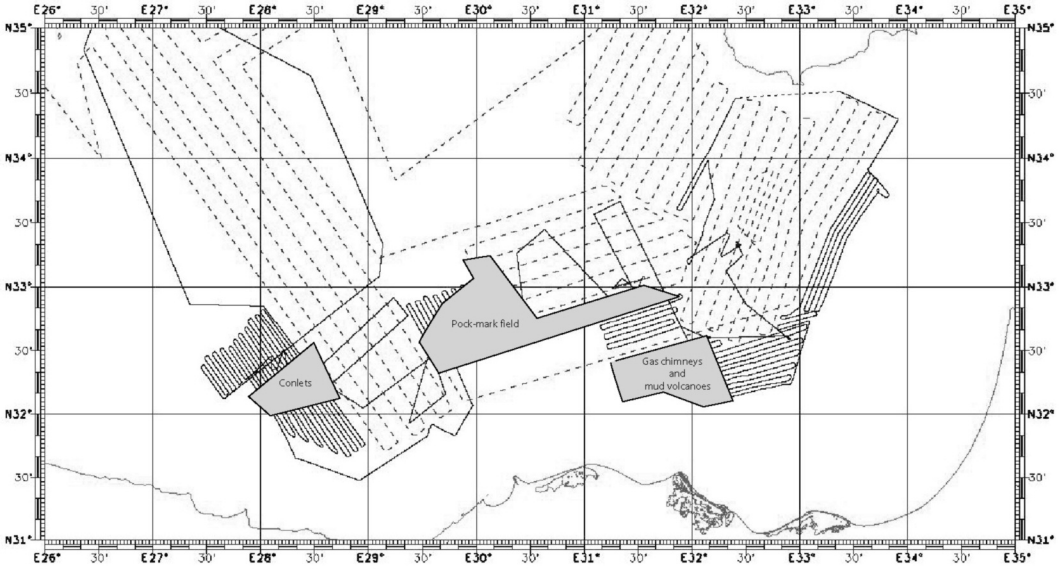
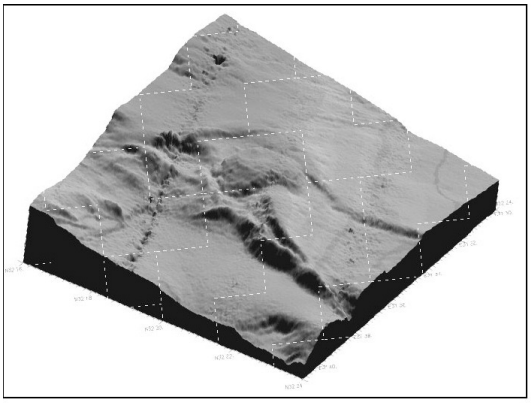
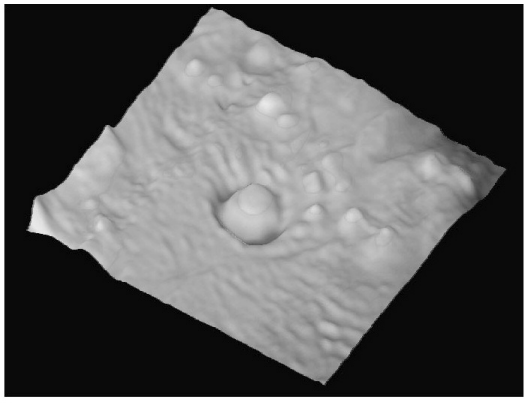


Figure1: Track-lines of the Prismed II (dotted) and Fanil (plain) surveys recently acquired along the Nile deep-sea fan (Multibeam swath bathymetry and acoustic imagery, seismic reflection data, HR seismic profiling and a few piston-cores). Areas displaying pock-marks, conlets or gas chimneys are indicated.



Structurally controlled gas chimney, Eastern Nile-deep sea-fan.



Structurally controlled mud volcanoe, Mediterranean ridge.

Figure 2: Shaded bathymetry of structurally controlled gas chimneys and mud-volcanoes, respectively belonging to the Easternmost Nile deep-sea fan province and to the Mediterranean accretionary ridge.

- Several features, similar to gas chimneys already discovered by industry, have also been observed, chiefly along the Eastern Nile deep-sea fan upper slope, where they appear as sub-circular and flat bathymetric features, bounded by depressed and faulted rims. These features reach diameters up to 4.5 kilometers and are characterized on seismic data by poorly reflective columnar bodies. They appear quite uniform on bathymetric data but show on acoustic imagery highly refective flows that may indicate to mud-flows. Finally, these gas chimneys are clearly emplaced nearby tectonic features that bound thickly sedimented grabens. Such a structurally controlled pattern may trigger fluid ascensions and is common in the nearby accretionary Mediterranean ridge (Figure 2).

The Nile deep-sea fan appears as an area releasing huge quantities of fluids (may be chiefly gas) as a consequence of several concurrent mechanisms such as sedimentary overload, growth faults activity, and potential activity of deep-seated tectonics.

We also notice that this

CRUSTAL SHORTENING ALONG THE CRETAN ARC OBTAINED BY ACTIVE SEISMIC EXPERIMENTS

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Keywords: crustal mapping, tectonics, Crete, Libyan and Cretan seas

The crust and upper mantle structure of Crete, the Cretan and Libyan Seas were obtained by two onshore-offshore seismic experiments performed in 1997 and 1999. Onshore we deployed up to 100 stand alone digital seismic stations and offshore 67 OBS. They were used to record seismic energy generated by a 3050 cubic inch airgun array. Six seismic profiles were recorded and approx. 700 locations were occupied by the onshore-offshore seismic stations (Figure 1). Technical details of both experiments have been described obtained at

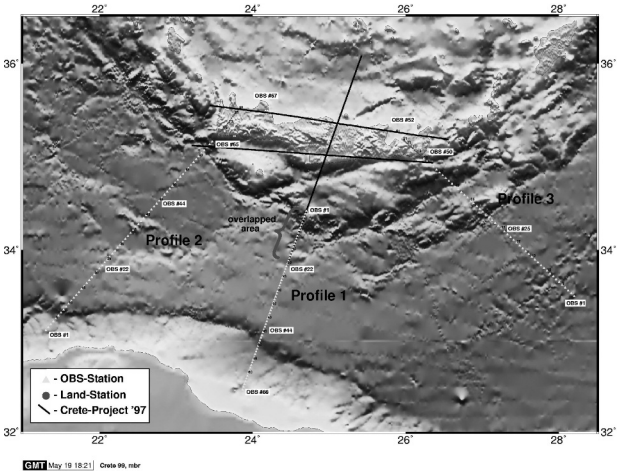

Figure 1: Crete -Projekt, Distribution of OBS- and Land- Stations.

Bohnhoff *et al*.[1] and Broenner and Makris [2].

Crustal structure on Crete proved to be laterally very variably. At the central part of Crete the crustal thickness exceeds 30 km whereas to the east and west the continental crust thins to approx. 26 km and to the east 22 km. In general the southern part of the island is thinner than the northern part of it and even at central Crete obtains values of the order of 29 km. To the north of Crete (Cretan sea) the continental crust does not exceed 16 km at its thinnest part and seems to be associated with transtensional processes that created pull apart basins (see also [3]). The sediments in the Cretan sea do not exceed 5000m and high velocity metamorphic limestones partly exposed on Crete do not seem to be present. On Crete the metamorphic limestone formations (Plattenkalk) have variable thicknesses ranging between 3 and 5 km. Their compressional velocities have values between 5.7 and 6.0 km/s. Below Crete we could identify in western and central Crete a second crustal layer of 5 to 6 km thickness which is clearly separated by the continental crust by first order discontinuity mapped due its good reflectivity. This layer was interpreted as oceanic crust of the Ionian domaine which is presently subducted below Crete. The decoupling of this layer from the continental crust occurs at the north-eastern part of Crete and the decoupling front is northwest-southeast oriented. It

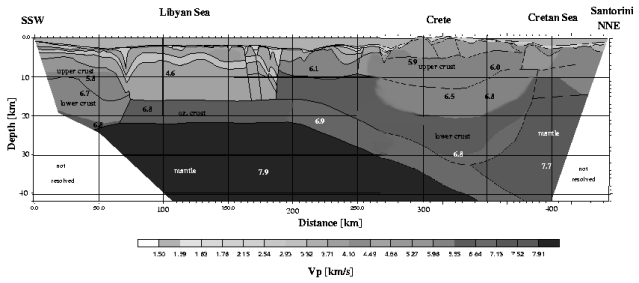

Figure 2: 2D Velocity- Depth model from the rim of Africa across Crete to Santorini, vertical exaggeration: 3.0

delineates the down dipping slab of oceanic lithosphere that generates the volcanic arc of the southern Aegean sea (Figure 2).

South of Crete the continental crust extends 100 - 150 km south and southwest of the Cretan coast and has been partly tectonized by the Ptolomeus and Pliny fault systems which are also associated with extensional structures. These propably involve strike slip as well as normal faulting. The crust of the Libyan sea which was mapped south of the Pliny fault is composed of oceanic crust and covered by thick sediments. Along the Mediterranean Ridge they exceed in some areas 12 km in thickness. This part of the Libyan sea is very strongly folded and faulted, expressing the intense tectonic deformation ongoing at present. In this part of the Mediterranean Ridge we have not identified high velocity limestones of the Plattenkalk type as those exposed on Crete or other Parts of the Hellenic Arc. Compressional wave velocities of 4.5 - 4.8 km/s denote the existence formations that have not been subjected to significant metamorphism. In most of the Libyan sea we identified one inversion zone of 3.0 -3.2 km/s underlying the 4.2 km/s limestones. In some parts two inversion zones have been mapped.

The African continental crust extends north to northeast for more than 100 km off the Libyan coast. This part of the crust is strongly thinned (25 -22 km thickness) and covered by thick sediments which are more intensely deformed to the west than to the east of Cyrenaica. Along our western profile we identified thick sedimental basins at the Libyan offshore areas that contain more than 8000m of sediments and are truncated to the northeast by intense faulting. By comparing the eastern profiles with the western line described above, we see that the intense tectonization is closer to the eastern Cretan coast than to its western side. In general whereas south of Crete the continent- ocean collision is oblique, to the west the subduction is oriented parallel to the Hellenides and of northeast- southwest orientation.

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GEODYNAMIC EVOLUTION OF NORTHERN EVOIKOS AND MALIAKOS BASINS, CENTRAL GREECE, DERIVED FROM DEEP SEISMIC SOUNDINGS

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Abstract

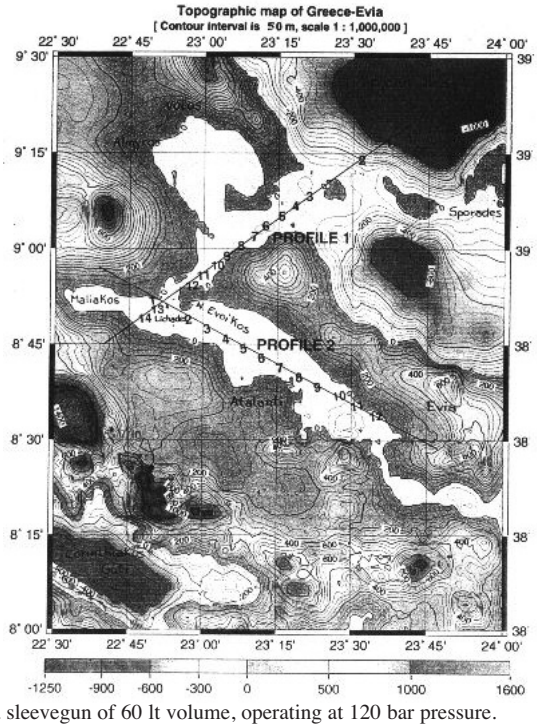
In March 1996, a wide aperture reflection/refraction (WARRP) profiling survey was carried out across the Maliakos-Sporades and northern Evoikos basins, central Greece. Two onshore/ offshore seismic lines were observed, using 14 ocean bottom seismographs (OBS) and 10 land stations. The results acquired during the survey provided evidence of a thinned, stretched continental crust, of only 19 km thickness below the central part of the northern Evoikos basin. This basin was developed by the separation of the island of Evia – with continental crust of approximated 30 km thickness – from the Greek mainland and transtension and stretching of the crust forming the north Evia and the Sperchios valleys.

Key words: deep seismic soundings, Evoikos basin, Greece

Introduction

The crustal structure at the interaction of the North Aegean Trough with the Maliakos-Sporades and northern Evoikos basins, central Greece and their tectonic significance have been poorly understood, since neither the geometry nor the nature and thickness of the crust have been seriously studied by geophysical methods. The tectonic evolution of this area however is important, since there are still unclarified questions concerning the development of the north Aegean domain and the Hellenides.

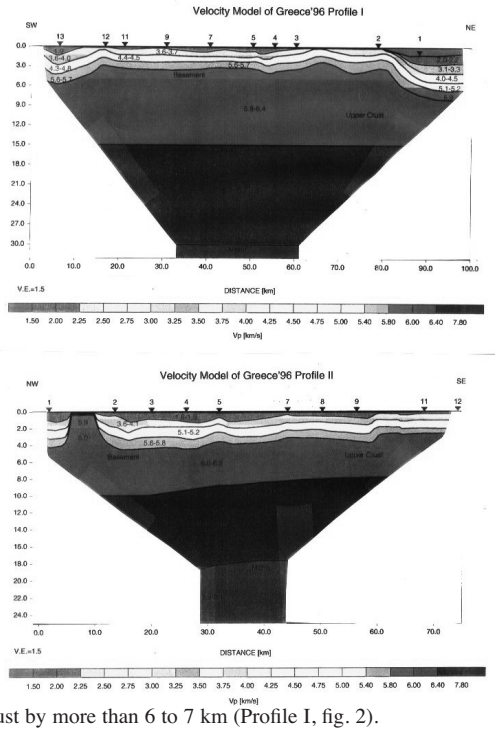
In spring 1996, the above mentioned Institutes conducted a wide aperture reflection/refraction seismic survey onshore/offshore the northern Evoikos and Maliakos basins. Two seismic lines were observed, using 14 ocean bottom seismographs and 10 land stations (fig. 1). The energy source



was a sleevegun of 60 lt volume, operating at 120 bar pressure.

Crustal structure

The results acquired by kinematic and dynamic two point raytracing modeling of the time sections provided evidence of a thinned, stretched continental crust, of only 20 km thickness, below the central part of the northern Evoikos basin (Profile II, fig. 2). This crust is comparable to that found under the Cretan Sea and has most probably evolved by transtension in a zone of crustal weakness between Evia and the Greek mainland. The basin was developed by the separation of the island of Evia – with continental crust of approximately 30 km thickness – from the Greek mainland, by transtension and stretching of the crust, forming the north Evia and the Sperchios valleys. Along the Maliakos – north Sporades basin the crust thins from 34 km at the mainland to 22 km at the Sporades basin. The crust at the northern part of the island of Evia and the Trikeri straits is 30 to 32 km thick and of normal continental structure; it is separated by an intercrustal discontinuity to an upper and lower crust. The sediments thicken significantly towards the Sporades basin, where they obtain maximum values of the order of 8 to 10 km. The igneous and metamorphic crust thins significantly in the basin maintaining however its continental character along the entire section. The transition from the Maliakos-Trikeri straits to the Sporades basin is controlled by a steep listric fault that downthrows the



basin crust by more than 6 to 7 km (Profile I, fig. 2).

The transtensional processes required to explain the rapid changes of crustal thickness follow the general trends of rifting observed in the Corinthiakos basin that deformed the areas between the Peloponnese and central Greece (1, 2). The thinned crust of northern Evoikos basin may be correlated with the Miocene palaeodynamic evolution of the Hellenides, since the basin itself is the NE extension of the Miocene Molassic Hellenic Trench that is expected – as a back arc basin – to have thin crust. A second interpretation might be that the thinned crust of northern Evoikos is the result of a tectonic process with a significant wrench component formed in a pull-apart environment. The transition of the Maliakos – Evia continental block to the thinned continental crust of the Sporades basin with the thick sediments that cover it, most probably delineates an ancient border of a passive margin developed along the Servo-Macedonian massive, presently compressed and crust-shortened between the Evia-Pilion unit, and the Servo-Macedonian massive.

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STRUCTURE OF THE SARDINIAN CHANNEL : CRUSTAL THINNING AND TARDI-OROGENIC EXTENSION IN THE APENNINIC-MAGHREBIAN OROGEN ; RESULTS OF THE CYANA SUBMERSIBLE SURVEY (SARCYA AND SARTUCYA) IN THE WESTERN MEDITERRANEAN.

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Abstract

A diving survey on the Sardinian Channel led to the characterisation of the structure of both the Sardinian and the Tunisian margins. The observations and in situ collected samples allow to precise the nature and the thermal evolution of the basement (Sardinian or Calabrian-Peloritanian-Kabylian), and to characterise the volcanic evolution, providing new constraints to the kinematic evolution of the region.

Key words : Crustal structure, Volcanology, Algerian basin, Tyrrhenian basin

The Sardinia Channel is located on a segment of the Apenninic-Maghrebides collision chain. Although this segment is nowadays completely submerged, it has not been broken apart by the opening of the Algerian-Provence and Thyrrenian oceanic basins. Previous seismic data have shown that the structure of the Sardinia Channel is due to the superposition of two successive regimes of deformation: a compressional event with crustal thickening followed by extension and thinning out. The morphology and structural patterns of the Sardinia Channel are still well preserved because the post-orogenic extension was moderate and submergence prevailed important erosion. Thus, the Sardinia Channel represents a key area for the study of the tectonic evolution of a collisional chain. Moreover, the use of the easy handling CYANA submersible allows a detailed structural and morphological survey, and the collection of well located and sometimes oriented samples.

The primary object of the campaign was to carry out in situ observations on the main morphostructures of the Deep Sardinian Channel, the escarpments of the south Sardinian Margin, where the Sardinian basement is exposed, the north Tunisian escarpments, corresponding to inverted crustal-scale thrusts of Calabrian-Peloritan-Kabylian (CPK) affinity, and the "Central Ridge", developed between the Sardinian and CPK zones. A second object of the diving campaign concerned the search of the syn- and post-orogenic magmatism, known from the dredged samples and on-land outcrops of Galite Archipelago and NW Tunisian Mountains. The samples collected on-site increased the compositional range of the magmatic rocks collection and allowed an examination of the emplacement mechanism.

The dives on the Sardinian Margin led to the discovery of a submarine volcano, dated at 12. 6 Ma and composed of shoshonitic andesites with lamprophyre inclusions, and to the characterization of the nature and structure of the underlying basement, consisting of tilted blocks of Hercynian metamorphic and granitic rocks and their sedimentary cover. The sea floor morphology reflects the structure.

The Southern Margin and Central Ridge, belong to the CPK group. They are composed of a metamorphic and granitic Hercynian basement deformed during the Alpine orogeny, which is stratigraphically overlain by a Oligo-Miocene detrital cover of Peloritanian or Kabylian type, and tectonically overlain by the so-called "flysch nappe". Throughout the CPK domain these formations were subjected during the Oligo-Miocene, at ca. 23 Ma ago, to a first denudation event, and during the Tortonian, ca. 10–8 Ma ago, to a second denudation, which has been connected to the opening of the Tyrrhenian basin. Structures, microstructures and thermochronological data indicate relatively low P-T conditions for the extensional deformations : this suggests that these units remained at shallow depths in the Apennine-Maghrebian Orogen, and were relatively sheltered from the Messinian erosion. The age (12.5 Ma) and nature of the volcanic sequence in the Sorelle is closely comparable with the calc-alkaline suite of the Galite Archipelago, Tunisia.

The data gathered during these dives in the Sardinian Channel give new constraints to the reconstruction of the kinematic evolution of western Mediterranean. The kinematic history of the Sardinian Channel can be divided into five stages:

1 -The first stage, between 35 and 22 Ma, is dominated by a regime of tectonic shortening and crustal thickening, which affected the former European Margin of the Tethys. Tectonic inversion of ancient extensional structures resulted in thrusted basement units.

2 - The second stage, between 22 and 12 Ma, is characterized by the thinning and gravitational collapse of the previously over-thickened crust. During this period, the Algero-Provencal-Ligurian Basin opened, the Corsican-Sardinian-Calabrian-Peloritanian-Kabylian block (CSCPK) rotated (20–16 Ma), and the thinning of the Sardinian Margin began, resulting in the splitting of the CSCPK block into a Corsican-Sardinian (CS) and a Calabrian-Peloritanian-Kabylian (CPK) one.

3 - The third stage, between 12 and 6 Ma, is characterized by a general thinning in the whole Tyrrhenian area. The Sardinian Channel corresponded to an extensional transform zone separating a thinned area in the south-west, from an area undergoing thinning in the north-east. The splitting of the CSCPK block was enhanced, with total detachment between the Calabrian-Peloritanian (CP) and the Kabylian (K) fragments. A morphological evolution of the area resulted from the Messinian Salinity Crisis, responsable for the regional leveling, the excavation of canyons, and the exhumation of the fault scarps.

4 - The fourth stage, between 6 and 2 Ma, begans with the flooding of the Mediterranean Basin, after the Messinian Crisis. At this time, oceanization takes place in the Western Tyrrhenian (Vavilov Basin). The Sardinian Channel was situated at one extremity of an extensional transform, zone which splitted Calabria from the Peloritani Mts.

5 - The fifth stage, between 2 Ma and the Present, corresponds to oceanization in the Eastern Tyrrhenian (Marsili Basin), far from the Sardinian Channel. The splitting of the CPK area is concluded with the separation of numerous small blocks such as Sila, Serre and Aspromonte. The Sardinian Channel is undergoing the first stages of the shortening, which is affecting the entire Western Mediterranean, well documented on the Algerian and Ligurian margins.

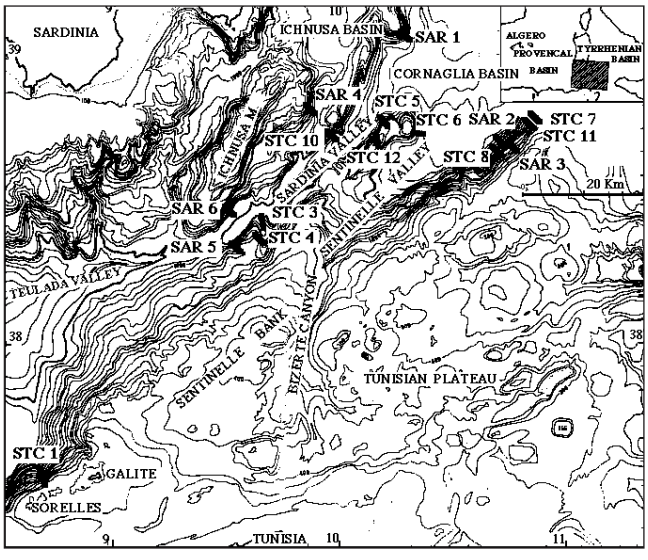

Fig. 1. Bathymetry of the Sardinian Channel and position of the Dives carried out on the escarpments (bathymetry after Gennesseaux and Stanley, 1983).

THE LIBYAN CONTINENTAL MARGIN, BETWEEN 23°30 E AND 25°30E

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Abstract

Between 23°30 and 25°30 Long. East, i.e over a distance of approximately 200km, the morphology, sedimentary cover and geological stuctures of the continental margin off Libya have been analyzed using swath bathymetry and seismic reflection data recorded during PRISMED 2 survey. This segment of the Mesozoic african continental margin of the Mediterranen sea shows three distinct areas characterized by contrasted morphology and geologic structures. Such variability is partly explained by differential overthrusting of the Meditterranean ridge over its foreland, the libyan continental slope and, by incipient continental collision processes.

Keywords: Eastern Mediterranean Sea, Continental margin, Libya, Geologic structure.

Introduction

On the basis of PRISMED 2 survey data, the Mesozoic passive margin of Eastern Mediterranean Sea, north of Libya, between Longitude 23°30 and 25°30 East, i.e. on a distance of about 200km, can be divided into three distinct segments showing different morphologies and contrasted geologic structures.

Morphology and structure

Over the study area, between Crete and Libya, the African margin faces the northern bordering Mediterranean Ridge (MR), which itself overthrusts the base of the former Mesozoic continental slope; the two features are now only separated by a narrow furrow.

A first segment constitutes the continental slope off Cyrenaica. There the continental margin has been tilted to the south as shown by southward dipping seismic sequences covered by unconformable and thin recent units. A second margin segment (about 80 km long), offset towards South from the previous one is cross cut by important canyons which have probably contributed to the sedimentary infill of the flat and narrow depressions that disconnect the base of the continental slope from the MR thrust front. In this domain seismic data show the MR accretionnary prism to be overriding on the base of the continental slope, as attested by the presence of discontinuous reflectors, detected at depth beneath the MR toe .Finally, a third margin segment, characterized by comparable sedimentary cover,made of two main units separated by an erosional unconformity, can be distinguished eastwards. Deep reflectors may also be locally detected at depth beneath the proximal overriding MR front of deformation. Within the three margin areas, the sea bottom displays numerous evidences of sedimentary slumps. Finally, the three segments face distinct domains of the MR front, characterized, either by few, almost flat and imbricated thrusts (western slope segment), northward dipping and steepy thrust zones, (central margin segment), or by a series of small and assymetric folds in which progressively eastward thickenning Messinian evaporites are involved.

Discussion and conclusion

Our seismic data, as well as a few previous MCS lines and other geophysical data (1, 2, 3, 4), do not show any evidence of typical Messinian evaporitic sediments in the investigated area of the libyan continental slope. We therefore believe that the late Miocene event has been either recorded on the margin by thin clastics, or more probably by an erosional unconformity, between the upper and lower seismic units.

On the western slope, this hiatus may well be mixed up with an angular unconformity detected between the southward tilted lower sequences and the upper ones.We are propose that the tectonic event which lead to this tilting, was coeval with the Messinian erosional episod. In other words, a pre-collision event between the MR and the Libyan margin, apparently better expressed westwards, may have already occured by latest Miocene times.

Finally, the differences at the contact between the margin segments and the MR frontal thrust zones appear to be not only related to differences in precollision setting (5), but also to the presence,or not, of evaporitic units. The availability of this material is inferred to have greatly facilitated the MR southward growth, and its progressive overthusting above the former Mesozoic continental slope (6, 4). We believe that this area of the Libyan continental margin can be considered, as a whole, as a good model where progressive geologic effects of an initiating continental collision migth be evaluated.

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STABILITE DES PENTES SOUS-MARINES DANS LE CANYON DE ZEMMOURI

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La baie de Zemmouri (Est algérois) se singularise par la présence de canyons sous-marins recoupant très haut le plateau continental. La présence de turbidites dans le bassin profond montre la présence de mouvements gravitaires. Ainsi l'application du modèle de glissement plan et de l'état de consolidation des sédiments sur des carottages font apparaître que la couverture sédimentaire du canyon de Zemmouri et ses abords sont des zones instables. La distribution des cohésions, des contraintes de pré-consolidation et des contraintes naturelles fait apparaître deux zones : une zone ouest où l'état de consolidation des sédiments est sous-consolidé, et une zone est à sédiments surconsolidés.

Mots clés: canyon, mouvements gravitaires, ,état de consolidation ,cohésion non drainée, instabilité

La sédimentation de la marge est algéroise est particulière dans le sens où les observations et résultats obtenus sur le plateau continental et le bassin profond sont en certains endroits contradictoires. En effet, les auteurs ayant travaillés sur le plateau continental (1) démontrent que les taux de sédimentation sont relativement faibles. Alors que les auteurs ayant travaillé dans le bassin profond rendent compte d'une sédimentation relativement importante. Stanley (2) mentionne des épaisseurs de couverture plio-quaternaire supérieures à 1000 m., en certains endroits du bassin profond de la marge algérienne. En outre, leclaire (3) estime ce taux de sédimentation entre 30 et 40 cm /1000 ans au débouché du canyon de Zemmouri. Ainsi, la confrontation des résultats de la sédimentation du plateau et du bassin profond pose la question du plateau continental algérien : serait-il une zone de transit et quelles sont les mécanismes de transfert des sédiments vers le bassin profond. ? Le site du canyon de Zemmouri a été étudié par 9 carottes prélevées à des profondeurs variant de 50 à 700 m (Fig. 1).et par deux profils sismiques

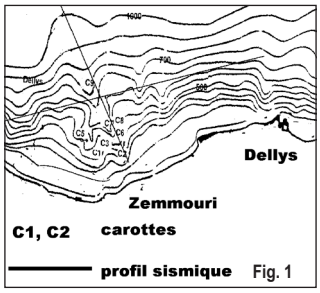


Fig. 1

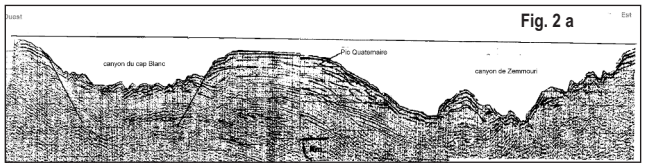
Caractéristiques morphologiques et géologiques

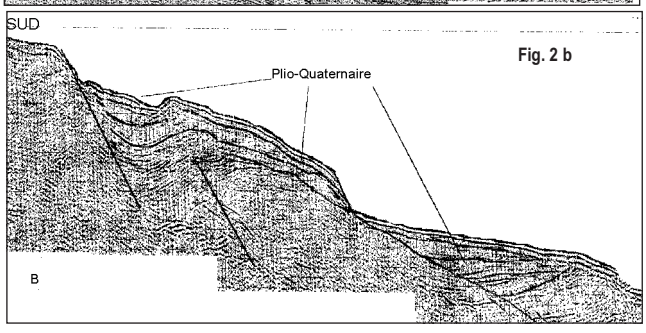
La marge est algéroise se singularise par un plateau continental très réduit (4Km) (Fig.1) et par la présence deux canyons: le canyon du cap Banc à l'ouest et le canyon de Zemmouri à l'est, dont la tête remonte très haut en amont sur le plateau. Ce système de canyon ne se trouve pas dans le prolongement du réseau hydrologique actuel. Un profil sismique transversal (W/E) (Fig. 2a) fait apparaître une dissymétrie dans la taille des canyons. Le canyon du cap blanc a une taille relativement modest , avec des parois abruptes et rectilignes. Il est encadré par un système de faille d'orientation NW-SE et NE-SW. En surface le fond du canyon est occupé par des réflecteurs de type chaotique, ce qui rendrait compte soit d'une morphologie accidentée, soit d'un recouvrement issu de mouvements gravitaires. Sur les flancs, la couverture meuble est très peu représentée, voire inexistante alors que sur les parties hautes aux abords du plateau, elle est bien représentée par des réflecteurs lités. A l'est, le canyon de Zemmouri présente une morphologie particulière. Les flancs sont dissymétrique avec un flanc ouest à pente moyenne et rectiligne et un flanc est festonné.

Un profil N/S montre un système de blocs effondrés (Fig. 2b). Selon Boucart et Glangeaud, l'âge du canyon de Zemmouri serait post pliocène.

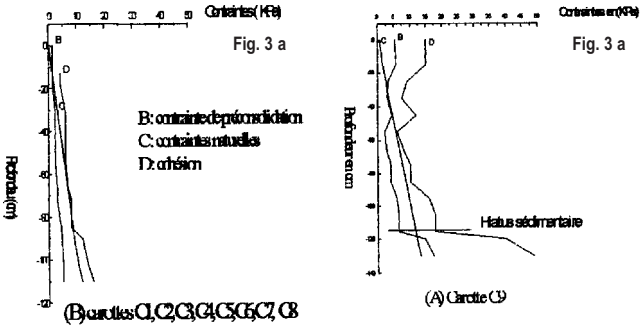
Résultats

Les résultats géotechniques obtenus sur les carottes prélevées dans le canyon de Zemmouri sont relativement classiques, avec des teneurs en eau comprise entre 33 et 63 %, des densités humides de l'ordre de1.75. Par contre, les cohésions non drainées (Cu) sont très variables (4 Kpa à 50 Kpa). Les valeurs les plus faibles (4 Kpa à 10 Kpa) du Cu sont localisées essentiellement dans les carottes C1, C2, C3, C4 ,C5, C6 C7.et C8. Verticalement ces dernières ne présentent pas de gradient avec l'enfouissement. Les cohésions les plus fortes (Cu variant de 15 kpa à 49 kpa) sont rencontrées dans la carotte C9. Dans cette dernière, la distribution des cohésions avec la profondeur d'enfouissement fait apparaître une rupture de pente très nette. A un profondeur d'enfouissement de 115cm, la cohésion passe de 18 à 49 Kpa. L'évolution des contraintes de préconsolidation s'p et des contraintes effectives s'v en fonction de la profondeur d'enfouissement fait apparaître deux types de distribution.





Une première distribution concerne les carottes à faible cohésion: celles-ci font ressortir un état de sur-consolidation en surface et un état de sous-consolidation dans le reste des carottes (Fig. 3.a). La seconde distribution est exclusivement rencontrée au niveau du prélèvement C9 (Fig 3.b). Les 20 premiers centimètres de la carotte sont occupés par des sédiments sur-consolidés, au dessous les matériaux deviennent normalement consolidés sur une puissance de 5 à 6 cm. Dans ce cas, les courbes des contraintes effectives et des contraintes de préconsolidation tendent à se confondre. Au-delà de cette côte, les sédiments se retrouvent dans un état de sous-consolidation, pour reprendre un état de surconsolidation dans les parties les plus profondes de la carotte



Les limites d'Atterberg mesurés sur les sédiments des carottes montrent que les sédiments de la zone d'étude ont une plasticité moyenne à forte (Ip variant de 10 à 25). Au point vue dynamique selon la monenclature (4) (Fig 4), les sédiments du canyon de Zemmouri appartiennent du fort alluvionnement par excès de charge

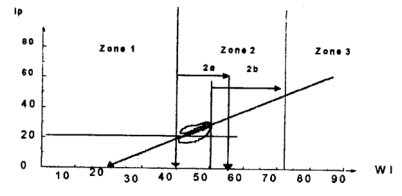


Fig. 4 zone 1: apports temporaires zone 3: faible alluvionnement
zone 2: fort alluvionnement
2a: excés de charge 2b: décantation

Ainsi, l'étude de la couverture sédimentaire au abord du canyon de Zemmouri fait apparaître que l'alimentation en sédiment de cette zone se fait essentiellement par des apports fins déposés par excès de charge. La présence de dépôts de vases brunes à tâches noires montre des vitesses de sédimentation relativement importantes La superposition de niveaux de matériaux d'état de consolidation différentes et la présence de hiatus sédimentaire montrerait ainsi des signes d'instabilité de la couverture superficielle

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STRUCTURE DE LA COUVERTURE PLIO-QUATERNAIRE DE LA MARGE ORIENTALE ALGERIENNE (EX- GOLFE DE BEJAIA)

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La région de Béjaïa appartient au domaine des Babors orientaux. L'analyse de plusieurs profils sismiques a permis de mettre en évidence deux directions majeures de failles NW-SE et NE-SW qui guident la marge de Béjaïa. La cartographie en isochrones et isopaques du recouvrement plio-quaternaire a permis de mettre l'accent sur l'étroite relation entre la tectonique et la sédimentation.

Introduction

La marge méditerranéenne de l'Afrique du Nord présente des caractères particuliers qui la distinguent des autres marges continentales du bassin occidental de la Méditerranée. Les données abondent relativement sur la bordure continentale aussi bien dans la cartographie géologique que dans la structure des formations qui constituent les Maghrébides. Dans le domaine marin, la marge algérienne reste encore très peu explorée. Ce travail préliminaire se veut une contribution à la reconnaissance des dépôts post-miocènes, bien que de nombreux problèmes de corrélation se posent entre les données sismiques et la géologie continentale (faute de forage sur la marge orientale algérienne).

Cadre géographique

Le Golfe de Béjaïa est situé à 200 Km à l'Est d'Alger. Il est encaissé dans la partie septentrionale de la chaîne montagneuse des Babors et limité par les falaises calcaires du Cap Carbon à l'ouest (longitude 5°05 E) et le massif volcanique d'El Aouana (ex-Cavallo) à l'est (longitudes et 5°35E).

Cadre géologique

La région de Béjaïa constitue un élément du tronçon septentrional de la chaîne des Maghrébides qui fait partie de l'orogène alpin. Les zones internes des Maghrébides disparaissent au niveau du Golfe et cèdent la place au domaine externe représenté par les nappes telliennes des Babors [1].

Morphologie sous marine

La topographie sous-marine de la marge algérienne est constituée par un plateau continental très peu développé aux abords des massifs montagneux. Il s'élargit avec un littoral bas et échancré au droit des dépressions néogènes et quaternaires. Le plateau continental du Golfe de Béjaïa se singularise des autres plateaux de la marge algérienne par la variabilité de son étendue ainsi que par l'absence de dépression côtière. La carte bathymétrique (Fig.1) [2] et les profils bathymétriques réalisés [3] font apparaître un plateau continental très étroit aux abords immédiat des massifs montagneux, qui s'élargit relativement face à l'embouchure de l'oued Soummam dans la partie occidentale.

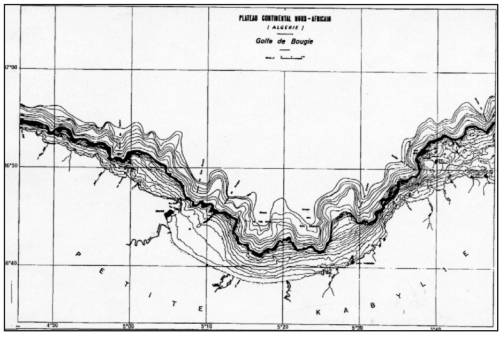

Fig. 1. Carte bathymétrique du Golfe de Bejaïa (2).

Identification des unités acoustiques

A partir des profils sismiques réflexions 2 unités ont été définies sur la base de la réponse sismique obtenue.
- une unité inférieure correspondant au substratum acoustique;
- une unité supérieure correspondant aux dépôts plio-quaternaires;

Le substratum acoustique de type chaotique correspond, par corrélation aux formations géologiques connues à terre (aux nappes telliennes et de flyschs dans le secteur occidental). Il se traduit par de petites réflexions discontinues souvent enchevêtrées et hyperboliques, dont l'amplitude est variable mais fréquemment forte. Une relative stratification est parfois reconnaissable en surimposition dans le secteur occidental. Dans le secteur oriental, cette stratification disparaît à la faveur d'un enchevêtrement plus prononcé des réflexions et traduit probablement la continuité des formations volcaniques décrites dans la région côtière d'El Aouana.

La limite entre les deux unités est représentée par une réflecteur de type hyperbolique, de forte amplitude qui constitue la surface de discordance messinienne. Les dépôts messiniens, représentés par une série de réflecteurs parallèles (faciès lité), sont bien définis dans le bassin. Ces dépôts se biseautent à l'approche du sommet de la pente où ils font place à la surface de discordance.

L'unité supérieure représentée par les dépôts plio-quaternaires repose directement sur le substratum acoustique profondément érodé. Cette unité est constituée par 2 ensembles :
- un ensemble inférieur à faciès transparent caractérisé par l'absence de réflecteur ou par des réflecteurs de très faible amplitude. La continuité est variable, mais en général assez faible. Ce faciès semble donc correspondre au Pliocène inférieur marneux riche en microfaune planctonique décrit dans la vallée de la Soummam [4] et dans différentes régions de la Méditerranée en particulier dans le forage (JOIDES-DSDP, Leg 371).
- un ensemble supérieur à faciès lité caractérisé par une séquence de réflecteurs parallèles, de forte amplitude et d'extension latérale relativement importante. Une bonne continuité des réflecteurs est observée exceptée dans les zones affectées par la tectonique. Ce faciès correspondrait au Pliocène supérieur à Quaternaire dans sa partie sommitale.

Structure du recouvrement

La cartographie en isochrone de la discordance messinienne a permis de mettre en évidence 2 directions majeures de failles, NE-SW dans le secteur occidental du Golfe et NW-SE dans le secteur oriental. Ce réseau de failles montre d'ouest en est, dans le golfe, une prédominance de structures en "marches d'escalier". Ces accidents ont structuré la région en zones hautes et basses. Les zones hautes sont localisées aux Cap Carbon et Cap d'El Aouana avec une couverture plio-quaternaire très réduite (100 à 500 ms en TD). La zone affaissée correspond au Golfe dont la couverture atteint 1300 ms en TD dans la partie centrale du plateau continental (Fig. 2).

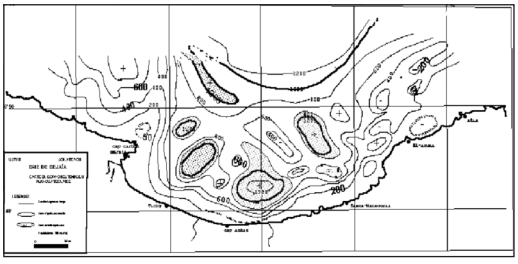

Fig. 2. Carte en isopaques temps du recouvrement Plio-Quaternaire du Golfe de Bejaia.

Conclusion

Ces travaux préliminaires mettent l'accent sur l'étroite relation tectonique-sédimentation. L'empreinte structurale de la surface de discordance se manifeste nettement dans la morphologie actuelle du plateau continental. Les accidents majeurs cartographiés sur le substratum antépliocène semblent être réactivés lors de la compression récente qui se manifeste le long de l'orogène alpin des maghrébides. Ce mouvement de convergence se traduit par des failles de direction NE dans la région occidentale (massif de Gouraya) et NW (massif d'El Aouana). Ces failles, correspondent, dans le massif de Gouraya, au décrochement senestre Gouraya-Arbalou, (1) ainsi que par la réactivation des contacts entre le massif éruptif d'Amizour et le Miocène post nappes de la vallée de la Soummam.

Ce travail a permis de mettre en évidence l'épaisse couverture plio-quaternaire dans le golfe (plus de 1300 ms) qui ne s'observe pas dans l'arrière pays, représenté par les nappes telliennes. Cette couverture se réduit considérablement aux abords immédiats des massifs de Gouraya et d'El Aouana. Cette structuration des dépôts plio-quaternaires est le résultat d'une tectonique encore active actuellement à l'image des dernières secousses sismiques de Beni Ouertilene.

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COLD SEEP COMMUNITIES IN THE DEEP MEDITERRANEAN SEA (SOUTH OF CRETE AND TURKEY): FAUNAL COMPOSITION AND SPATIAL DISTRIBUTION

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Abstract

Cold seep communities were observed by submersible on mud volcanoes and along a faulted ridge between 1700 and 2000 m depth along the Mediterranean Ridge south of Crete and South of Turkey. Methane rich fluids sustain benthic communities dominated by large size pogonophorans and several species of bivalves associated with symbiotic chemoautotrophic bacteria. Exceptionally dense and large fields of bivalve shells and bushes of tens to hundreds of pogonophorans were observed and mapped. The diversity of the "symbiotic" fauna is high compared to other cold seep site at similar depths. This discovery of diverse communities with high densities contrasts with the assumed poverty of the deep Mediterranean fauna.

Kew Words: Eastern Mediterranean Sea, Mud volcanoes, Cold seep communities, bivalves, pogonophorans

Introduction

Number of cold seep communities has been discovered on continental active or passive margins of the Pacific and Atlantic oceans (see for review ref.1). Mud volcanoes where methane rich fluids are expelled are one of the most common environments that favour their development. Chemosynthesis-based benthic communities have been described on mud volcanoes, diapirs and pockmarks along the Barbados accretionary prism (2, 3), in the Gulf of Mexico (4, 5) and in the Norvegian Sea (6). The communities are generally dominated by large-size bivalves (mytilids and/or vesicomyids) and pogonophorans. Lucinids and thyasirids living partially or totally buried in the sediment occur in lower abundance at the shallowest sites (1).

Two mud volcano fields were explored during the french-dutch MEDINAUT cruise with the submersible Nautile, south of Crete along the Mediteranean Ridge at about 2000m depth (Olimpi mud field) and south of Turkey between 1700 and 2000 m depth (Anaximander mud field). High methane concentrations were measured in the water sampled over the mounds (7). Methane is oxidised and sulphide is produced in the sediment with contribution of a consortium of bacteria and Archea (8). Methane and sulphide are therefore available for other chemoautotrophic bacteria including invertebrate symbionts.

Results and discussion

Chemosynthesis-based communities dominated by bivalves and pogonophorans including large size Lamellibrachia sp. were observed and sampled on 6 mud volcanoes upon the 7 explored and along a faulted ridge. Five bivalve species, belonging to 4 families commonly found in cold seep environments, were sampled: two presumed new species of Lucinidae (Lucinoma sp. and Myrtea sp.), the Mytilidae *Idas modiolaeformis, Isorropodon perplexum* (Vesicomyidae) and *Thyasira striata* (Thyasiridae). Shell sizes are from 2 to about 20 mm, and up to 40 mm for Lucinoma sp., which is less than bivalves usually living at seeps but large compared to deep Mediterranean sea species. Two pogonophorans, large size (tubes up to 80 cm long) Lamellibrachia sp. (*Pogonophora Obturata*) and small size Siboglinum sp. (*Pogonophora Monilifera*) were sampled in both areas. Iotopic ratio measurements evidence use of chemosynthesis originated carbon (Fiala-Médioni, this issue) by three bivalve species and the Lamellibrachia sp. assumed to be associated with chemoautotrophic bacteria. Exceptionally large specimens sponge *Rhizaxinella pyrifera* may be also associated with symbiotic bacteria. Analysis of samples and of video records reveals a great diversity of the "symbiotic" mega- and macrofauna, compared to other cold seep areas at similar depths. Four bivalve species and one gastropod were described from the Nile cone (9) where similar environmental conditions may occur. Associated fauna appeared to be abundant in terms of vagile species (fishes, shrimps and crabs) and detritivorous species such as echinids, which may be attracted by the local enrichment. Eigth species of gastropods were sampled on all the volcanoes and the ridge. Negative values of $\delta^{13}C$ of the tissue of one Echinus sp. (from –35.67‰ to –42.33‰) indicate a nutrition using chemosynthesis origin carbon.

Spatial analysis of community distribution on 3 volcanoes show that dense bivalve shell accumulations (mainly lucinids) spread over large areas, from 10 to 25 % of the explored areas (3000 to 15000 m_) on the different volcanoes. The pogonophora Lamellibrachia sp. shows variable density on the different volcanoes (mean density from 0.02 to 0.44 ind./m_). Bushes of several hundreds of individuals were observed at some places in the Anaximander area. This observation, together with contrasts in number of sampled living bivalves and gastropods, and differences in terms of diversity suggest that the Anaximander area is presently more active than the Olimpi area.

These dense and rich cold seep communities contrast with the assumed poverty of the deep Mediterranean. Abundant associated fauna was observed and the food web complexity has to be further studied. Differences in faunal distribution, abundance and diversity between mud volcanoes suggest different activity stages. Dating of bivalve shells and relation with geology processes should help in understanding temporal evolution of these fluid emissions.

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ACTIVE DEFORMATION AND MICROSEISMICITY OF THE MESSINIAKOS GULF, SOUTHERN GREECE, DEDUCED FROM AN ONSHORE/OFFSHORE LOCAL SEISMIC ARRAY

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Abstract

The microseismic activity in the area of Messiniakos gulf, southern Greece, was observed by an onshore/offshore seismic array. In a period of 45 days more than 1600 events were detected and the distribution of the seismic activity confirms the existence of an active fault system of NW-SE orientation correlating with tectonic elements mapped by geological techniques. It is of particular significance that in the immediate vicinity of the city of Kalamata the distribution of epicenters delineates an NW-SE fault (F1, Fig.1) which coincides with the fault system activated during the 1986 M6.0 catastrophic earthquake. Apart from this a deep fault of NE-SW orientation was mapped in the lower part of the Messiniakos gulf (F2, Fig.1) which is associated with the subduction process below southwestern Greece.

Keywords : active tectonics, microseismicity, southern Greece

Introduction

After the destructive Ms6.0 earthquake of Kalamata, southwestern Greece, of September 13, 1986, that caused significant economic damage and human losses, several investigations were initiated aiming at a more precise location of the active fault systems in order to better estimate the seismic hazard and risk of the broader Messiniakos area. In this respect particular interest was given to the study of the poorly understood submarine tectonic elements of the Messinian bay and their connection to the onshore tectonics (1). In an attempt to better locate the offshore active faults of this region, a combined onshore/offshore microseismicity survey of 30 seismic stations was carried out in the Messiniakos Gulf, by the above mentioned Institutes. The correlation of microseismicity with regional tectonics is discussed in the present study.

Microseismicity

We deployed 20 stand alone seismic units onshore that recorded continuously for 45 days three seismic channels at a sampling rate of 8 msec (2). Data were stored on hard disk and the timing and position were obtained by an intergrated GPS system. 10 ocean bottom seismographs (OBS) were used for the offshore observations. These systems have the same recording capacity as the land stations, are housed in a glass sphere and can be deployed to water depths over 6,000 m. Timing is obtained by a thermal stabilized quartz clock. The OBS are anchored on the sea floor by a specially designed weight and can be released from it acoustically or by a timing device (3,2).

In a period of 45 days, in Fall 1999, more than 1600 events were detected. In the immediate area of interest about 930 events were located (fig. 1) with an accuracy better than 3 Km in the epi- and hypocentral position. Their local magnitudes callibrated by records of the National Seismograph Network of Greece ranged between ML1.2 and 4.0.

Discussion and conclusions

The distribution of the foci delineated mainly two active fault zones in the Messiniakos basin and one onshore the northern costal area, and particularly the city of Kalamata. The main offshore active tectonic element strikes NE-SW and terminates in the area of Kardamili. This part of the Taigetos peninsula is truncated by a NW-SE major tectonic fault which is also characterized by high seismic activity. More important however is the identification of an active fault zone, south of the city of Kalamata. Its proximity to this densely populated urban center creates a hazardous situation that has to be considered in any major urban planning and construction. A dense distribution of deeper events in the lower part of the Messiniakos gulf is associated with the subduction process which takes part in southwestern Greece, at an approximately 50 km distance from the study area. The western coast of the Messinian bay is less affected by seismic activity and only at the southernmost part of the peninsula an NS striking active fault system has been identified. A large number of seismic events were located outside the local network. Their accuracy, particularly that of the hypocentral depth, is smaller than that within the array. In spite of this shortcoming, the strong Athens ML5.9 earthquake of September 7, 1999, has been recorded including all the foreshock and part of ist aftershock activity. The larger events identified two active zones. One is striking E-W with the Athens main shock at ist center, having a length of approximately 20 Km. The second one, striking NE-SW, extends all the way from the Parnis mountain over the island of

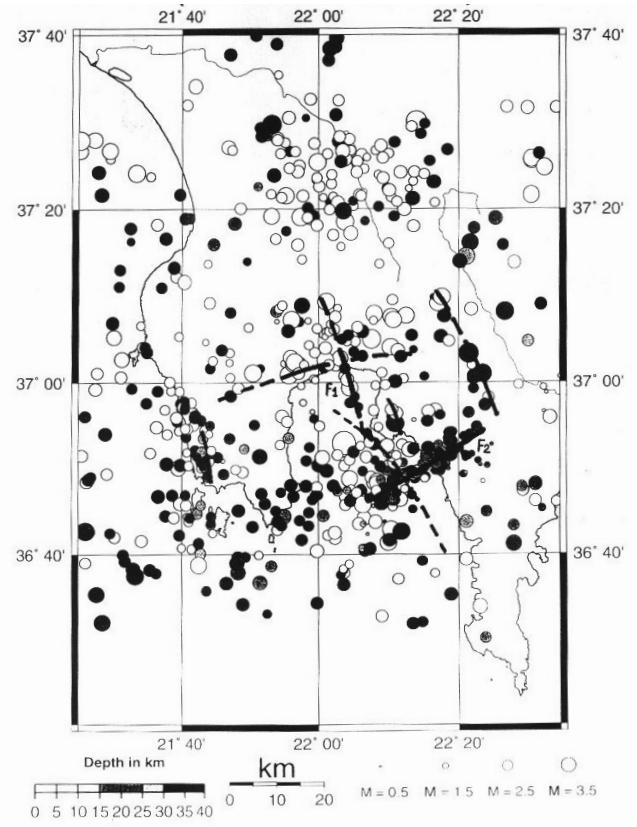

Fig. 1. Microseismicity of Kalamata 99 (number of events : 1458)

Salamina to the eastern coast of Peloponnese. The Saronic bay is truncated along this line by an active fault. A new research program was recently initiated aiming at the more precise location of the seismic activity of the Saronic area.

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AN ATLAS OF THE MARMARA SEA: THE RESULT OF THE MULTIBEAM REFLECTIVITY SIDE SCAN SONAR AND HIGH DEFINITION SEISMIC SURVEY
for a better understanding of the western termination of the North Anatolian Fault

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The Marmara Sea is located at the western end of a major dextral strike slip fault, the North Anatolian Fault.

The Marmara Sea system is generally considered to correspond to a number of short, en echelon strike-slip fault segments distributed within three distinct depressions described as pull-apart basins (Armijo et al. [1]). Recently, Le Pichon et al. [2] proposed that there is a continuous fault across the sea, along the projected trace of the North Anatolian fault, from the Gulf of Izmit to the east to the Ganos Fault to the west. They called it the Marmara Fault. Aksu et al.[3] interpreted the results of a single channel seismic reflection survey over the whole Marmara Sea in terms of a highly complex transtensional flower structures that could corresponds at depth to this single major strike slip fault. On the basis of Turkish multi-channel seismic and multibeam bathymetry data, Imren et al. [4] demonstrated that the active strike slip fault system is located in a narrow zone along the axis of the Sea of Marmara.

On basis of these available data, a cruise was planned for the year 2000 in cooperation between INSU-CNRS-IFREMER and Tubitak and ITU with the support of the EC. A complete mapping of the Sea of Marmara below 100m depths was achieved. This study was followed by a sparker seismic profiling and side scan sonar (SAR) survey with capability to record just over the bottom (Pasisar).

The results of this survey on September 2000 on board R.V. le Suroit will be published by the Marmara scientific party and IFREMER in the form of an Atlas. Fine scale bathymetry and reflectivity with 1/100,000 scale maps are presented. The Atlas includes also representative SAR imagery as well as significant sparker and pasisar seismic profiles.

- Precise cartography using EM300 multibeam system was 25 m gridded. Bathymetric maps are presented in 3 overlying sheets. Three basins separated by highly deformed highs were mapped in detail in the Sea of Marmara.

- The reflectivity maps are presented at the same scale and the same framing. The trace of a single fault is clearly visible in the western part of the Marmara sea (Tekirdag and Central basins), meanwhile east of the central high, the Cinarcik basin is actively deformed along both its northern and southern margins.

-The Atlas includes also a mozaic of SAR imagery in the Central Basin where a small trantensional zone was identified. Additional side scan sonar images were selected to illustrate the trace of the active fault on the bottom, both in the Tekirdag Basin in the west and the Cinarcik Basin in the east.

- Selected high definition seismic profiles with a maximum penetration of 1,5 sdt provide as series of section views across the uppermost part of the fault zone.

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ACTIVE FAULTING IN THE GULF OF CORINTH, GREECE

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Abstract
High resolution seismic profiling in the Gulf of Corinth indicates more complicate structure than thought up to now. Two equivalently active fault zones, each one composed of several en echelon arranged fault-segments, border the basin north- and southwards. The basin becomes narrower and shallower toward west, while significant transpressional deformation occurs along narrow zones.

Key words : Tectonics, Stratigraphy, Seismics, Sea Level

Introduction

The Gulf of Corinth is the most active extensional feature in Europe with a maximum extension rate in N-S direction of 7-16 mm/yr (1,2). With a general WNW-ESE elongate shape, the Gulf of Corinth separates the clockwise rotating Peloponese to the south from the relatively stable Central Greece to the North. The up to 900m deep basin crosscuts the NNW-SSE trending alpine structure of the Hellenides, limiting the occurrence of Parnass unit to the North and the external metamorphic belt to the South, and disrupting the nape structure of Pindos unit.

Faulting and evolution

A grid of densely spaced (every 1 mile) N-S single-channel Air Gun profiles was performed in the entire Gulf of Corinth (from Rion-Antirrion to the Gulf of Alkyonides) and provided maximum penetration of 1sec twtt within the basin's sediments and relatively high-resolution.

The present Gulf-of-Corinth basin is controlled by two main marginal fault zones, which run along the foot of the southern and northern submarine slopes. Each fault zone consists of a number of E-W trending, en echelon arranged, fault-segments. Both slopes are steep and display extensive failure phenomena. In contrast to the proposed asymmetric character of the basin (3), favoured by most workers up to now, the structure of the present-day Gulf of Corinth appears much more complicate.

Starting from the East, the Psatha fault and its westward prolongation along the foot of the southern slope controls the evolution of the Gulf of Alkyonides basin. Both the sea-bed and the sediments dip southwards, while the lowermost horizons of the 400m thick basin infill are correlated with the Pleistocene conglomerates of the inactive Megara basin, presently exposed at 300m altitude (4).

Moving to the West, the 800-900 m deep basin of the central Gulf of Corinth displays rather symmetric character. The basin infill consists of continuous turbidite sedimentation and is intersected by narrow zones of transpressional deformation, bordered by E-W trending, intra-basinal, high-angle faults. Massive sliding structures occur all along the steep southern and northern slopes. The Perachora peninsula, which is bordered by the NW-facing Perachora fault and the S-ward dipping Loutraki fault, separates the central basin of the Gulf of Corinth from the N-ward tilted Lechaion Gulf basin.

Further to the West the active Gulf of Corinth basin becomes significantly narrower and shallower, while the maximum sediment accumulation thickness decreases gradually from >800m in the eastern part to <400m off Aigio. Between Galaxidi and Aigio the basin infill consists mainly of chaotic slide masses, while continuous sedimentary reflectors are poorly observed. The lower horizons of the sedimentary sequence are strongly deformed and dip gently to the N, indicating a possible N-ward tilting of this part of the basin.

The westernmost part of the basin is occupied by the prodelta and distal deposits of Erineos and Mornos rivers. Frequent slope failure phenomena occur along both the southern and northern 200m high escarpments, which border the narrow basin.

The southern margin of the present Gulf undergoes continuous uplift, indicated by the presence of elevated marine terraces (5,1), and the uplifted Pleistocene delta deposits in Northern Peloponese (6). Opposite to that, the northern margin of the Gulf undergoes continuous subsidence during the last 250 ka, as shown by the presence of several low-sea-level-stand prograding sequences on the outer self and upper slope off Eratini (7).

Discussion

The present Gulf of Corinth represents the last stage of an older structure, which initiated in Upper Miocene – Lower Pliocene. The opening of the basin either started earlier in the eastern part or prograded faster in the east than in the west. This assumption may explain the widening, deepening and higher sediment accumulation of the basin toward East and coincides with the clockwise rotation of Peloponese. During the evolution of the basin the southern active margin was migrating northwards and the northern one remained more or less stable inducing northward shifting of the active basin. The rather complicate structure of the present day Gulf of Corinth basin is not easily explained by the presence of a low-angle N-dipping normal fault / seismogenic layer below the Gulf, which is proposed by many authors.

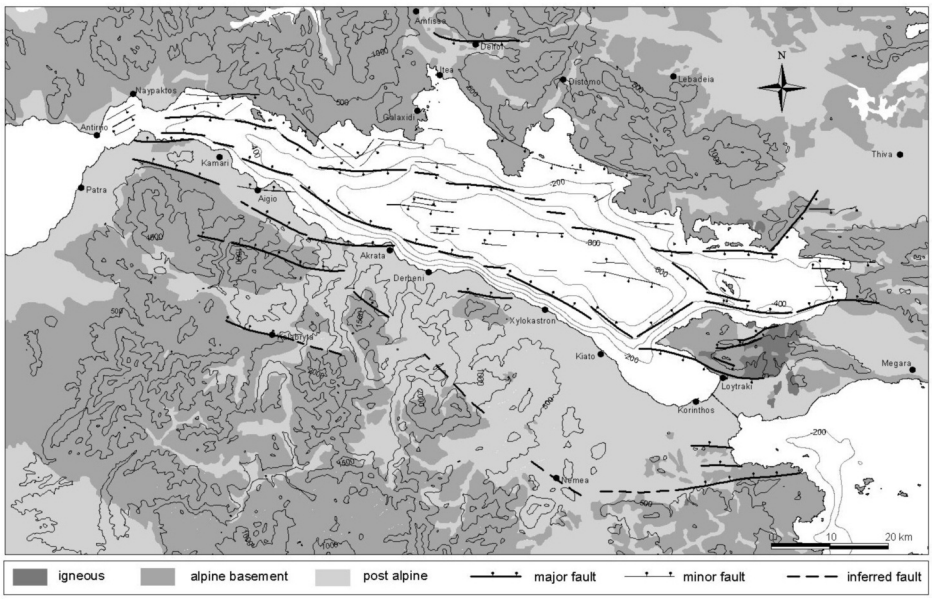

Fig. 1: Active faulting in the Gulf of Corinth basin.

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GEOLOGICAL EVOLUTION OF WESTERN ANATOLIA AND THE GEOPHYSICAL STUDIES IN THE BAY OF IZMIR

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Izmir Bay was formed by an asymmetric E-W directed graben to other important bays in western Anatolia. It was partially separated by Karaburun Peninsula from the Aegean Sea morphologically, and was formed and controlled mainly by NE and N directed uplifted and subsided blocks (1, 2, 3).

The geology of Izmir Bay and its surrounding is given in the Figure 1. In the Bay, which formed in a subsided walley, the effects of Alpine Orogenesis in general can be seen. The area was first established in the Valanginian period and the surrounding rocks were represented with Crateceous deposits of flysh facies. This suggests that the deposisonal environment was not stable. Periodic sea level oscillations caused conglomerate, sandstones-marl and limestone alternations. But the greater thickness of limestones suggests that the marine

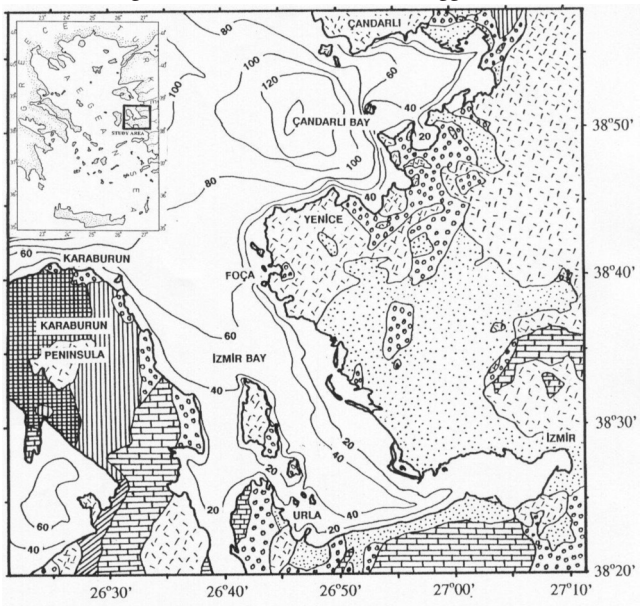

Figure 1: Geology of Izmir Bay and its surrounding (5) on the Bathymetry (6)

environment continued in a longer period (4).

Miocene period started with shallow lake sediments after an important absence between Cretaceous and Miocene. The gradual subsidence of the lake caused the continental depositions. Volcanic tuffaceous and similar materials, which cover large areas in the Miocene period were deposited after the extension in N, NW-SE and NE-SW directed fault systems caused by orogenic movements.

According to some scientists, Izmir Bay was formed by normal faults at the end of the Neogene or probably in Middle Pleistocene. Terraces located on the shore and in the valley suggest that the movements continued also in the Quaternary. In the Quaternary, Izmir Bay was a deep walley in the glacial (cold) periods, and it was a Bay like today in the interglacial (warm) periods. It can be said that Izmir Bay reached the present form first in the Flandrien transgression.

Numerous shallow seismic, multichannel reflection and several seismic refraction studies were done in the Bay in various times. Most of these studies were carried out by the R/V K. *Piri Reis* of the Institute of Marine Sciences and Technology in Izmir. After the multichannel seismic studies an exploration well Foça-1 with 2220 m final depth was drilled in the outer bay between Foça and Karaburun (Figure 2).

In this well of thick Miocene sequence was cut. The lower 1000 m of this sequence was volcanic origin. This is a negative point for the oil potential in the Bay. However, 360 m thick evaporites were also cut during the drilling (7). Finally, for a better understanding of the geology of Izmir Bay seismic refraction studies along a profile, which cut

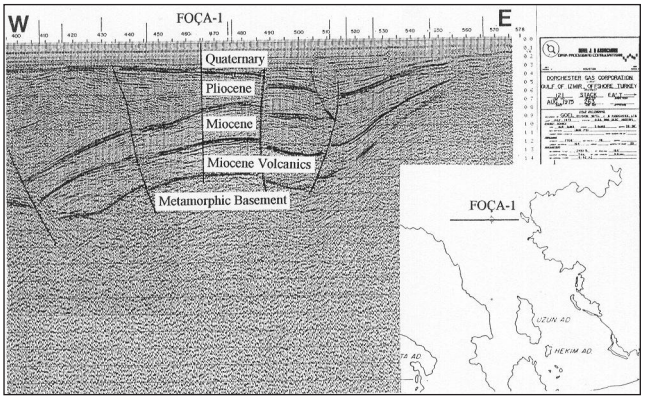

Figure 2. Multichannel seismic reflection section from the Izmir Bay.

the Foça-1 oil well, were carried out and compared with older data.

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EVIDENCE FROM ISOTOPICALLY DEPLETED ARCHAEAL AND BACTERIAL BIOMARKERS IN EASTERN MEDITERRANEAN MUD VOLCANOES FOR CARBON CYCLING IN SPATIALLY HETEROGENEOUS ANAEROBIC METHANE OXIDIZING MICROBIAL COMMUNITIES

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Significant amounts of methane are produced in marine sediments, but little escapes from the sediments to the overlying water column or atmosphere. A number of recent studies have implicated anaerobic methane oxidation (AMO) as the primary process responsible for scavenging of methane in the sediments, yet the organisms, mechanisms, and pathways of carbon cycling in anaerobic methane oxidizing microbial communities remain topics of significant debate. The present study is a molecular and isotopic assessment of the spatial variation and pathways of carbon cycling within the anaerobic methane oxidizing microbial community in mud volcanoes in the eastern Mediterranean Sea.

Keywords: Eastern Mediterranean, Mud Volcanoes, Geochemistry, Organic Matter, Bacteria

Mud volcanism in the Eastern Mediterranean Sea has been a subject of considerable investigation for the past several years for several reasons. Among these are the potential contributions of methane from mud volcanoes and related cold seeps to the atmosphere and subsequently to global warming, and also the impact of mud volcanism on the chemical budget of bottom waters1. Recently, multiple expeditions to study mud volcanoes and related cold seeps in the eastern Mediterranean were undertaken by a joint Dutch-French multi-disciplinary investigation (the MEDINAUT and MEDINETH cruises, see 1 for details). One of the major topics of investigation of the MEDINAUT/ MEDINETH expeditions has been the biogeochemical processes involved in scavenging methane that would otherwise be released into the atmosphere, potentially contributing to global warming. A number of recent studies have implicated the process of AMO, performed by a consortium of methane oxidizing archaea and sulfate reducing bacteria, as the primary process consuming methane in anoxic sediments before it is released to the overlying watercolumn (2-4). Authigenic carbonates are often observed to form in conjunction with the anerobic oxidation of methane (5-7).

One of the most diagnostic indicators of AMO has been the identification of organic biomarker compounds linked to methanogenic archaea and sulfate reducing bacteria that are extremely depleted in ^{13}C relative to typical biomass (2,4,6,8,9). For example, $\delta^{13}C$ values in the range of –80‰ to-100‰ have been identified in biomarkers from eastern Mediteranean mud volcanoes (3), cold seeps from the California margin (2), and Miocene carbonate crusts (9), among others. Despite intensive study in recent years, however, much remains unclear about the processes and organisms involved in AMO. Among the questions still under debate are the specific biogeochemical pathways involved in AMO, the specific organisms responsible for AMO, and the possible diversity of the anaerobic methane oxidizing microbial community. The present study attempts to constrain these variables using molecular isotopic studies of sediments and carbonate crusts from eastern Mediterranean mud volcanoes. Specifically, we are investigating spatial variability in the lipid distributions and the relative carbon isotopic signatures of AMO related biomarkers in these different environments.

A sediment core was taken for this study from Kazan mud volcano in the Anaximander Mountains area (MNLBC19, 35°25.950'N, 30°33.679'E, water depth 1673 m). The core was analyzed for archaeal and bacterial biomarkers that could be associated with AMO. Archaeal biomarkers identified include glycerol diethers such as archaeol and hydroxyarchaeol, saturated and unsaturated isomers of the irregular isoprenoid pentamethylicosane (PMI), and a series of glycerol dialkyl glycerol tetraethers (GDGT's) which had previously been attributed to anaerobic methane oxidizing archaea (10). All of these compounds had concentration maxima at a depth corresponding to the current depth at which AMO was expected to be occurring based on pore water profiles of methane and sulfate concentration (Fig. 1). The carbon isotopic compositions of these compounds ranged from –85‰ to –105‰, suggesting the possibility of either contributions from different archaea utilizing methane or its derivatives, spatial or temporal variations in the δ13C of methane, or variations in carbon isotopic fractionation associated with the pathways of methane-derived carbon assimilation and biosynthesis of different lipids.

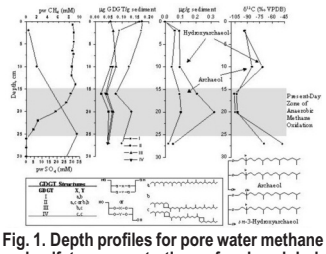

Fig. 1. Depth profiles for pore water methane and sulfate, concentrations of archaeal derived biomarkers (GDGT's and dlycerol diethers) and carbon isotopic compositions of archaeal diethers.

A number of bacterial biomarkers were also identified, including C30 hopanoids such as tetrahymanol, which has not previously been associated with AMO, and a series of dialkyl glycerol diethers previously associated with AMO as well as previously unidentified glycerol diethers (Fig. 2). The carbon isotopic compositions of these bacterial markers lie in the range of –70‰ to –93‰. The fact that these biomarkers are slightly less depleted than those attributed to archaea supports the hypothesis that the bacteria are utilizing methane-derived carbon provided by the methane oxidizing archaea, and in fact, this series of non-isoprenoid diethers is extremely likely to be derived from sulfate reducing bacteria. Previously, these diethers have only been identified in carbonate crusts related to AMO, where they were a significant fraction of the extractable organic matter. Parallel gene surveys of the crust revealed unknown archaeal and bacterial strains most closely related to methanogens and sulfate reducers. The distributions of these archaeal and bacterial biomarkers vary significantly over very small spatial scales of only 10 cm. AMO related biomarkers such as both archaeal and bacterial diethers, for example, dominate the polar fraction of the extracted organic matter at 20 cm, and decrease significantly in shallower sediments. Also, the relative concentrations of archaeol and hydroxyarchaeol vary significantly over the 30 cm length of the core, and the carbon isotopic compositions of these compounds vary over a range of more than 30‰. The existence of AMO related biomarkers in near surface sediments, however, suggests that the zone of AMO has migrated within the sediments over time, and that what we currently observe is merely a snapshot of current conditions rather than an accurate representation of long term conditions. Thus, these observations suggest differences not only in the availability of methane and the size of the methane oxidizing archaeal community over just a few centimeters sediment depth, but also over potentially short temporal scales. In addition, at least one biomarker was identified, 5a-cholestane, which is probably derived from eukaryotes and has a carbon isotopic composition of –52‰, suggesting that even eukaryotic organisms may be ultimately partially utilizing methane-derived carbon sourced from cold seeps associated with eastern Mediterranean mud volcanism. Finally, the presence of this series of bacterial diethers, which we have previously identified only in cold seep related carbonate crusts, suggests that similar organisms may be responsible for AMO in multiple environments. Conversely, the relative distributions of lipids in crusts and sediments are very different, suggesting that the overall microbial community probably varies considerably between different environments in which anaerobic methane oxidation is occurring.

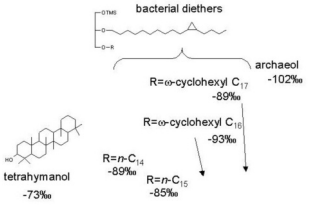

Fig. 2. Partial gas chromatogram of polar fraction of extractable organic matter form Kazan mud volcano, showing isotopicallydepleted archaeal (archaeol, hydroxyarchaeol) and bacterial (tetrahymanol, non isoprenoid dialkyl glycerol diethers) biomarhers, indicating that AMO is a sigificant influence on carbon cycling within the cold seep community.

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NEW INFORMATION CONCERNING CLAY MINERAL PROVENANCE IN MUD VOLCANOES

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Abstract

X ray-powder diffraction (XRD) analyses were conducted on matrix mud breccia samples from the MEDINETH expedition to the eastern Mediterranean mud volcano fields. The clay assemblage is dominated by high abundance of expanding clay minerals (smectite). The relative abundance of clay minerals reflects different sources of the original material: more from sources in Africa for the Olimpi area and from Turkey and Cyprus for the Anaximander and Florence areas. No evidence of deep burial diagenesis has been found.

Keywords: Eastern Mediterranean, Mud volcanoes, Clay mineralogy

Introductio

In the Eastern Mediterranean Sea, several areas of mud volcanism were surveyed in 1999 during the MEDINETH expedition, conducted on board R/V Professor Logachev, which provides more than fifty cores. XRD analysis of the < 2μm-size fraction of the matrix sample from several mud volcanoes and from an hemipelagic core, were carried out at different percentages of relative humidity (0-50-100%) in order to identify expanding clay minerals in the complex mixture. Carbonates were removed and an internal standard was added. Analysed samples came from three different areas (Fig. 1): the Olimpi field, a well-known mud volcanic field on the top of the central Mediterranean Ridge [1], the Anaximander Mountains, rifted blocks from Turkey [2] and the Florence Rise, west of Cyprus, a newly discovered mud volcanism area [3].

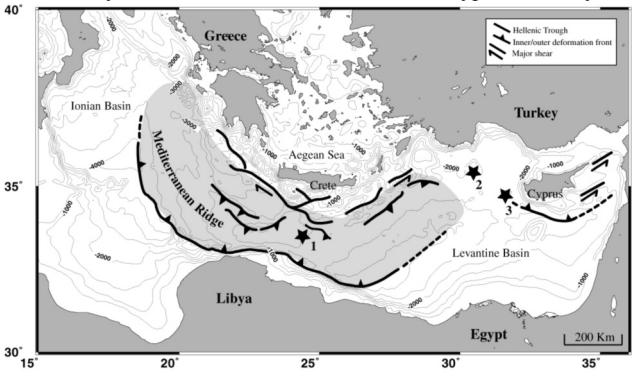

Fig.1: Main structures of Eastern Mediterranean Sea and location of surveyed area (stars), 1: Olimpi field, 2: Anaximander Mountains, and 3: Florence Rise.

Results

All the samples show a similar clay assemblage, suggesting more a detrital origin of clay minerals than real diagenesis during burial and/or during the eruptive process of the mud volcanoes. The clay assemblage is largely dominated by an expanding type of clay mineral, smectite. Clay minerals from the kaolin group (kaolinite and hallyosite) and the palygorskite group are also found in significant abundance. Minor occurrence was observed for primary chlorite and illite. In non-mud volcanic areas of the Eastern Mediterranean Sea, this type of smectite-rich assemblage is found mainly in Messinian deposits [4]. This could suggest a Messinian source for these mud breccia matrix sediments. Other origins could be detrital input from Africa or, especially for the Anaximander and Florence Rise areas, inherited from Cyprus and Turkey ophiolitic complexes. This high abundance of smectite, and minor illite content, indicates that no burial diagenesis transformation (from smectite into illite) has taken place in these sediments, supporting a shallow source for the matrix. This is in accord with clay mineral results from ODP core samples on Napoli and Milano mud volcanoes (Olimpi area) [5].

The relative abundance of clay minerals, however, shows significant differences from one area to another. Kaolin group minerals (kaolinite and hallyosite) are more abundant in the Olimpi field than in the Anaximander /Florence area (Fig. 2). It could either reflect a difference of source of the original material or alteration processes, but the latter is less probable. Palygorskite is also a quite abundant mineral in the Olimpi area, but absent from the Anaximander and Florence Rise samples. Both these clay minerals are inferred to have originated from Africa, especially palygorskite, suggesting aeolian input from a desert environment. This observation is consistent with the location of these mud volcanic fields: the Olimpi area, on the top of the Mediterranean Ridge, mainly composed of Nile-derived sediments, and the Anaximander Mountains showing a clear affiliation with Turkey units.

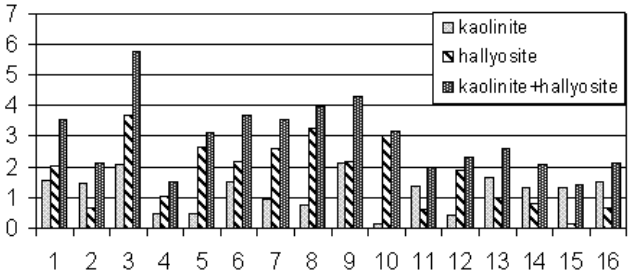

Fig. 2: Standardized abundance for kaolin group minerals (ratio of the mineral peak area on the internal standard peak area) in the different samples. Numbers refer to samples in Olimpi field: Milano mud volcano (1), Napoli mud volcano (2,3,4), Moscow mud volcano (5,6,7,8,9,10), in the Anaximander area: Amsterdam mud volcano (11,12) Kazan mud volcano (13), and in the Florence Rise area: Texel mud volcano (14,15); (16) is an hemipelagic core from the Florence Rise area.

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NIVMAR : A SPANISH STORM SURGE FORECAST SYSTEM

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Abstract
The NIVMAR system was developed in 1998 by Puertos del Estado to provide sea level predictions for the Spanish harbours which included also the meteorological forcing. This is particularly important for the Mediterranean coast, due to the small range of the tide. The system is based on the operational running of an ocean circulation model (which performs the prediction of the meteorological residuals), and the use of the tide gauge data both to obtain the astronomical prediction in the harbour and to validate the system. A description is made of the model, data transmission and near real time verification, this one fundamental to correct and improve the quality of the predictions. Examples of the good operation of the system in Mediterranean harbours are presented.

keywords: sea level, circulation models, western Mediterranean

Introduction

The HAMSON is a three dimensional and finite difference ocean circulation model developed by the IFM (Institute fur Meereskunde, Hamburg) and Puertos del Estado (1, 2, 3). It can take into account the tides, wind, atmospheric pressure, heat fluxes and baroclinic gradients inside the ocean. It has been applied to a large variety of scales and phenomena.

On the other hand Puertos del Estado is responsible for a permanent tide gauges network (REDMAR) (http://www.puertos.es/Mareas/index.html) that consists of 14 acoustic sensors along the Spanish coast, most of them in operation since mid 1992. Three of the stations are located at Western Mediterranean harbours: Barcelona, Valencia and Málaga. The tide gauges provide 5-min sea level data that are transmitted to the central station in Puertos del Estado, where the data are quality controlled and analysed (4).

Description of the system

The Nivmar system consists of a set of different applications and programs that makes use of the barotropic and vertically integrated version of the HAMSON model. The model domain covers an area extending from 20°N to 48°*N* in latitude and from 34°W to 30°*E* in longitude (all the Western Mediterranean). The bathymetry employed, based on the DTM5 data set (4), was built by using a variable grid size scheme in order to reduce the number of computational points. The region from 25°*N* to 48°*N* and from 20°*W* to 30°*E* keeps a constant resolution of 10'x15'. The grid size in the rest of the domain is increased progressively to the boundaries.

The HAMSON is executed twice a day using the output from the INM (Instituto Nacional de Meteorología) application of HIRLAM (5) to give the meteorological sea levels with a forecast horizon of 48 hours. The meteorological data consist of 6 hourly fields of pressures and winds at 10 m, with 0.5°x0.5°resolution.

The ocean model run really covers a period spanning from 12 hours before the starting time to 48 hours later. Data from REDMAR tide gauges are used, allowing the system to correct systematic errors in the mean sea level due to physical processes that are not included in the ocean model (i. e. steric height).

The tide predictions obtained from analysis of the tide gauge data are added to the meteorological sea level component given by the HAMSON model in order to have a 48 hours forecast of the total sea level. Results from NIVMAR are placed on a massive storage system (Unitree) and distributed through the web (http://www.puertos.es/Nivmar).

Table 1: Statistical comparison of measured and simulated residuals. Nr: number of records; X mean value of the measured residuals; rmse: Root Mean Square Error; rmax: maximum error; m and b: slope and interception of the linear fit and CI: Correlation Index.

Estación	Nr	X	rmse	rmax	m	b	CI
Bilbao	3648	7.89	5.66	21.03	0.82	1.44	0.90
Santander	3571	9.30	5.72	24.73	0.88	1.14	0.91
Gijón	3382	-0.68	6.13	19.70	0.88	-0.08	0.89
La Coruña	3648	17.58	5.89	20.69	0.81	3.30	0.92
Vigo	3614	15.23	5.04	20.86	0.81	2.82	0.95
Bonanza	3483	11.59	10.17	66.93	0.44	6.54	0.80
Málaga	3648	11.63	5.14	26.12	0.69	3.66	0.86
Valencia	3612	11.84	5.75	17.38	0.63	4.42	0.85
Barcelona	3630	10.88	5.14	20.04	0.71	3.15	0.89
Tenerife	3610	9.20	4.24	17.08	0.64	3.35	0.77
Las Palmas	3392	6.73	3.70	11.60	0.65	2.34	0.83

Validation of the system

The Nivmar system was validated with data from the REDMAR tide gauge network. A very stormy period was chosen for validation (November 1995 to March 1996), which is the PROMISE Spanish Coast Data Set Period.

The mean value of the simulated series was modified to the value of the measured one. These techniques are usually employed in hindcast studies of surge simulations (6). Table 1 shows a statistical comparison between simulated and measured series in different stations of the REDMAR. Validation of the system for other harbours in the Mediterranean sea was proposed within MedGLOSS project and is under development.

Near real time verification

When predicting the sea level a problem is found to relate the "datum" of the measured series and the one of the simulated series at a particular station. The technique employed consists of matching the means of the last measured data at the tide gauge and the mean of the prediction (7). In this way the information provided by the tide gauge for the recent past is used to improve the quality of the predictions, by incorporating the long-term variability not reproduced by the model.

The use of the Nivmar system is particularly important in our Mediterranean coast, due to the nearly negligible amplitude of the tide. For the three stations located in this sea (Málaga, Valencia and Barcelona), this simple scheme of assimilation is already working. In Figure 1 an example of the near real time verification performed twice a day is shown for Barcelona harbour.

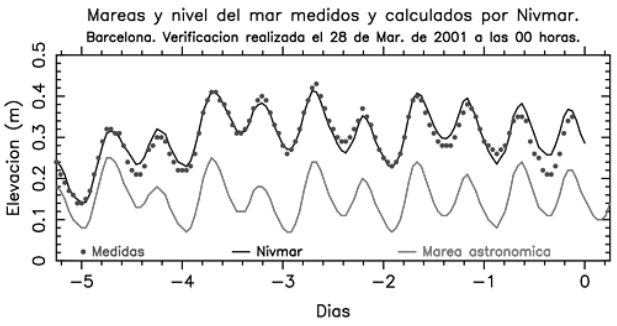

Figure 1: Example of the operation of the system in Barcelona.

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THE ROLE OF OPTICAL PROPERTIES FOR THE DYNAMICS AT THE OPEN SEA STATION STONCICA

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Abstract
Trend of decrease of transparency at the open sea station Stoncica motivated us to include different optical water conditions in the numerical simulations. Different optical types used, resulted in changed vertical thermal structures, and the differences, after few days of integration were higher for the simulation of summer than for winter conditions.

Key words: numerical model, Adriatic Sea, optical water types

Introduction

The hypothesis that optical conditions of the heat transfer may have significant dynamical effect has been tested here through the two numerical experiments run for the set of optical water types, according to the classification of Jerlov (1). The used water types were those present in the earlier period at the Stoncica station (Middle Adriatic Sea), and the type prevailing recently (2).

Numerical hydrodynamic model

Here the Princeton Ocean Model (POM) (3), three-dimensional primitive equation nonlinear model, with the complete thermodynamics, was used. The thermodynamic properties of the sea were simulated during two episodes of the bora wind: the first one 5th August 1972 and the second one the 13th March 1973. The equations, which capture the model physics, are the traditional equations for conservation of mass, momentum, temperature and salt, coupled with the equation of state (4). Oceanographic model was forced with the spatially variable wind stress (5) and the heat fluxes. Heat fluxes were calculated using bulk formulae according to Large (6) with the atmospheric parameters (wind, air temperature and humidity) obtained by measurements above the sea at the Stoncica station and instantaneous SST calculated by the oceanographic model.

The incoming short-wave radiation at the air-sea interface was calculated according to Haurwitz (7), assuming sun altitude was a function of hour angle s, geographic latitude j and declination d. In the model equations, short-wave radiation attenuation with depth was introduced through coefficients for each respective water types (I, IB, III) according to Paulson and Simpson (8). Model domain was Adriatic shelf with the horizontal resolution of 10 km. In the vertical direction 16 sigma layers were chosen.

Results and discussion

Results of the numerical experiments were shown in Figure 1.

The sea surface temperature time series at the model node, that corresponds to Stoncica station, show regular diurnal variations. During both bora episodes stronger heating in the surface layer was obtained in the optical type III. It is also obvious that during summer, temperature in the surface layer in the optical type III shows stronger deviation from temperature in other two optical types, for the same atmospheric conditions.

The reason for that could be lower wind speed during summer bora episode, which resulted in the reduced vertical mixing and therefore lower vertical heat transport. Summer pycnocline also prevents vertical heat transport which caused increased sea surface temperature.

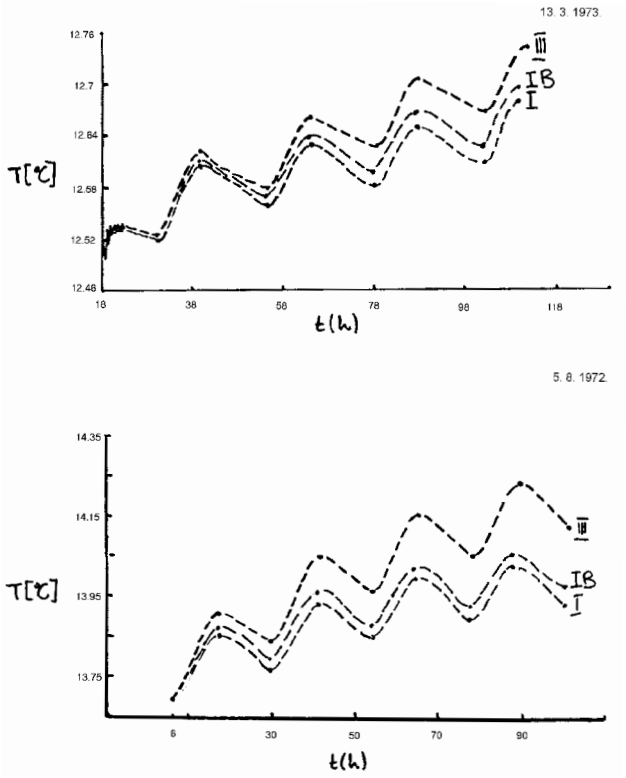

Figure 1. Temperature course with integration time for optical water types I, II and III in the surface layer.

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MODÉLISATION HAUTE RÉSOLUTION DE LA MER MÉDITERRANÉE : LE BASSIN OCCIDENTAL

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Résumé:
Une simulation numérique de la circulation méditerranéenne a été effectuée avec le modèle Ocean PArallel, développé au Laboratoire d'Océanographie DYnamique et de Climatologie. La résolution horizontale est de l'ordre de 6 km et 43 niveaux sont utilisés sur la verticale. Le modèle a été forcé pendant 11 ans par un forçage journalier perpétuel (mars 1998 - février 1999) issu des flux du Centre Européen pour les Prévisions Météorologiques à Moyens Termes (ECMWF). La circulation thermohaline et la formation des masses d'eau sont étudiées en comparaison à des mesures in situ, des simulations numériques existantes et aux climatologies. Les principaux résultats discutés ici concernent la Méditerranée occidentale.

Mots clef: modélisation, circulation thermohaline, transport, flotteurs.

Introduction

Une configuration haute résolution (5 à 7 km) de la Mer Méditerranée a été définie dans le cadre du projet MERCATOR [1]. Le domaine s'étend de 11°W à 36°E en longitude et de 30°N à 46°N en latitude. L'épaisseur des niveaux verticaux utilisés dans le modèle varie de 6 m en surface à 200 m au fond. La grille horizontale est déformée à Gibraltar pour bien représenter le détroit. Le code utilisé est le code Ocean PArallel (OPA)[2]. La température et la salinité sont rappelées sur toute la colonne d'eau vers une climatologie dans la zone Atlantique comprise entre 11° W et 7.5° W.

Le modèle a été forcé pendant 11 ans par un forçage journalier perpétuel (mars 1998 - février 1999) issu des flux du Centre Européen pour les Prévisions Météorologiques à Moyens Termes (ECMWF).

Une expérience simulant des flotteurs lagrangiens a été lancée dans la zone Liguro-Provencale et le Bassin Algérien. Les résultats sont comparés aux expériences lagrangiennes i*n situ* MAST2/SOFARGOS en 1994/95 [3, 5] et MATER/ELISA en 1997/98 [4].

Résultats:

De manière générale, les résultats du modèle sont très satisfaisants. L'augmentation de la résolution améliore sensiblement les résultats par rapport aux modèles de plus basses résolutions, notamment en ce qui concerne les propriétés dynamiques.

Les flotteurs isobares du modèle et ceux des expériences in situ sont comparés à l'aide, de diagrammes θS pour étudier les caractéristiques des masses d'eaux, d'images de trajectoires à des profondeurs données pour étudier la dynamique, et aussi d'un point de vue statistique.

Hydrologie

En ce qui concerne les caractéristiques en salinité et en température, on observe une bonne cohérence par rapport aux conditions initiales et aux observations.

Circulation générale

Les eaux atlantiques entrant dans la Mer Méditerranée au détroit de Gibraltar (Fig.1) transportent entre 0.8 et 0.9 Sverdrups. La circulation des gyres de la Mer d'Alboran est variable au cours de l'année. Le Courant Algérien longe la cote et se sépare en deux branches au niveau du Détroit de Sicile. Une branche entre dans la Méditerranée orientale. L'autre branche circule dans la Mer Tyrrhénienne. Une partie de ce courant circule dans la Mer Tyrrhénienne et l'autre partie passe le canal de Corse pour rejoindre le courant Liguro-Provencal. Ce dernier, de structure très barotrope, rétroflecte au nord des îles Baléares.

Variabilité de méso-échelle

La dynamique de méso-échelle est bien représentée, en bon accord avec les observations. C'est le cas dans la Mer Tyrrhénienne, où l'on observe des circulations cycloniques et anticycloniques (Fig.1). Et plus généralement dans la Méditerranée occidentale, où au cours de l'année, on observe des structures tourbillonnaires de taille moyenne dans la partie Nord, et des gyres de taille variable dans la partie sud.

La variabilité saisonnière

La variabilité saisonnière du transport est observée aux détroits avec un transport maximal en hiver.

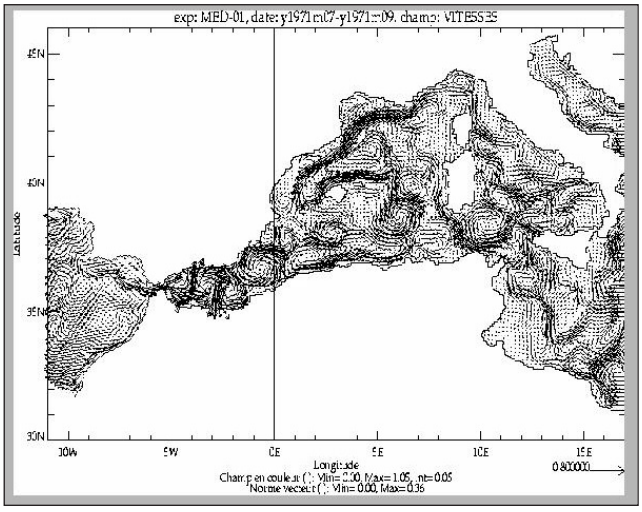

Fig. 1. Courants moyens de surface en été en Méditerranée occidentale pour l'année 11 du modèle.

Conclusion

Onze ans de simulation de la circulation méditerranée ont été effectués avec un modèle à une très haute résolution. Les résultats sont encourageants surtout en ce qui concerne la dynamique et la variabilité saisonnière.

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ANOMALIES DANS L'EAU PROFONDE DE MEDITERRANEE OCCIDENTALE EN 1999 ET 2000, VARIABILITE DEPUIS 1970.

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Résumé

La série hydrologique acquise en mer Ligure entre 1993 et 2000 a permis: 1- de suivre la hausse des température et salinité observée depuis 1959; 2- de mettre en évidence en juin1999 des anomalies profondes de température, salinité et turbidité; 3- de les relier au cascading d'eau dense observé en février 1999 dans le Rech Lacaze-Duthiers. D'autres campagnes océanographiques ont permis de suivre l'extension des anomalies de température et salinité à l'échelle du bassin Algéro-Provençal, et de les observer à nouveau, fortement diminuées, en juin 2000 en mer Ligure.

Mots clés : Western Mediterranean, Deep Waters

Méthode et résultats

Depuis 1994, trois stations hydrologiques (CTDO2, rosette) ont été faites chaque année, entre 40 et 70 milles au large de Nice (station 1 : 42°50N, 07°29E; station 2 : 42°41, 07°54 ; station3 : 42°32, 07°15), pour surveiller la variabilité inter-annuelle des eaux profondes (1, 2) et l'évolution des augmentations de température et salinité précédemment mises en évidence (3). Alors que les profils verticaux de température potentielle et salinité dans l'eau profonde (à plus de 1000m de profondeur) se sont révélés réguliers, c'est-à-dire continuellement décroissants avec la profondeur entre 1994 et 1998, les profils acquis les 15-16 juin 1999 aux stations 1 et 3 ont présenté des anomalies, à savoir des augmentations de température et salinité de 2400m jusqu'au fond, à plus de 2760m. Inversement les profils à la station 2 (la plus à l'est) ne montraient pas d'anomalies. Un diffusiomètre monté sur la CTD a de même montré des augmentations de turbidité concomitantes aux augmentations de température et salinité aux stations 1 et 3. Ces anomalies concernent la nouvelle eau dense formée en hiver (février, mars 1999), puisqu'elles n'ont pas été observées en juin 1998, et la turbidité est le signe d'une formation à proximité des côtes. Dans le canyon Lacaze-Duthiers du golfe du Lion, les enregistrements à 500 et 1000m de profondeur ont montré une accélération des courants, jusqu'à 60 cm/sec, et une diminution de température de près de 1°C entre le 14 février et le 12 mars 1999, alors que sur la période 1994-1998 aucune anomalie similaire n'avait été enregistrée. Diminution de température et forts courants sont la signature d'un cascading d'eau dense, tel que précédemment décrit (4, 5), avec entraînement de particules (6). Ce processus de formation d'eau dense peut être relié à un automne-hiver particulièrement venteux, et à une tempête entre le 26 janvier et le 23 février 1999, le vent restant compris entre 16 et plus de 25 m/sec. (données de Météo-France). Dans l'hypothèse où les anomalies de température, salinité et turbidité découvertes en mer Ligure proviennent de ce cascading d'eau dense dans le canyon Lacaze-Duthiers, la vitesse de propagation de cette eau dense est de 3,5 cm /sec pour atteindre les stations 1 et 3 les 15-17 juin 1999 et n'avoir pas encore atteint la station 2. En début juillet, la campagne MATER à bord du bateau de recherche grec *Aegaio* découvrait les anomalies de température et salinité dans les eaux profondes de part et d'autre de l'île de Minorque (7). Les 15-17 septembre, la campagne française PROSOPE détectait l'anomalie par 38°N, 3°50E, mais ne la trouvait pas ni en mer d'Alboran ni à proximité du canal de Sardaigne. A nouveau une vitesse d'écoulement de l'anomalie de 3,5 cm/sec peut être calculée depuis le point source hypothétique, le canyon Lacaze-Duthiers, et la date du 14 février. Une dernière station de la mission PROSOPE au début d'octobre 1999 attestait la présence de l'anomalie au large de Nice et donc son extension à toute la mer Ligure.

Les trois stations de l'années 1999 ont été répétées les 3-5 juin 2000, complétées d'une station 4, située plus à l'ouest (42°20N, 6°40E). Des anomalies de température et salinité y ont été observées, très faibles aux stations 1 et 2, plus fortes aux stations 3 et 4, mais cependant réduites d'un facteur 5, à la station 3 par rapport à celles de l'année 1999. L'absence d'enregistrement de forte anomalies de température et courant par les capteurs mouillés dans le Rech Lacaze-Duthiers au cours de l'hiver 1999-2000 ne permet pas l'hypothèse d'un cascading d'eau dense. En conséquence, les anomalies hydrologiques observées en mer Ligure en juin 2000 sont le souvenir estompé des anomalies propagées au cours de l'année 1999.

A partir des anomalies hydrologiques, on peut calculer une première estimation du volume d'eau dense formée par le cascading qui s'élève à $2{,}2 \times 10^{12} m^3$, en 1999. Ceci ne correspond qu'à environ 4% du volume total de formation annuelle d'eau profonde ou du flux profond sortant au détroit de Gibraltar (soit $50 \times 10^{12} m^3$/an), ce qui prouve que le processus majeur de formation d'eau profonde se situe dans la zone hauturière MEDOC (8). Par contre, la découverte de l'anomalie de turbidité associée aux anomalies de température et salinité prouve un transport horizontal de matière, probablement important pour la géochimie des eaux profondes (6). Une synthèse des données hydrologiques historiques permet de détecter quatre épisodes d'anomalies hydrologiques des eaux profondes, en 1971, 1980, 1988 et 1999 et donc un possible transfert itératif de matière du plateau continental à l'ensemble du bassin Algéro-Provençal, tous les 8 à 11 ans.

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MECHANISM FOR NEW DEEP WATER FORMATION IN THE AEGEAN SEA

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Abstract

We analyse whether the observed newly formed deep water in the Aegean Sea could be formed locally by the combination of an increase in net evaporation and wintertime water mass transformation. With a simple mixed layer model, we show that an effective increase in net evaporation slowly increases the depth average salinity and decreases the stratification in the Aegean Sea until a severe winter leads to deep convection and new bottom water formation. We argue that the increased amount in net evaporation over the Eastern Mediterranean basin is due to river diversion projects in Russia and Egypt since the 1950´s.

Keywords : Aegen sea, water convection, air-sea interaction, depp-waters.

Introduction

In an experiment to examine wintertime water mass conversion in the Aegean Sea, Charnock and Miller made pre-winter hydrographic stations in October 1961 aboard R/V *Chain* and post-winter stations in March 1962 aboard R/V *Atlantis II*. In 1961-62 the deep water in the Aegean Sea had potential temperature of 14.15°C and salinity of 38.95‰ with a potential density anomaly of 29.25 kg m^{-3}. For both the October and March profiles, the deep water is separated from the surface waters above 500 m depth by lower salinity (38.75‰) called Transition Mediterranean Water by Theocharis et al.[1].

In September 1987 *Meteor* surveyed the Eastern Mediterranean including full-depth profiles in the Aegean Sea. In 1987 the deep water properties in the Aegean were effectively the same as in 1961-62. Notably, the 1987 profiles show a near absence of the low salinity TMW as the minimum intermediate water salinity is about 38.9‰, much higher than the TMW salinity of 38.75‰. Comparison of September 1987 and October 1961 and March 1962 depth-averaged salinities shows an increase in salinity of 0.03‰ to 0.05‰, which would be equivalent to a local net evaporation of 1.5 m to 2.5 m or an average extra net evaporation between 6.3 and 10.7 cm yr^{-1}.

In January 1995, Roether *et al*. [2] made another *Meteor* cruise to survey the modern deep water properties of the eastern Mediterranean. Remarkably, newly formed deep water was found in the Aegean Sea and it was spilling over the connecting sills and spreading out into the deep eastern Mediterranean basins [2]. The new deep water is about 0.2°C colder, 0.12‰ saltier and 0.13 kg m^{-3} denser than the deep water of 1961-62 or 1987. The structure of the vertical stratification, however, had returned to 1961-62 conditions with the reappearance of low salinity intermediate waters (TMW).

Modelling

We develop a simple mixed layer model where the initial profiles are taken to be the March 1962 observations of temperature and salinity (and hence density) versus depth linearly interpolated to 20 m intervals down to 2350 m. In time steps of one year, a net evaporation of 10 cm of freshwater is imposed on the uppermost 20 m layer. We run the model for 25 years, removing a net evaporation of 10 cm yr^{-1}. Then we continued to run the mixed layer model in monthly time steps using monthly anomalies of e-p and air-sea heat exchange anomalies from the SOC climatology [3] from March 1987 to December 1995. In addition we continue to remove a net evaporation at a rate of 10 cm yr^{-1} (0.83 cm $month^{-1}$).

Within the model, deep convection had reached 1950 m depth in March 1987. By March 1988, the entire water column is mixed with a bottom salinity of 38.99‰. After the winters of 1991-92 and 1992-1993 when large wintertime heat and freshwater losses occur over the Aegean, the deep water becomes colder as well as saltier. As a result of mild conditions in 1993 and 1994, no new deep water is found in March 1994 or in March 1995. By 1995, the deep water in the model has a salinity of 39.01‰ and a potential temperature of 14.05°C. The model deep water has cooled by 0.11°C and become saltier by 0.04‰ over the 8 years from 1987 to 1995.

Discussion and Conclusions

The model shows how persistent long-term changes in net evaporation can slowly change the stratification in the Aegean basin until suddenly deep water formation occurs during a severe winter. We attribute the observed increase in depth-averaged salinity from 1961-62 to 1987 to the increase in net evaporation following river diversion for irrigation in Russia and Egypt [4].

The formation of new deep waters in the Aegean is therefore a result of the two processes: a long, slow increase in the salinity due to changes in the water budget and then a catastrophic deep water formation event during a suitable cold, dry winter. The presence of low salinity intermediate waters in 1995 while the newly formed deep waters are still flowing out of the Aegean over the sills into the deep eastern Mediterranean [5] strongly suggests that deep water will not be formed again for several years in the Aegean. On the basis of observations and understanding to date, it appears that salinity initially increases near to where the water balance has changed; salty deep water is then formed in a local deep basin which then spills out over the sills spreading into the greater deep basin; within the local basin the outflowing dense waters are replaced by lower salinity waters which then shut off deep water formation. The cycle may repeat: we eagerly await new observations of the next stage as the Mediterranean becomes saltier and new model simulations brave enough to predict what will happen next.

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HYDROGRAPHIC AND CIRCULATION PROPERTIES IN THE CRETAN SEA FROM THE M3A DATA

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Abstract
The sub-inertial variability of hydrological and circulation properties in the Cretan Sea is studied, using upper thermocline data from a prototype multi-parametric ocean observing system. The EOF analysis indicates a highly coherent and barotropic variability of temperature (T) and salinity (S) during the winter period. The two parameters are less correlated during spring and more variance is explained by higher modes, probably as a result of the developing stratification. The baroclinicity of the flow field is also increased during spring indicating a decoupling between the upper 300m and the deeper layers. Finally, the T and S variability is partially explained by advective processes with stronger coherence at the synoptic time scale.

Key-words: temperature, salinity, currents, time-series, Cretan Sea

Introduction

Current, T and S time series obtained at M3A buoy site (Mediterranean Moored Multi-parametric Array) make part of an extensive multidisciplinary monitoring in the southern Cretan Sea, which has been conducted almost continuously since March 2000 within the framework of MFSPP (Mediterranean Forecasting System Pilot Project). The buoy is situated in an area characterised by the presence of quasi-permanent anti-cyclonic and cyclonic gyres [1].

A sub-inertial variability of the three properties within a 400 m water column for the two time intervals as indicated below, is summarised using an EOF (Empirical Orthogonal Function) analysis.

Data and methods

T and S are measured at three levels: at nominal depths of 40, 65 and 115 m below the surface. Current measurements are obtained every 10m from an upward looking 75 KHz ADCP, and sub-sampled at 11 levels, unequally spaced in the range between 45 and 445 m. Original data, collected every three hours, are smoothed by a moving average in order to filter out high-frequency (daily) variability. EOF analysis has been applied to a normalised data, which were organised into two sets: the first contains all meridional current component (north-south) of 11 levels and the other consists of T and S at the three depths. The main reason that only meridional (v) component is included lies in the fact that the mooring is presumably located in the boundary region between Cretan cyclonic and anticyclonic gyres primarily characterised by the north-south flow (Fig.1). The investigated time series is divided into two parts: part A related to the period Apr. 15 - May 14 and part B relative to the period May 18 - Jun. 30.

Results and Conclusions

For period A, the principal characteristics of the EOF eigenvectors (Table 1) show the prevalence of a barotropic structure, especially between 65 and 355 m (with 81% of the total variance [t.v.] explained), and a variability of the T and S being coherent at all three depths (72% of the t.v.). The second mode of the v component (8%) exerts baroclinic-like variability: upper layer (down to 360 m) is out of phase with respect to a lower one (below 360 m), while that of the TS (18%) reflects primarily T variability at 40 m i.e. at the level of the seasonal thermocline.

Table 1 – EOF eigenvectors and t. v. explained for the v-current component and the TS during period A.

MODE	t.v.	Depth (m)										
	(%)	45	65	95	115	155	255	325	355	375	405	445
1	81	0.28	0.31	0.31	0.32	0.32	0.32	0.31	0.30	0.30	0.29	0.24
2	9	-0.45	–0.24	–0.19	–0.18	–0.15	–0.14	0.01	0.30	0.30	0.26	0.63

For period B (Tables 2), the first mode of the v component (84 %) resembles the structure observed during period A. For the T and S parameters the most important features are reflected in the first and the third modes. The structure of the first TS mode is again characterised by a relatively coherent variability of the T and S along the water column, while the total variance explained is much lower (56 %) than during period A. The third mode is probably associated to the vertical mixing which induces the increase of the water temperature in deeper layer and the out-of-phase behaviour of the surface water temperature.

A comparison of the amplitudes of the modes and time-series of both T and S data (not shown here) indicates that the peaks of the first TS mode mainly correspond to a temporary increase of both temperature and salinity, probably due to some advective processes or downwelling. In order to determine to which degree the variability of the hydrographic properties is linked to a variability of the current field, a correlation coefficient between current and TS modes has been calculated (Table 3). Relatively significant correlation coefficients indicate a wide variety of their possible interconnections. The correlation between the first mode of the v current (V1) with either first or second TS mode for both periods, indicates that an increase in a northward flow is associated with a decrease of T and S at all three levels. In other cases the same increase of the flow is coherent with an increase of temperature at the thermocline depth and a decrease of it below that layer. The baroclinic-like mode (V2) is significantly correlated only with the first TS mode (TS1).

Table 2 – EOF eigenvectors and t. v. explained for the v-current component and the TS during period B.

MODE	t.v.	T/S Depth (m)					
	(%)	T-40	T-65	T-115	S-40	S-65	S-115
1	72	0.04	0.44	0.44	0.43	0.46	0.46
2	18	0.94	0.23	–0.10	0.08	–0.15	–0.14

Table 3 – Correlation coefficient between the v component EOFs' (V1 and V2) and TS EOFs' (TS1, TS2, and TS3).

MODE	t.v.	Depth (m)										
	(%)	45	65	95	115	155	255	325	355	375	405	445
1	84	0.29	0.29	0.31	0.31	0.31	0.32	0.32	0.30	0.30	0.29	0.29
2	13	-0.34	–0.40	–0.30	–0.26	–0.20	–0.02	0.18	0.31	0.32	0.36	0.38

Table 4 – EOF eigenvectors and t. v. explained for the TS during period B.

MODE	t.v.	T/S Depth (m)					
	(%)	T-40	T-65	T-115	S-40	S-65	S-115
1	56	0.33	0.41	0.44	0.42	0.40	0.45
2	19	-0.25	–0.06	–0.46	0.53	0.58	–0.33
3	17	-0.67	–0.47	0.34	0.03	0.15	0.44

Table 5 – Correlation coefficient between the v component EOFs' (V1 and V2) and TS EOFs' (TS1, TS2, and TS3).

	Period A	Period B
V1 : TS1	- 0.28	- 0.20
V1 : TS2	0.30	- 0.10
V1 : TS3	-	- 0.16
V2 : TS1	- 0.34	0.17
V2 : TS2	0.01	0.02
V2 : TS3	-	- 0.03

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SOME RESULTS FROM THE AUTOMATIC METOCEAN STATION SPLIT MARJAN-CAPE

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Abstract
From the data measured in 10-minute intervals from March 1999 to February 2000 basic statistics of 10 meteorological and oceanographic parameters were calculated.

Key words: Automatic Metocean Station Split, Adriatic Sea, undersampling error

Introduction

The data from the station situated at the entrance at the Kastela Bay have a special meaning for studying the processes in the Bay, especially for defining boundary conditions for the dynamic model initialisation. Therefore, the Institute of Oceanography and Fisheries (IOF) maintains the station, which worked since fifties. The data set became long enough [1,2,3] for climatic variability studies, especially when assembled with other data [4,3]. Long-term data set from the permanent station consists of discrete measurements, acquired by classical met-ocean instrumentation. Keeping up with GOOS (IOC-UNESCO'S program Global Ocean Observing System) recommendation for automatic metocean measurements, advanced measurements techniques and data transmission methods have been introduced in addition to the classical metocean measurements.

Material and methods

Coastal oceanographic station Split Marjan-Cape established in 1946 in front of the main building of the IOF at the entrance of the Kastela Bay, works since 1950, as well as the classical tide-gauge Kepmen with 1:5 reduction. Sea temperature is measured at 0m and 2m, with classical thermometer in the first two climatological terms: 7h and 14h local time. Samples for the salinity determination are taken twice weekly. Meteorological station, established in 1951 (fixed meteorological screen and rain-gauge) is located 25m form the coast, at the 12m altitudes. The thermograph (SIAP) measures continuously, while minimal, maximal and actual temperatures are recorded at 7h (local time), as well as daily precipitation sum. Based on the General Purpose Data Acquisition System [5], the real-time data transmission has been realized in March 1999 through the Internet web page www.izor.hr [6], from the experimental automatic metocean station (AMOS), which utilizes Aanderaa instruments sensors. AMOS measures wind (direction, speed and gust), air and sea temperature, humidity and pressure, precipitation, radiation (solar and net), salinity, and sea level. For all the measured parameters monthly means and variances were analysed. Because of the specific location relative to the coast, wind speed and direction are not always representative for the larger area; the winds from the southeast to northeast direction show considerably lower speeds (relative to the first order meteo-station Split-Marjan). Sea temperature and salinity were measured at 0.5m depth and are considered the sea surface measurements, and other parameters were measured at 10m altitude, acquired in ten minutes intervals, but hourly values were taken for calculations.

Results and discussion

Based on the hourly values, daily means were calculated for all the measured parameters (Fig.1). There were some interruptions of measurements, due to electricity breaks, or other malfunctions. In spite of occasional short breaks and four breaks of measurements longer than a day, and malfunctions of some sensors in some shorter intervals, the overall work of the AMOS could be considered successful. The sea surface daily mean temperature (Fig. 1C), compared to the daily mean air temperature (Fig. 1A) showed that sea surface temperature was higher from September through March, while air temperature was higher in the rest of the year.

Relative humidity (Fig. 1E) showed very high variability. The highest variability was observed from December 1990 to February 2000. It varied in the range from 25-90 %, while the mean value was 61%. Salinity (Fig. 1F) ranged from 29.82 - 37.51 psu, showing occasionally strong pulses of fresh water in fall and winter months, brought in the Kastela Bay by Jadro River. The longer duration of fresh water intrusions occurred in spring season. During most of the 1999, precipitation sensor was out of work, so only data for period January, 2000-November, 2000 were plotted. Very high monthly precipitation sum occurred in November 2000 as a result of unusual weather conditions over Europe. Sea level records were compared to the classical tide-gauge data showing equivalent response of sea surface elevation (not shown). This reflects seasonal heating/cooling processes. The difference between the two temperatures was highest in January (5ºC). Fluctuations (not shown) within one month, reached about 10ºC, for the air temperature, while sea surface temperature within one month didn't change more than 5ºC. The strongest winds (not shown) from N and NE were observed in winter season, however the northward direction was predominant in all the seasons. It is rather peculiar that characteristic summer winds from W directions were not so energetic.

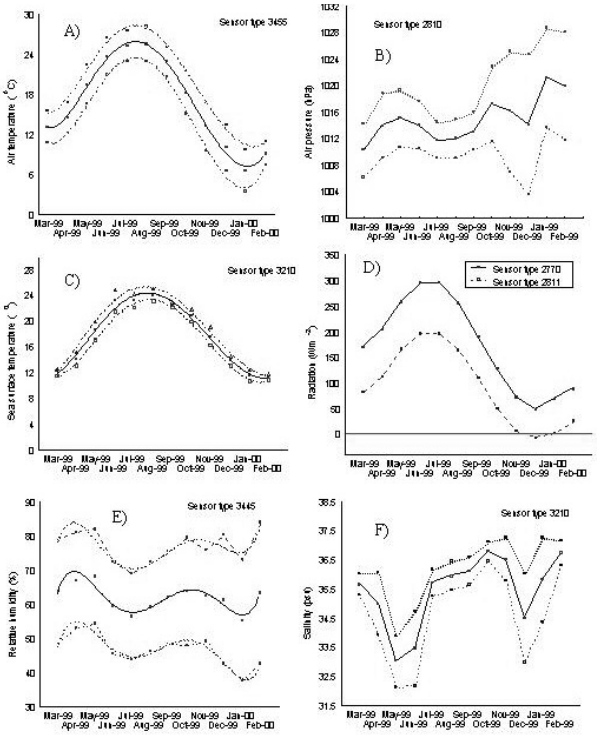

Figure 1. Monthly means and monthly variances for the period March, 1999 - February, 2000 for A) air temperature; B) air pressure; C) sea temperature; D) radiation; E) relative humidity; F) salinity.

Conclusions

The statistical output, based on hourly values of all parameters, calculated first time for a station at the eastern Adriatic coast, matched with data on the monthly scale obtained from a half century long classical measurements at Marjan-Cape station.

Continuous measurements of relevant parameters by AMOS minimise the undersampling error, which impact on output results gathered from classical measurements.

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A ONE-WAY NESTED HIGH RESOLUTION CIRCULATION MODEL IN THE MALTA CHANNEL

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Abstract

A high resolution (1.2Km) eddy-resolving 3D prognostic numerical model based on the Princeton Ocean Model (POM) is used to simulate the seasonal circulation in the Malta Channel with perpetual year "climatological" forcing and with one-way nesting to an intermediate coarser resolution model (5Km) implemented over the Sicilian Channel area. The coupling between the two models is explained. The general results of this experiment are presented to assess the performance of the model.

Keywords: coastal models, circulation, Sicilian Channel

Introduction

One of the activities within the Mediterranean Forecasting System Pilot Project (MFSPP) consists in developing techniques and nested models to downscale the hydrodynamics to the shelf areas of the Mediterranean Sea [1]. The strategy is to downscale the large scale Ocean General Circulation Model (OGCM) (≈12.5Km resolution) flow field into an intermediate model with 5Km resolution. This intermediate model is implemented in the Sicilian Channel area [2]. The flow field from the intermediate model is further downscaled to the Malta shelf area with a resolution of 1.2Km. Both the intermediate and shelf model implementations are based upon the Princeton Ocean Model [3]. POM is a free surface, baroclinic, sigma-coordinate model that uses a time splitting technique to solve the depth integrated and the full 3D equations with different time steps. The vertical eddy viscosity/diffusivity parameters are calculated by an embedded 2nd moment turbulence closure [4]. The horizontal grid uses an 'Arakawa C' differencing scheme.

Model set up

The shelf model is implemented in the area spanning 13.8°E to 15°E longitude and 35.45°N to 37.1°N latitude, with a spatial resolution of 1/60° x 1/60° (71 x 107 grid points) and 15 sigma layers (bottom following) with logarithmic distribution near the surface. The model is closed at the northern boundary by the Sicilian coast and open at the western, southern and eastern boundaries. The average computational grid size is 1493m along latitude and 1853m along longitude. The U.S. Navy Digital Bathymetric Database 1 (DBDB1) with a 1/60° x 1/60° resolution is used for the computation of depth at each grid cell using bilinear interpolation. The maximum depth of 1054m to the SW of Malta limits the external courant time step to 4s. The shelf model is initialised from rest with T/S fields from the intermediate model.

Surface boundary condition

The monthly mean surface fluxes are taken from the climatological atmospheric forcing data set derived from the ECMWF Re-Analysis data set (ERA) for the period January 1979 to December 1993, initially mapped on a regular grid with a horizontal resolution of 1 degree for the Mediterranean Sea. The adopted momentum, heat and salt surface boundary conditions are:here τ is the wind stress, Qsol is the solar radiation, Qup

$$k_M \frac{\partial \dot{u}}{\partial z}_{\eta=0} = \frac{\dot{\tau}}{\rho} k_H \qquad \frac{\partial T}{\partial z}_{\eta=0} = \frac{(Q_{sol} - Q_{up})}{\rho C_p} + \frac{C_1}{\rho C_p}(T^* - T)$$

$$k_H \frac{\partial S}{\partial z}_{\eta=0} = S(E - P) + C_2(S^* - S)$$

is the upward heat flux, r is the density and Cp is the specific heat capacity at constant pressure. The heat and salt fluxes are relaxed to the monthly climatology given by the Med-6 data set, using a flux correction term with C_1=25W/m^2 °C and C_2=0.7m day^{-1} respectively. T* and S* are the monthly averaged climatological sea surface temperature and salinity, while T and S are the model first level temperature and salinity, respectively. The relaxation is that proposed by Zavatarelli *et al*. [5].

Lateral boundary conditions

The open boundary conditions are provided through one-way nesting to the Sicilian Channel Intermediate Model. The nesting of temperature, salinity and velocities (total and barotropic) is necessary in order to transfer values from the coarsely spaced grid to the finely spaced grid at the location of boundary region. The grid nesting ratio is 3. The ten-days averaged fields from the intermediate model are interpolated in space over the higher resolution grid and linearly in time at each time step through an off-line, one-way nesting. The internal and external normal velocities to the boundary are directly specified from the coarse resolution model. The tangential component velocities at the boundary are set to zero. In this specification the mass transport at the open lateral boundary is constrained to be equal to that prescribed from the coarse model at each respective open boundary
where U is the coarse grid total velocity field, U is the interpolated velocity field, hcoarse and hhigh are the respective bathymetries of the coarse and high resolution grid model. The free surface elevation is not nested (zero gradient boundary condition), while an upstream advection is used for temperature and salinity:

$$\int_{l1}^{l2}\int_{hhigh}^{\eta} U_{total}^{high}\,dl\,dz = \int_{l1}^{l2}\int_{hcoarse}^{\eta} U_{total}^{coarse}\,dl\,dz$$

$$\frac{\partial (T,S)}{\partial t} + U\frac{\partial (T,S)}{\partial x} = 0$$

In the case of outflow through the open boundaries, temperature and salinity are prescribed from the coarse model.

Results

The ability of the model to reproduce a realistic circulation of the Siculo-Maltese shelf area is briefly examined. The main general circulation patterns are well reproduced with seasonal variability in both spatial extent and flow intensities. The model replicates the results of the intermediate model with additional mesoscale detail. This is exemplified by the velocity and temperature fields plotted in superposition for January and July in Fig.1 at 5m. During winter the temperature field is characterised by a sharp line of demarcation running in a SSE direction parallel to the axial orientation of the Maltese Islands. This is corroborated by satellite thermal infra-red images of the area. The surface velocity field is dominated by the Atlantic Ionian stream which is present throughout the year with significant seasonal modulation. During winter it follows closely the Sicilian coast up to 14.4°E longitude after which it detaches in a SE direction following the bathymetry. During summer this flow intensifies in magnitude and horizontal extent carrying a streak of relatively fresh water along its main axis; it spreads southwards and engulfs and flows around the Maltese Islands. The stream is accompanied by a persistent cyclonic pattern south of the eastern tip of Sicily which is enhanced during summer and occurs in association to density gradients produced by the intrusion of more saline water from the Ionian. At 280m the circulation is dominated by the westward flow of LIW to the south of Malta. This flow is most intense during winter and becomes slightly cooler during summer.

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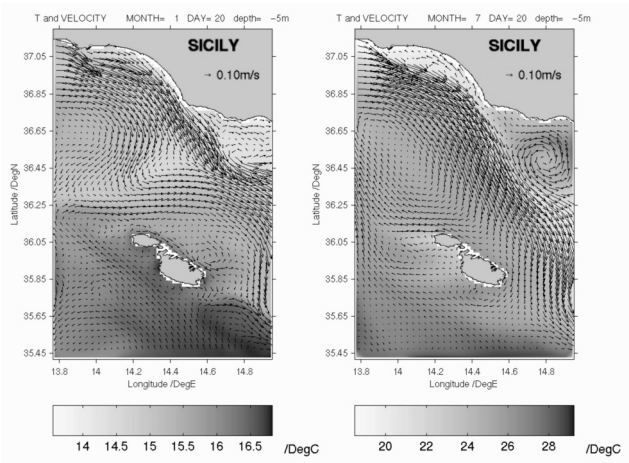

Figure 1. Model velocity and temperature at 5 mn during (a) winter, and (b) summer.

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ATMOSPHERIC INPUT OF INORGANIC NITROGEN TO THE ADRIATIC SEA

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Abstract

In order to study atmospheric transport of pollution to the Croatian Adriatic coast, cluster analyses of isenthropic backward trajectories, together with mean pH and nitrogen compounds precipitation concentration and wet deposition, for one-year period were calculated. In that particular year west flow was predominant. Adriatic coast is under the combined influence of local, regional and long distant pollution sources. The influence of local and regional pollution sources prevail on average, but the influence of long distant sources can not be neglected.

Keywords: Adriatic Sea, eutrophication, trajectory analyses.

The influx of man-made nutrients in the form of inorganic nitrogen compounds to coastal areas may result in the long-term decline of marine life. Some undesirable events occurred in the Adriatic Sea in the past decades: invasions of jellyfish and other species, hypertrophic formations of mucilaginous aggregates, and an increased frequency of toxic dynoflagellate appearance (1). Atmospherically derived dissolved inorganic nitrogen (NO_3^- + NH_4^+, components of acid rain) contributes 25-35% of total loading of this primary nutrient (2,3,4). Model calculations show that approximately 80% of nitrogen compounds comes to Croatia from neighbouring countries, while about 70% of nitrogen from Croatian sources is deposited in Croatia (5,6).

Computation of air parcel trajectories is a very powerful tool to estimate the long-range transport of substances. To study atmospheric transport to the northern, mid and southern Adriatic coast, 72-hours backward isentropic trajectories were computed for three locations, from 10 m asl once a day, beginning at 00 UTC, for the one year period October 1998 - September 1999. HYSPLIT4 (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model (7), developed in NOAA Air Resources Laboratory (http://www. arl.noaa.gov/ready/ hysplit4.html) was used. Cluster analyses of trajectories in days with precipitation was made using cluster program developed by Stunder (8). For each cluster volume-weighted average pH value, nitrate and ammonium concentrations and wet deposition were calculated.

The main differences between cluster-mean trajectories are in their length and direction, depending specially if trajectories come from inland or sea. At all three stations there are short (50-400 km), medium (50-400 km), long (1500-2500 km) and very long (2000-5000 km) cluster-mean trajectories. Short trajectories, representing local and regional pollution transport, are very frequent (about 50% of all) during all seasons. They are connected with zero pressure gradient field, typical for summer, or the case of stationary low pressure field over the north Adriatic. Characteristics of those situations are weak winds of variable direction, maximum turbulent vertical exchange in summer, but very stable conditions with temperature inversions and no mixing in winter. Direction of short trajectories depends on location, but more frequently they come from inland in warm part of the year and from the sea in cold part of the year. The main characteristic of SW and W cluster-mean trajectories is crossing over the Mediterranean Sea and coming to the measurement site from the sea side. They are connected mostly with Genoa low pressure field. The region they cross over is not very polluted, so they do not bring a lot of anthropogenic air pollution. Those clusters contain sometimes several trajectories from Sahara, bringing Saharan dust to the Adriatic.

From NW-W come long and very long trajectories. In those situation southwest Europe is under the high pressure field, while northeast under the low pressure. Strong wind is mainly connected with frontal passages and fast advection of cold air over the warm land. Trajectories cross over the sea with natural sulphur emission (affecting chemical composition of precipitation, specially pH) with significant part of their length. They also cross over the west and northwest Europe with high anthropogenic pollution emission.

Most of trajectories are curved and very often the main direction of the cluster differs from the direction of its incoming to the site. Local and regional conditions (meteorological, and specially orographic) cause turning of general west and northwest airflow, which is the most common for Croatia, to local northeast. This analyses is made for one particular year. The conclusions cannot be generalised. However, they agree with similar investigation for the GAW regional station Zavizan (9) and for several other stations in Croatia (10).

In precipitation days about 65% o trajectories on the northern, 71% on the mid and 78% on the southern Adriatic come from western quadrant (Fig. 1). On average the most acid is precipitation connected with short or medium long trajectories from west, which are more or less curved before reaching the monitoring station (Tab. 1). Those trajectories bring the greatest amount of nitrate wet deposition to the northern and mid Adriatic coast. Air mass belonging to those cluster-mean trajectories circulates over industrial developed, anthropogenic and natural polluted European regions, northern Italy, Mediterranean and northern Adriatic (Kvarner Bay). The highest ammonium wet deposition at the northern Adriatic is connected with short trajectories from SE (inland sources), while at the mid Adriatic from S-SW (across the sea). On the southern Adriatic wet deposition of both nitrogen compounds is the greatest connected with short NW trajectories (inland), although they bring only 15% of total precipitation amount. Concentration of nitrate and ammonium ions could be very high in precipitation coming from very distant sources from NW or N, because of the high anthropogenic pollution in NW Europe (11). It seems that Adriatic coast is under the combined influence of local, regional and long-distant pollution sources. On average, higher nitrogen concentrations were found in weather situations reflecting local and regional pollution source influence, with frequency of about 20% of time giving cca 20% of total precipitation amount. However, higher individually concentrations were connected with weather situations reflecting mainly distant source influence which frequency is about 45% of time and gives 60% of total precipitation amount.

Table 1. Characteristics of wet deposition in different trajectory clusters on the Adriatic coast, for the period Oct. 1998. to Sept. 1999. (N = number of trajectories; Σ RR = total precipitation amount in cluster (mm); pH_{vw} = prec. volume-weighted average pH; $(NO_3^-N)_{vw}$ = prec. volume-weighted nitrate concentration (mg/l); $(NH_4^+N)_{vw}$ = prec. volume-weighted ammonium concentration (mg/l); Dep.NO_3 = nitrogen wet deposition from nitrates (g/m^2); Dep. NH_4 = nitrogen wet deposition from ammonia (g/m^2); numbers in brackets indicates only one or two samples).

	Northern Adriatic								Mid - Adriatic					
Cluster	short	S	W	SW	NW_l	NW	N	NW_{vl}	short NE	short SW	NW_l	NW	NW_{vl}	W
N	31	28	22	12	5	6	10	2	29	29	11	26	4	1
S RR (mm)	428.3	500.9	223.9	157.3	54.1	13.6	38.6	3.8	108.8	227.6	127.3	293.2	15.8	0.4
pHvw	5.39	4.98	5.47	5.41	5.33	6.70	6.10	6.10	6.4	6.3	6.1	5.7	6.7	7.8
(NO_3^-N)vw	0.86	1.06	0.68	0.75	0.70	(2.2)	0.79	(1.4)	0.94	0.85	0.72	0.74	0.70	/
(NH_4^+N)vw	0.91	0.67	0.87	0.61	0.48	(2.2)	0.81	(1.2)	0.48	0.57	0.73	0.40	0.54	/
Dep. NO_3 (g/m^2)	0.37	0.53	0.15	0.12	0.04	0.03	0.03	0.005	0.10	0.19	0.09	0.22	0.01	/
Dep. NH_4 (g/m^2)	0.39	0.33	0.20	0.10	0.03	0.03	0.03	0.004	0.05	0.13	0.09	0.12	0.01	/

	Southern Adriatic								
Cluster	short NW	short S	E	E_l	W	SW	NW	NW_l	$NW-N_{vl}$
N	15	17	17	3	13	6	7	8	3
S RR (mm)	143.9	164.6	203.9	34.2	151.5	107.4	58.3	55.4	15.3
pHvw	6.06	6.23	5.76	5.85	5.74	6.50	5.97	6.38	6.38
(NO_3^-N)vw	1.28	0.95	0.41	(0.4)	0.75	0.92	1.07	0.76	1.51
(NH_4^+N)vw	3.79	0.82	0.47	(0.2)	0.66	1.12	1.66	0.42	1.12
Dep. NO_3 (g/m^2)	0.184	0.156	0.084	0.014	0.114	0.099	0.062	0.042	0.023
Dep. NH_4 (g/m^2)	0.545	0.135	0.096	0.006	0.099	0.120	0.097	0.023	0.018

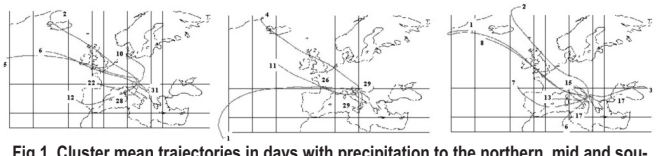

Fig 1. Cluster mean trajectories in days with precipitation to the northern, mid and southern Adriatic coast, in the period October 1998 – September 1999 (number at the end of cluster-mean trajectory indicates the number of belonging single trajectories).

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WISE 2000: CAN WE MEASURE SALINITY FROM A SATELLITE ?

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Abstract

Satellite observation of ocean salinity has not been possible until now due to the challenge of flying a microwave radiometer able to detect sea surface emission variations related to salinity. The European Space Agency SMOS mission is the first attempt to solve this problem. A new radiometric concept and recent improvements in understanding the processes that modify the ocean water emissivity have made it possible. The WISE 2000 campaign has been conducted in the NW Mediterranean to obtain radiometric and in situ data to improve the understanding of the sea state effect on the sea surface L-band microwave emissivity.

Key-words: remote sensing, salinity, instruments and techniques, air-sea interactions

Introduction

Significant progress in terms of weather forecasting, climate monitoring and extreme event forecasting has been made during recent years using sophisticated models fed amongst others by data acquired by operational satellites. However, further significant improvements now depend to a large extend on the availability of global observations of two crucial variables, Soil Moisture (SM) and Sea Surface Salinity (SSS). To date this information is lacking because in situ measurements are far from global, and so far no SM and SSS dedicated, long-term space mission has been attempted.

This situation led to the formulation of the Soil Moisture and Ocean Salinity (SMOS) mission, the European Space Agency's second Earth Explorer Opportunity Mission planned for launch in 2005. The SMOS mission was proposed by a team of scientists from 10 European countries and the United States of America, gathering most of the available expertise in the related fields. The main objective of the SMOS mission is to demonstrate the observation from space of SSS over oceans and SM over land using a common instrument: a microwave L-band two-dimensional interferometric radiometer. It uses a synthetic antenna very thin as compared to an equivalent real one [1].

Material and methods

The dielectric constant for seawater is determined, among other variables, by salinity [2]. In principle it is possible to retrieve SSS from microwave measurements as long as variables influencing the brightness temperature (TB) signal (SST, roughness, foam,) can be accounted for e.g. by the use of different viewing angles, polarisations and frequencies, as well as ancillary data from other sensors and sources. The sensitivity of TB to SSS is maximum at low microwave frequencies and the good conditions for salinity retrieval are found at L-band (1.4 GHz, 21cm wavelength). However, it must be stressed that at this frequency the sensitivity of TB to SSS is low (0.5K per psu for an SST of 20∞C, decreasing to 0.25K per psu for an SST of 0∞), placing demanding requirements on the performance of the instrument [3].

To address new challenges that this mission presents, such as incidence angle variation with pixel, polarization mixing, effect of wind and foam and others, a measurement campaign (WISE 2000: WInd and Salinity Experiment) was sponsored by ESA for autumn 2000. The objective was to perform, for the first time, radiometric measurements of the sea surface from a fixed tower at different azimuth and incidence angles during a long period to allow the occurrence of different environmental (mainly wind and water temperature) conditions. Some airborne campaigns with L-band radiometers had taken place in the US [4], but long-term tower based measurements had never been organised.

Results

An L-band and an IR radiometers, a video, a stereo-camera and four oceanographic and meteorological buoys were installed in and around the oil platform "Casablanca", 40 Km off the coast of Tarragona (NW Mediterranean), where the sea conditions are representative of the Mediterranean open sea with periodic influence of the Ebro river fresh water plume. Events of strong NW and NE winds are not uncommon in the area during autumn.

The experiment was initiated on 14 November 2000, although rough seas did not allow the full deployment of buoys until two weeks later, and some sensors, especially the accelerometers of a wave rider buoy, were damaged and could not be further used. The initially planned duration of one month was extended until 15 January 2001. At present the different data sets are being processed and preliminary results are expected for mid 2001. Although some interferences appeared in different moments and at some look directions, the quality level of the recorded radiometric data appears to be quite good, and consequently the outcome of WISE 2000 is expected to be an important contribution to the SMOS scientific definition studies. These and future measurements will allow a better understanding of the sea state effects on the sea surface emission at L-band, and then improved emissivity models formulation for the development of salinity retrieval algorithms to be used during the SMOS mission.

It is expected that, with these kind of scientific studies and the instrument technological development being carried out by ESA, the observation of salinity from space will be possible in the next future. However, the low radiometric sensitivity to salinity changes, and the expected errors in the measurement, do not allow using single observations for oceanographic applications. It will be necessary to make spatial and temporal averages to reduce noise. The aim of SMOS is to provide salinity data with an accuracy (0.1 psu) adequate for climatic and large scale studies, and with a spatial and temporal resolution similar to the presently available oceanographic atlases and climatological data bases [5]. Of course we are still far away from having a satellite sensor able to be used for mesoscale oceanography in the Mediterranean, but we are in the first step to fill the dramatic gap in salinity observations all over the world oceans.

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PHYSICO-CHEMICAL PARAMETERS IN SEAWATER AND SEDIMENT IN SOUTH AEGEAN SEA, JULY 2000

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Abstract
The Transitional Mediterranean Water (TMW) and the Cretan Dense Water (CDW) were well defined in the south Aegean Sea during the cruise of July 2000. The dissolved oxygen concentrations at the TMW layer ranged between 4.66-4.77 ml/l. The deep layer of the Cretan Sea appeared well oxygenated with values reaching 4.93 ml/l at 1170m depth. The maximum of nutrient concentrations were recorded at the same layer that exhibits the minimum oxygen concentrations (TMW layer).

Keywords: Aegean Sea, seawater, sediments.

Introduction

The southern Aegean Sea is one of the most oligotrophic sub-basins of the Mediterranean Sea. It is noticeable that nutrient concentrations in the Aegean Sea are twelve times lower than in Atlantic Ocean and three times lower than in Ionian Sea. In the framework of several international programs during the last years (*e.g.* POEM, POEMBC, PELAGOS/MTP-I, MED/POL–Aegean Sea), a number of studies have dealt with the Southern Aegean Sea (Cretan Sea) and the straits of the Cretan Arc [1,2,3].

This paper aims to record the dissolved oxygen and nutrient distributions in the south Aegean sea and the organic contend in the sediments as well as to compare with data from previous studies.

Materials and Methods

Seawater and surface sediment samples (0-3 cm) were collected at five stations in the Aegean Sea, with the oceanographic vessel "Aegeo" (fig. 1). DO measurements were performed on the oceanographic vessel "Aegeo" using the Winkler method [4]. Phosphate were also measured *on board* with a Perkin-Elmer UV/VIS (Lambda 2S) spectrophotometer using standard method [5], whereas silicate, nitrate and nitrite were measured with a RAN+LUEBBE autoanalyzer according to standard methods [6,7].

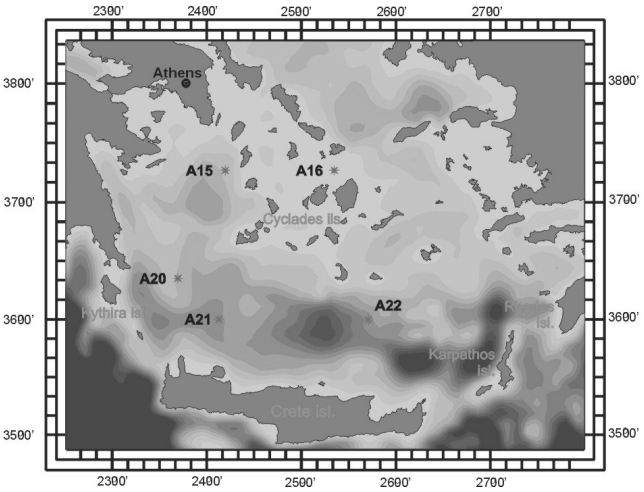

Fig. 1: Bathymetric map and location of the sampling stations in the Aegean sea during July 2000.

Results and discussion

In the upper layer (up to 100m) of the south Aegean Sea, the temperature, salinity and density values ranged as follows: temperature: 15.09-24.65°C, salinity: 37.84-39.18 psu and density: 25.91-28.93. In the deep layer (100m-bottom) the respective temperature, salinity and density variations recorded as follows: temperature: 14.24-15.67°C, salinity: 38.86-39.04 psu and density: 28.82-29.26.

DO concentrations at the surface do not exceed 4.9 ml/l, diminishing with depth below 75 m. Below 400m strong negative gradient of DO concentration is observed, associated with the presence of Transitional Mediterranean Water (TMW) in the intermediate layer (500-700m), which is a rather "old" water mass [2]. The deeper (>700m) layers of the Cretan sea are well-oxygenated (4.93 ml/l at 1170m), identifying the presence of the Cretan Dense Water (CDW), which is relatively "young" water mass.

Nutrient distribution shows enrichment in reactive phosphate, nitrate and silica below 200m, which rises progressively with depth (figs.1, 2). The TMW layer of the Cretan Sea is characterized by the maximum nutrient concentrations associated with the biochemical processes (oxidation, regeneration) that occur in this layer. The TMW layer is a "nutrient-rich and oxygen- poor" water mass. The nutrient concentrations recorded in the intermediate layer of the Cretan Sea, are within the same range of values reported after 94-95, and much higher than those measured during 1980-90 [8].

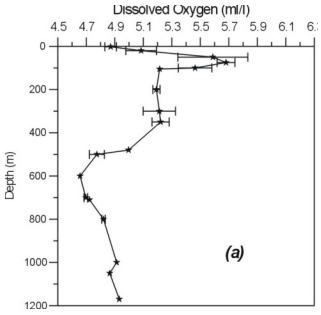

Fig 2: Vertical distribution of the mean concentrations of DO in the Aegean Sea during July 2000

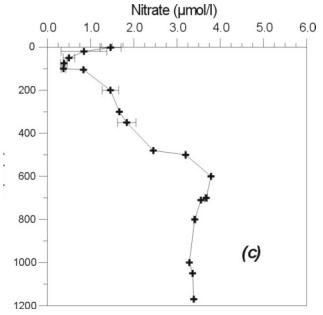

Fig 3: Vertical distribution of the mean concentrations of nitrate in the Aegean Sea during July 2000

Total carbon content in sediments ranged between 7.1 to 9.3. The ratio organic carbon to nitrogen is rather high according to the Redfield value and ranged between 9.0-11.6, indicating that surficial sediments are relatively impoverished in nitrogen, possibly due to the oligotrophic character of the study area and/or to the higher turnover rate of nitrogen relative to carbon. The C:N ratio of these Southern Aegean sediments is comparable with the recently reported values for sediments from the northern Aegean Sea.

Conclusions

Minimum values of dissolved oxygen and maximum of nutrients were observed at the TMW layer, whereas the higher oxygen and lower nutrient content observed in the deep layer of the South Aegean is related to the presence of the Cretan Dense Water (CDW).

The nutrient concentrations recorded in the intermediate layer of the Cretan Sea are within the same range of values reported after 94-95, and much higher than those measured during 1980-90. The relative nitrogen deficiency of the sediments defines the oligotrophic character of the Aegean Sea.

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LARGE TEMPERATURE AND SALINITY TRENDS IN THE DEEP TYRRHENIAN AND ORIGIN OF THE TYRRHENIAN DEEP WATER

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Abstract
Large θ-S trends (~+0.016°C.yr^{-1} and ~+0.01 psu.yr^{-1}) recorded with a CTD moored during 8 months at ~3400 m in the southern Tyrrhenian are supported by CTD profiles performed there ~4 years apart and by historical data. Together with relatively large θ-S values, they allow questioning the origin of the Tyrrhenian Deep Water. We hypothesise that deep water formation process might occur in the northern Tyrrhenian.

Key-words: Tyrrhenian Sea, Temperature, Salinity, Deep waters

From June 1999 to February 2000, a few-metre mooring supporting a Seacat SBE16 (T/C accuracy-resolution of 0.01-0.001°C/ 0.001-0.0001 S.m^{-1}) was set at ~3505 dbar, ~25 km North-East of Ustica, as a preliminary survey to the deployment of the GEOSTAR observatory [1]. Both the temperature and salinity time series increased tremendously and almost continuously (fig. 1) by ~0.012°C/8 months and ~0.007psu /8 months. The idea that the 8-month trends reflected a several-year phenomenon is supported first by ship-handled SBE911+ profiles performed there ~4 years apart. The θ/S bottom values were ~12.90°C/~38.46psu (at 3470 dbar) in October 1996 and ~12.95°C/~38.48psu (at 3440 dbar) in September 2000. These isolated values are remarkably aligned with the SBE16 θ/S ones.

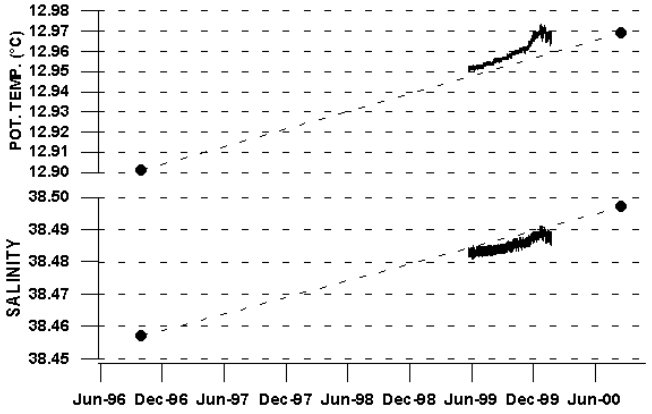

Fig. 1. θ-S time series from SBE16. Black dots: terminal values of 1996/2000 profiles.

Also, annual averages computed from the Medatlas database [2] reveal that the θ-S of the Tyrrhenian deep water (depth >3000m, TdeepW hereafter) increased continuously during the 1909-1990 period, with slopes comparable (few 0.01°C-0.01psu / decade) to those already reported for WMDW (Western Mediterranean Deep Water) in the Algero-Provençal Basin (*e.g.* [3]). Our observations complete the historical data and demonstrate that the θ-S of TDeepW markedly increased during the last decade, with slopes up to ~10 times greater than before (and than for WMDW now). Such dramatic trends put into light the question of the origin of TdeepW which cannot be considered as a mixture of waters having lower trends. Moreover, historical data clearly show that TdeepW has always been warmer (~0.1°C) and saltier (few ~0.01) than the WMDW inflowing from the deepest part of the Sardinia Channel (~2000m). θ-S diagrams show that TdeepW cannot be considered as a mixture of WMDW and waters originated from the Eastern Mediterranean. We hypothesise that TDeepW might be generated by a deep water formation (DWF) process within the Tyrrhenian.

Up to now, it has been demonstrated [4] that, due to strong (and cold, in winter) westerlies blowing through the Bonifacio Strait, the region east of the strait was occupied by a year-round cyclonic gyre, extending at depth and surrounding cold dense waters. Associated processes invoked by [4] are an upwelling that enhances mixing of MAW (Modified Atlantic Water) and LIW (Levantine Intermediate Water) below, making the region a privileged place for vertical exchanges between the different water masses. But, to our knowledge, DWF has never been said to occur there.

We think that the stratification and circulation described by [4] east of the Bonifacio Strait are very similar to what is encountered in the Gulf of Lions where WMDW is formed. We note, as shown by fig. 2, that the deep values of historical θ and S profiles east of the Bonifacio Strait (E9°-12°/N 41°-42°) display a striking continuity with the deepest Tyrrhenian values (depth >2000m), contrary to the profiles representative of the water which comes from the Algerian Basin or from the Eastern Mediterranean (profiles collected in regions E6°-10°/N37°-38° and E12°-14°, N38°-38.5°, resp.). We also note that TdeepW is warmer (+ ~0.1°C) than WMDW, which could be related to LIW east of the Bonifacio Strait being saltier than in the Gulf of Lions. We thus believe that these three features strongly support the hypothesis of DWF east of the Bonifacio Strait.

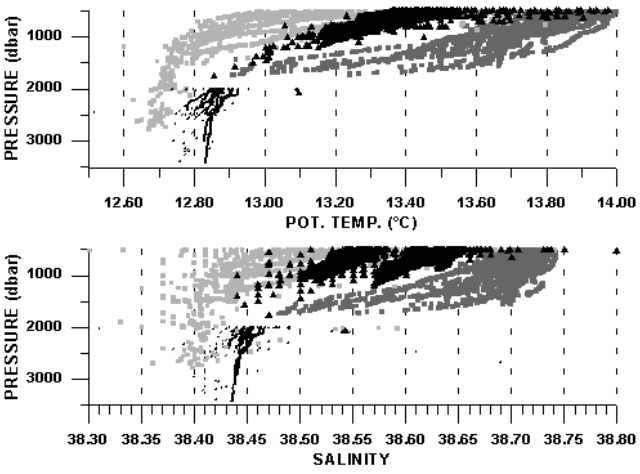

Fig. 2. θ and S profiles in the southeastern Algerian Basin (light grey squares), east of the Bonifacio Strait (black triangles), north Sicily (dark grey squares), and deep profiles (>2000m) in the central Tyrrhenian (thin dots).

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YEAR-TO-YEAR VARIATIONS OF THE PHYTOPLANKTON BIOMASS IN THE SOUTHERN ADRIATIC (SEAWIFS DATA) AND WINTER CLIMATIC CONDITIONS

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Abstract

The high-chlorophyll content patch, which regularly occurs in early spring in the open-sea area of the Southern Adriatic, coincides with the vertically mixed patch formed during the winter deep convection. This spring phytoplankton biomass maximum is highly variable on an interannual time scale. Analysing the SeaWiFS data and air-sea winter heat fluxes, we will show that the spring phytoplankton bloom depends not only on the integrated winter heat loss but also on the high-frequency (weekly) variability of the air-sea heat transfer function.

Key-words: Adriatic Sea, air-sea interaction, remote sensing, phytoplankton

Introduction

Inspection of the available SeaWiFS imagery from the Southern Adriatic area have revealed the regular occurrence of the high-chlorophyll content patch in the centre of the basin in early spring. More detailed analysis for a specific winter (1997/98) and the comparison of the chlorophyll a distribution with the sea surface density field (1) show that the high-chlorophyll content patch coincides with the density maximum and the centre of the South Adriatic Gyre. Similar feature was documented in the Gulf of Lions (2). The occurrence of the chlorophyll patch is due to the local nutrient enrichment of the euphotic layer by winter deep convection processes, which presumably control a local spring phytoplankton bloom. The purpose of this paper is to relate the interannual variations of the spring phytoplankton biomass in the Southern Adriatic to winter climatic conditions and consequently to the intensity of the deep convection.

Discussion and conclusions

The phytoplankton biomass as a function of time is represented by the spatially integrated chlorophyll a on a 40X40 pixel domain centred at the presumable position of the South Adriatic Gyre (Fig. 1) for each cloud-free SeaWiFS image from September 1997 until May 2000. Main features and the shape of the spatially integrated chlorophyll concentration as a function of time did not change appreciably using different integration domains (15X15 pixels, 20X20 pixels and 40X40 pixels

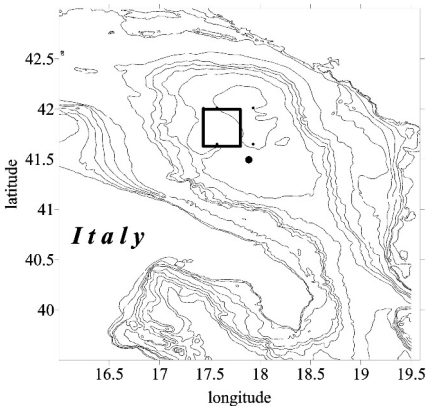

Fig. 1 Adriatic Sea map. The square represents the domain of 40x40 pixels for the integration of the surface chlorophyll content from the Sea WiFS images. The dot denotes the location for which air-sea heat fluxes were calculated.

The presented time-series (Fig. 2) reveals the existence of a prominent seasonal signal in the phytoplankton biomass with a primary maximum in early spring (March/April) reaching as much as 1 mg/m3 which is a rather high value for the Adriatic open-sea areas. A secondary maximum occurs in early autumn (October), while summer is characterized by very low surface chlorophyll a contents. This seasonal signal is modulated on an interannual scale and the most prominent spring phytoplankton biomass maximum occurs in 1999 followed by that in 1998 and in 2000. Earlier evidences (1) suggest that the spring phytoplankton biomass can be related to the intensity of the deep convection which on its turn depends to a major extent on the air-sea heat losses. Therefore, we will try to relate the interannual variability of the spring phytoplankton maximum to winter climatic conditions as represented by either integrated winter heat losses, or high-frequency air-sea heat flux variability.

Air-sea heat losses were calculated from European Center for Medium Weather Forecast (ECMWF) re-analysis six-hourly data for a single point in the centre of the Southern Adriatic using bulk formulas (3). Time-series of daily integrated heat losses for the period January – April for each of the three years in which the SeaWiFS data were available (Fig. 3) shows that the high-frequency variability of the heat-loss as a function of time differs from year to year. More specifically, winter 1998 was characterized by two strong cold events separated by almost a month-long interval of calm weather with slightly positive heat fluxes, in winter 1999 an isolated and strong event of a duration of only few days occurred at the beginning of February followed by almost two months of moderate heat losses, while the winter 2000 was characterized by a continuous and rather strong heat losses for almost entire January-March period. In addition, the interannual variability of the total winter heat loss is very prominent and characterized by its continuous increase from 1998 through 2000.

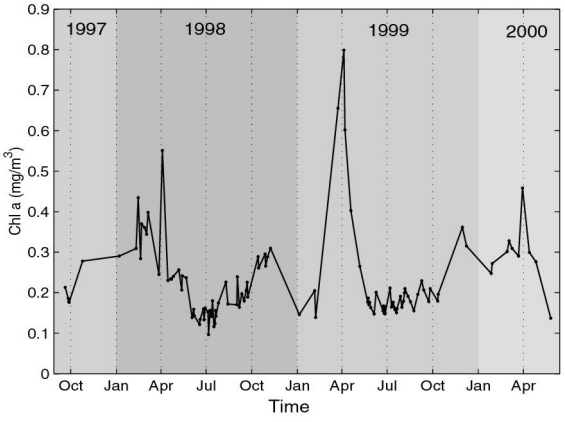

Fig. 2: Spatially integrated chlorophyll *a* concentration as a function of time.

If the winter convection depends only on the integrated winter heat losses and if it determines the spring phytoplankton biomass maximum, winter 2000 would have the most prominent spring maximum of all three years. However, this is not the case and thus we may conclude that the spring phytoplankton biomass is only partially controlled by the winter heat losses. An additional determining factor is probably the high-frequency variability of that function; more efficient in generating a spring phytoplankton bloom is a series of heat loss events, separated by at least a week long periods of calm weather with almost no heat losses.

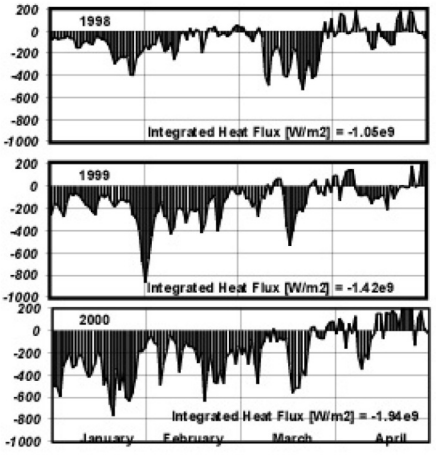

Fig. 3 : Daily integrated air-sea heat fluxes. Negative values denote sea surface heat losses.

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SEASONAL VARIABILITY OF THE EXCHANGE THROUGH THE STRAIT OF GIBRALTAR AND THE MEDITERRANEAN MEAN SEA LEVEL

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Abstract

Currentmeter observations at the eastern section of the Strait of Gibraltar were used to determine the seasonal signal in the exchanged flows. The computed signal of the net barotropic flow is compatible with the water mass balance within the Mediterranean sea at a seasonal scale. The enhanced response of the inflow to the annual cycle of the density contrast between Mediterranean and surface Atlantic waters appears to be the cause of this cycle. This enhanced response is possible if the exchange is submaximal, in which case seasonally-induced variations of the size of the Western Alboran Gyre can become an effective mechanism to induce the observed seasonal signals.

Keywords: Alboran Sea, Strait of Gibraltar, sea level.

Seasonal signal in the flows through the Strait

From October 1995 to May 1998 a mooring array of recording currentmeters was deployed in the eastern part of the Strait of Gibraltar within CANIGO Project. The observed velocities were used to produce time series of the slowly-varying inflow (Q_1), outflow (Q_2), and the depth of the interface (η_2), defined as the surface of null along-strait velocity. Time series were fitted to a sinusoidal model of annual and semiannual periodicity in order to investigate the existence of seasonal signals [1]. Table 1 shows the annual parameters, the cycle in which the present work concentrates.

Table 1. Annual parameters of the model. All phases are referred do the yearday 1.

Variable	A_a	φ_a
$Q_{1,a}$ (Sv)	0.101±0.038	225º±21º
$Q_{2,a}$ (Sv)	0.028±0.025	201º±51º
$Q_{0,a}$ (Sv)	0.077±0.044	234º±33º
$\eta_{2,a}$ (m)	4.557±3.269	61º±42º
$(\Delta\rho)_a$ (kg/m^3)	*0.29*	*238º*

The net barotropic signal and the Mediterranean Sea level cycle

The simplest model to balance the net barotropic signal in the Mediterranean Sea is $Q_{0,a}=dV_{MED}/dt= A_{MED}\, d\xi/dt$ (V_{MED} is the volume of the Mediterranean Sea, A_{MED}= 2.5 10^{12} m^2 its area, and ξ the sea level), and ignores the evaporative seasonal cycle $(E-P)_a$. Taking $Q_{0,a}$ from Table 1, this equation would imply an unrealistic annual signal in ξ of 15±9 cm with maximum value in November. TOPEX/POSEIDON altimetry data provide evidence of a seasonal cycle in the Mediterranean mean sea level of 8 to 10 cm of amplitude with maximum value in October [2]. This annual signal is quite evident in longer time series of altimetry data (P.Y. LeTraon, personal communication). However, part of this signal is due to steric effects. In [1] and using the MEDATLAS data set, these anomalies (averaged over the whole Mediterranean) are computed to give an amplitude of 5.5±0.4 cm and a phase of 253±12º for the thermal contribution and non-significantly different from zero for the haline part (0.11±0.24 cm).

Taking into account the thermal steric anomaly, the effective mass variation within the sea is $\xi_m = \xi_{obs} - \xi_{str}$, where ξ_{obs} is the observed sea level signal mentioned in [2] and ξ_{str} the steric contribution. The RHS of the aforementioned balance equation should be 0.02 Sv at 230º, far from the value of $Q_{0,a}$ reported in Table 1. The correct mass balance must include the climatological $(E-P)$ forcing, $Q_{0,a}-(E-P)_a=A_{MED}\, d\xi m/dt$, where $(E-P)_a$ is the annual signal in the net evaporation. Using the previous value for the RHS and $Q_{0,a}$ of Table 1, we obtain 0.06 Sv at 237º for $(E-P)_a$.

The seasonal net evaporative cycle is difficult to measure. [3] suggests a cycle of around 6 cm/month (0.06 Sv) that peaks in August (215º), while [4] indicates a seasonal signal of 7.1cm/month (0.07 Sv) at 181º using the *World Survey of Climatology*. The agreement of these amplitudes with the amplitude deduced from the mass imbalance is good. Phases will probably agree within the confidence intervals of the aforementioned values of $(E-P)_a$. The estimate of $Q_{0,a}$ from our observations is consistent with the requested mass balance within the Mediterranean.

Driving force for the net barotropic flow annual signal

Table 1 includes the seasonal signal of the density contrast between Atlantic and Mediterranean waters given in [4]. The phase agreement between $(\Delta\rho)_a$ and $Q_{0,a}$ suggests a cause-effect relationship. A simple unidimensional two-layer model for the exchange [1] shows that under maximal exchange, a positive net barotropic signal, for instance, is achieved by means of an increase of half this signal in Q_1 and a similar diminution in Q_2. Table 1 shows that this is not the case since both $Q_{1,a}$ and $Q_{2,a}$ oscillate near-in-phase with $(\Delta\rho)_a$. The seasonal signal in $Q_0=Q_1-Q_2$ arises because the amplitude of $Q_{1,a}$ is greater than the amplitude of $Q_{2,a}$, that is, the inflow is more sensitive to $\Delta\rho$ variations than the outflow. The model shows that this "asymmetry" is only compatible with submaximal exchange. The observed composite Froude number at the eastern section during CANIGO was clearly subcritical [1], which implies submaximal exchange [5] according to our reasoning.

The hydraulic theory says that if the exchange is submaximal, the conditions in the adjacent reservoirs are able to influence the exchange [5]. For instance, well-developed anticyclonic gyres in the Western Alboran Basin may favour the inflow and hamper the outflow by sinking the interface near the eastern entrance of the Strait (the opposite if the gyre reduces), thus linking the seasonal signals in the exchange with the hydrographic features in the Western Alboran Sea. This possibility is explored in [1] to put forward that the $(\Delta\rho)_a$ signal favours the presence of greater (smaller) and more (less) stable anticyclonic gyres during summer (winter), a fact easily observable in SST imagery. This seasonal pattern would induce a phase of the interface depth like that in Table 1.

Acknowledgements

This work was supported by the European Commission through the Canary Azores Gibraltar Observations, "CANIGO", Project (MAS3-PL95-0443). Partial support by the Spanish National Programme of Marine Science and Technology (MAR95-1950-C02-01) is also acknowledged.

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A HISTORY OF THE IRAPETRA GYRE.

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Abstract

A combined POEM-Russian data base allowed us to follow the detailed history of the Irapetra Gyre between 1987 and 1995, when, according to some reports it disappeared. Throughout this period, we describe the changes in intensity, size, and position of the Irapetra Gyre. The examination of previous investigations as well as a thorough search through the data of Med Atlas I indicated that the Irapetra Gyre may have occurred earlier than the POEM description. Examination of satellite data indicates that Irapetra was present after 1995.

Key words: Eastern Mediterranean circulation, Cretan Passage circulation, Irapetra Gyre.

Two large scale investigations of the Eastern Mediterranean: POEM, an international cooperative effort, and GOIN, an initiative of the former USSR, were carried out between 1985 and 1995. The two were integrated into PGDB, a combined Poem Goin Data Base (1).

A very conspicuous feature on the PGDB maps is the Irapetra anticyclonic gyre situated South-South-East of Crete. This gyre was discovered by two independent cruises: the POEM 05 cruise of August-October 1987 (2) and the Gakkel 29 cruise of September-October 1987 (3, 4), as well as by drifter buoy and satellite thermal imagery (5). Each of the investigators called this gyre by a different name, however it seems that by now Irapetra is the accepted name. The gyre was not observed during March-April 1986 (2), and there is no data for the summer of 1986. The amalgamation of POEM 04 (February-May 87) with Gakkel 28 (March-April 87) proved conclusively that, indeed, there was no Irapetra Gyre during the winter of 1987 (1).

Gakkel 31 (February-April 88) does not provide sufficient information for a definite statement about the presence of the Irapetra Gyre, and none of the POEM 06 (July-August 88) stations were located in the Cretan Passage. According to Popov *et al*. (4) the Passat 56 cruise, shows the Irapetra during the summer of 1988 but we do not have this data. The Irapetra gyre is clearly depicted during the winter of 1989 (Gakkel 33 and LBDS01 cruises), and the summer of 1989 (Parshin 02 cruise), the winter of 1990 (Gakkel 36), the summer of 1990 (Gakkel 38 together with Parshin 06 and LBDS02). We do not have any data for the winter of 1991, but we do have the Irapetra Gyre in the data of POEMBC during the summer of 1991. There is no data between POEMBC and the LIWEX cruise of 1995 where we can clearly see the Irapetra Gyre. From 1987 to the fall of 1995, the Irapetra was also discovered, followed and investigated by La Violette *et al*. (6) via drifter buoy and satellite thermal imagery. According to La Violette *et al*. (6) the Irapetra Gyre can not be found in the satellite imagery after 1995, and they conclude that the gyre has dissipated.

Irapetra is described as permanent seasonal feature of the Eastern Mediterranean summer circulation by Popov *et al*. (4) and although they did observed the gyre during the winter of 1990 (Gakkel 36), they suggest that this is either a remnant from the previous summer or the initial beginning of the gyre of the following summer. However, the same gyre as described by La Violette *et al*. (6) appears to be a large and very intensive gyre. Apparently, the Gakkel 36 stations were not sufficiently dense nor sufficiently extensive to give a proper description of the gyre.

We conclude that the Irapetra Gyre was present almost continuously from its discovery in 1987 to 1995, the last of our data. Its position and intensity varies seasonally, it is smaller in the winter than in the summer and by and large, each summer it was larger then during the previous one. Its intensity reached its peak during the summer of 1990. Its size reached its peak during the summer of 1991, when the Irapetra reached almost to the middle of the Cretan Passage and down to about 700 m, displacing (downward) both the MAW and the LIW.

One of the intriguing questions regarding the Irapetra Gyre is whether summer 1987 is really the first time it appeared or only the first time it was noticed.

The Cretan Passage was investigated during the six R/V *Vavilov* Mediterranean cruises (1959 to 1963). Unfortunately, this data is not available. The R/V *Vavilov* results, [Figs. 60 and 61 in (7)] indicate the presence of an anticyclonic feature South-South-East of Crete, sometimes in the winter (January 1962) and sometimes in the summer (September-October 1959, May 1962, and October-November 1963). Fig. 61 [in (7) also] presents an analysis of the data from R/V *Atlantis* (April-May 1948), which shows a cyclonic feature south of Crete, and the data of R/V *Calypso* (September-October 1956), which shows an anticyclonic feature South-South-East of Crete. However, the station distributions of the cruises indicate that the R/V *Vavilov* stations were not dense enough to reveal the size and the intensity of mesoscale features, and the stations of the R/V *Atlantis* or the R/V *Calypso* were even sparser.

A careful search of the MEDATLAS 1 Data Base revealed that, although many of the cruises, preceding the POEM project, occupied some stations in the Cretan Passage none of those stations were dense enough to map the Irapetra Gyre. Nevertheless, some of those stations, indicated that the region of the Irapetra Gyre was warmer than its surroundings both in the winter as well as in the summer. Thus we are led to the conclusion that, in all probability, the Irapetra Gyre was present in the region for a long time and it was revealed only thanks to the detailed investigation of POEM and GOIN. On the available evidence it would appear that the Irapetra Gyre is not a permanent feature but a recurring one.

The formation of the Irapetra Gyre was related to the outflow from the Aegean (6, 3). Its exceptional intensification during the summers of 1989 and 1990 was related to the anomalous intensive outflow of Aegean water via the Kassos and Karpathos passages (3). However, no other report, and in particular (8) who investigated this outflow extensively, seems to have made this connection.

Oceanographic Features Analysis maps of the Naval Oceanographic Office show the Irapetra distinctively both in the summer and in the winter.

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UNDERSAMPLING PROBLEM FOR HEAT FLUX CALCULATION

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Abstract
The results of the data analyses presented in this work consisted of the long-wave radiation, sensible and latent heat, calculated using the bulk method. Errors due to undersampling of the calculated parameters were determined for different sampling intervals.

Kex words: Automatic Metocean Station Split, Adriatic Sea, undersampling error

Introduction

The two radiation parameters: global (incoming solar and sky radiation within 0.3-2.5 μm) and net radiation (the difference between incoming and outgoing radiation within 0.3-60.0 μm) measured from the AMOS (Automatic Metocean Station) station at Split Marjan-Cape were analyzed in this work. The scope of this paper is to show differences in calculated values when the data from different sampling intervals were used. The methods for the heat flux calculations utilized here are presented in details in Grbec *et al*. (1).

Results and discussion

For determination of individual components of thermal equilibrium, the selection of formulae is very important. Heat fluxes for the Mediterranean (2) showed different results from those in this work. The discrepancies depended upon the selection of formulae used for calculation. Different results obtained using different input values can be also the reason for discrepancies, as a result of undersampling. In order to demonstrate how large can be these differences on the seasonal scale, different input values were used and the heat fluxes were calculated in the three ways: $(Q_{NET})^{10}$ - based on the row data (from 10 min intervals); $(Q_{NET})^{d}$ - based on the daily means; $(Q_{NET})^{m}$ - based on the monthly means. These are listed in the table 1, together with the amount of error, calculated using the following formula:

$$error^{j} = \frac{\left|(Q_{NET})^{i} - (Q_{NET})^{j}\right|}{(Q_{NET})^{i}} \cdot 100; \quad \begin{cases} i = 10, d \\ j = d, m \end{cases}, \quad i \neq j \qquad (1)$$

The fluxes calculated from 10-min intervals, daily means and monthly means are presented in the Fig. 1. Heat loss due to evaporation was higher from March to September, and in January, than the others, calculated from daily means or 10min intervals. However, the values were negative, reflecting that the heat loss due to evaporation was present all the seasons. This shows that, calculating with monthly means, we may overestimate the heat loss due to evaporation, up to 10% in June, or less in other months.

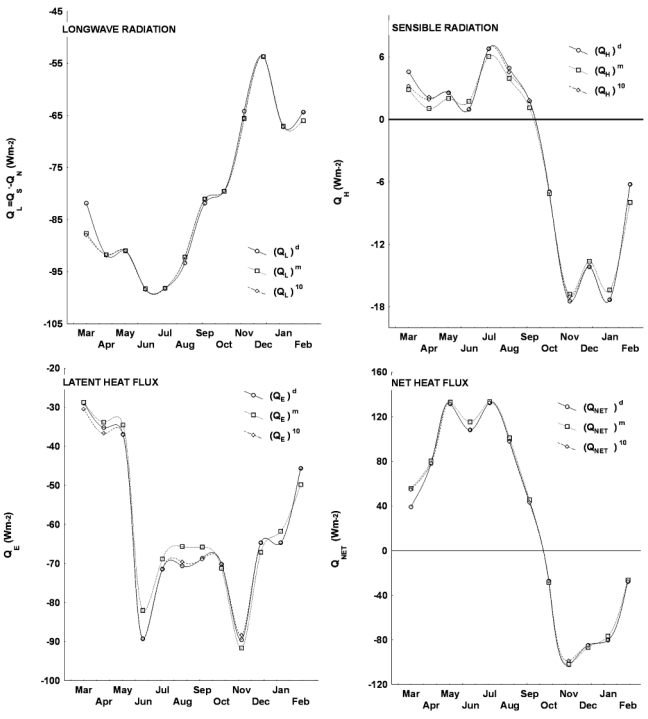

Figure 1. Monthly mean a) global radiation, net radiation and longwave radiation fluxes, calculated from hourly means; b) monthly mean flux lost/gained by evaporation and conduction calculated from hourly means at the metocean station AMOS for the period March, 1999 - February, 2000.

From March to September, sensible heat flux is positive, and the rest of the year negative. Maximum values are reached in July and minimum in November and January. In March, the heat gain due to conduction, calculated from daily means, showed highest departure from the conduction calculated from monthly means or 10min intervals. Heat loss due to longwave radiation was highest in June, and lowest in December. Only in March, the departure between the values calculated from daily means and others was considerable, and showed about 10% difference.

Resulting heat budget (Fig. 2) shows that the sea looses heat from October to February and gains heat from March to September. The only considerable departure between the results if different averaging is considered was in March, when daily mean values resulted in lower heat gain. From the climatological point of view, it seems that daily values are good enough for heat flux calculation.

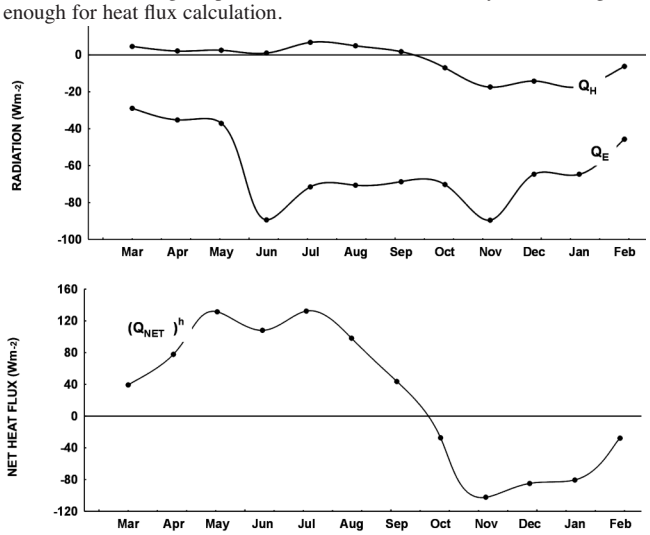

Figure 2. Monthly mean net heat fluxes (QNET), calculated from hourly means, at the metocean station AMOS for the period March, 1999 - February, 2000

Global and net radiation were measured with the error 20Wm^{-2}, while all other parameters were measured with the error neglectable in relation to those originated form the mentioned equations. Since continuous measurements of relevant parameters minimise the undersampling error, which is important for better understanding of heat exchange.

	$(Q_{NET})^{d}$	$Q_{NET})^{m}$	$Q_{NET})^{10}$	$(error)^{d}$	$error)^{m}$
March	39.14	55.56	54.61	28.33	1.74
April	77.86	80.37	78.12	0.33	2.89
May	131.42	133.13	131.39	0.02	1.33
June	108.03	115.31	108.08	0.05	6.69
July	132.35	133.46	132.37	0.01	0.82
August	98.17	101.18	97.59	0.59	3.68
September	43.83	45.48	43.01	1.89	5.72
October	-27.36	-28.58	-27.36	0.00	4.45
November	-102.37	-101.89	-98.93	3.47	2.98
December	-84.86	-86.84	-84.86	0.00	2.34
January	-80.44	-76.84	-80.44	0.00	4.47
February	-27.72	-26.58	-27.72	0.00	4.12

Table 1. Errors according to equation 1 for heat fluxes calculated from 10 minutes intervals relative to the monthly means and, from daily means relative to the monthly means (%), and heat flux (Wm-2) calculated using different measurement intervals.

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A PRELIMINARY ANALYSIS OF THE ALONGSLOPE CIRCULATION IN THE EASTERN MEDITERRANEAN AS INFERRED FROM INFRARED IMAGES

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Abstract
In continuation of the work in the Algerian Basin, thermal patterns of NOAA/AVHRR images have been analyzed in key-areas of the Eastern Mediterranean to clarify some surface circulation features. The mesoscale structures (filaments, meanders and eddies) observed all along coastlines from Libya to Turkey are interpreted as the manifestation of a surface circulation which, at least during the period studied (1996-2000), was mainly alongslope and markedly unstable.

Keywords: Eastern Mediterranean, circulation, mesoscale phenomena, remote sensing

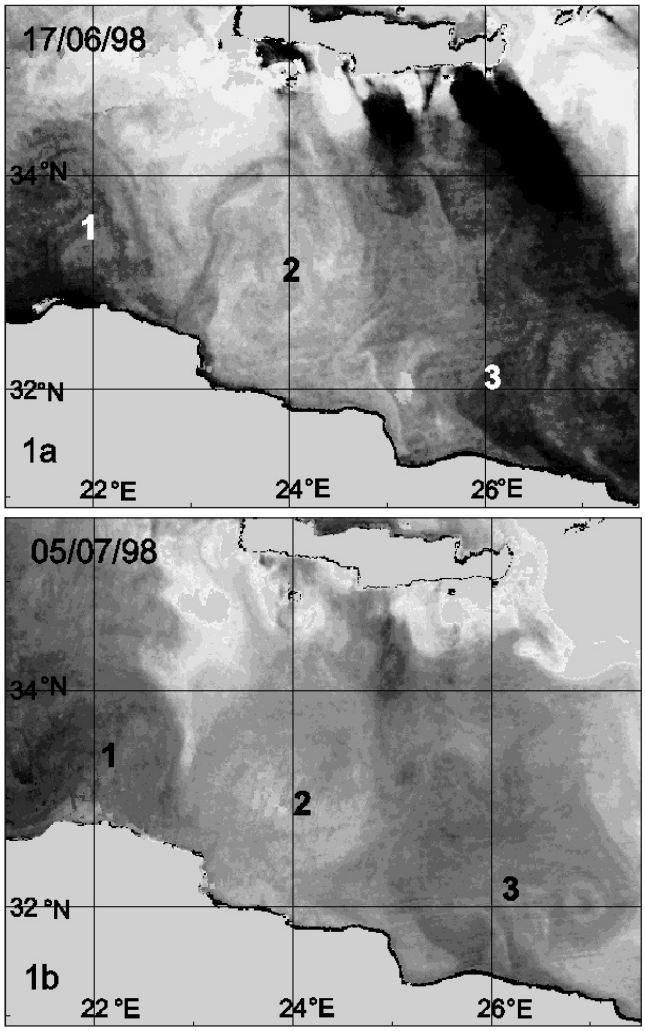
Infrared images are extremely efficient in monitoring mesoscale eddies for periods up to several years. The Eastern Mediterranean has been described as "nearly full" of eddies, but whether some of these eddies are permanent or transient features has never been fully addressed. It is all the more important since many of the eddies considered as permanent in the literature are pivotal features of the widely accepted general circulation scheme [1].

We have analyzed NOAA/AVHRR images [2] of the Ionian and Levantine basins over the period 1996-2000. Examples are illustrated in figures 1 and 2, and these analyses will be presented in detail.

Preliminary results show that (anticyclonic) eddies commonly have lifetimes exceeding 1 year (sometimes up to 3 years, as in the Algerian Basin [3]). Some can remain motionless for periods > 6 months, and/or propagate at low speed (~1-2 km/day), hence look misleadingly "permanent".

The mesoscale features show similarities with the ones observed in the western Mediterranean, where many complementary measurements have been collected. The mesoscale eddies displayed in figure 1 resemble those described in the Algerian Current, and the meanders displayed in figure 2 resemble those described in the Northern Current. We can thus infer with reasonable confidence that such mesoscale features result from the instability of an alongslope flow. The overall impression is that the surface circulation is mostly alongslope and continuous from Libya to Turkey.

Figure 1: Daily composites of the Cretan Passage. Eastward alongslope propagation of three eddies. Showed (a) on 17/06/98, (b) on 05/07/98 (propagation speed is low, so that at a 19-day interval translation is hardly visible) and (c) on 03/10/98 ("1" is not well signed).



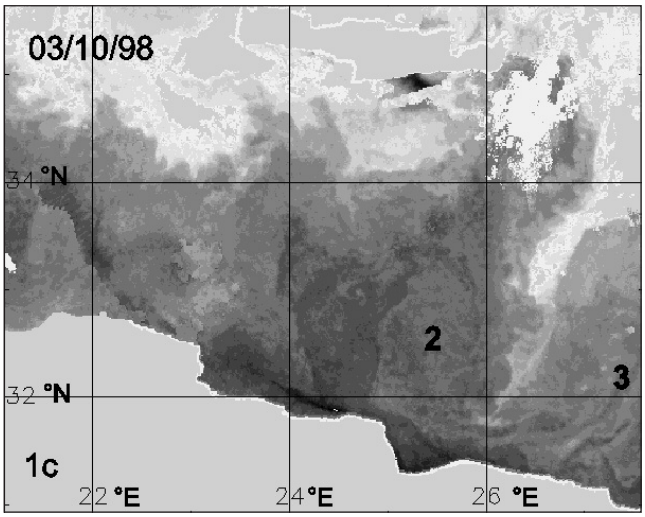
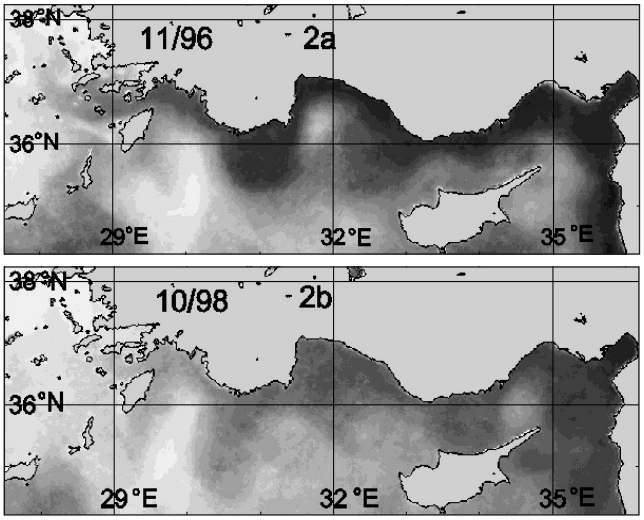


Figure 2: Monthly composites of the Northern Levantine Basin. (a): Nov.1996, (b): Oct.1998. The warmer (darker) signature of the coastal current is continuous from the Syrian to the Turkish coasts, and meanders. (Partial) continuation of this current northwestward into the Aegean Sea is visible.



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ALTIMETRIC OBSERVATIONS OF PROPAGATING OPEN-SEA EDDIES IN THE ALGERIAN BASIN

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Abstract

A key question to adequately understand the circulation of the Western Mediterranean sea is the dynamics of the eddies within the Algerian basin. Such eddies in most cases are generated by instabilities of the Algerian current and last for several months within the basin. To adequatley study their dynamics and evolution we need observational data able to track them over their lifetime. This may be done efficiently by means of remote sensing data and commonly the infrared thermal images are used as a source to identify such mesoscale structures. In this work we present some results obtainned by analyzing the Sea Level Anomalies (SLA) maps, with a technique based on the second Galilean-Invariant of the velocity gradient tensor. This technique allows us to clearly detect the core regions of the mesoscale eddies within the Algerian basin. The analysis applied on SLA maps between 1992 and 1999 show that this methodology is coherent with previous studies and is able to distinguish two interacting eddies which can not be distinguished from visual inspection. It reveals that eddies follow a circuit in the eastern part of the Algerian basin composed by three main branches. In particular, The observations and the analysis show a region in the Algerian coast, near 3 ° E, where eddies detach and drift westwards following the continental slope south of Ibiza Island.

Keywords : Algerian basin, mesoscale phenomena, remote sensing

The Algerian basin occupies most of the southern part of the western Mediterranean Sea. The Algerian basin dynamics is dominated by the interaction between light waters incoming from the Atlantic Ocean through the strait of Gibraltar and resident denser waters. The major feature of this thermohaline circulation is the coastal flow of Atlantic waters along the African slope which is called the Algerian current (AC). Instabilities of the Algerian current are manifested as coastal meanders and eddies, that in some cases develop into bigger open sea anticyclonic eddies. As seen in satellite infrared images, these mesoscale structures can last for many months or even years while strongly interacting between them and with the Algerian current. They lay a major role in the configuration of the general circulation and the distribution of water masses and biogeochemical parameters in the western Mediterranean [1]. The difficulties to survey the dynamics of the generation and propagationof such eddies are beyond the traditional experimental designs (ship cruises and moored instruments). Most part of studies have focused in the systematic analysis of thermal images which can cover the whole domain synoptically with enough resolution. However, the studies only can cover small time periods (free cloud periods) and limits to the sea surface temperature. Here we present results of a methodology able to extract information on such eddies by means of the analysis of altimetric data. To study the eddy dynamics and survey their evolution from data, one needs to unambiguously identify them. The eddies cores can be defined as the connected region with a positive value of the second Galilean-invariant of the velocity gradient tensor [2.3]:

$$Q = \left(\frac{\partial u}{\partial x}\right)^2 - \left(\frac{\partial u}{\partial y}\right)\left(\frac{\partial u}{\partial y}\right)$$

then the vorticity sign of the detected regions allows to distinguish between cyclonic and anticyclonic eddies (figs.1, 2). Once detected, the eddies can be tracked and their evolution can be studied. We have applied this criterion to geostrophic velocities derived from Sea Level Anomalies (SLA) maps. First we test our methodology with previous results and then we study eddies evolution for the period from October 1992 to September 1999.

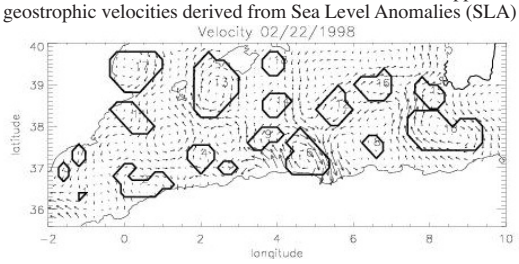

Fig. 1. Anticyclonic structures detected by Q>0

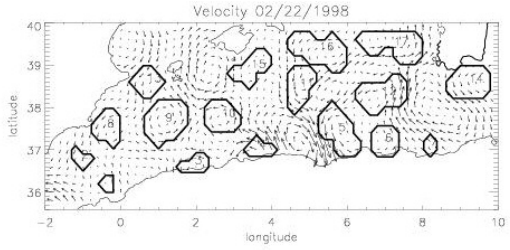

Fig. 2. Cyclonic structures detected by Q>0

SLA maps are regularly produced by the CLS laboratory (Toulouse, France) combining TOPEX/POSEIDON and ERS data interpolated onto a regular grid of 0.2º \ 0.2º [4,5,6,7]. One of the major problems in using altimetric data in the Mediterranen is the spatial and temporal resolution of the sensor relative to the characteristic scales of the structures of interest. As it has already shown [8,9,1] Algerian eddies are structures with length scales of 100-200 km and surface elevations of the order of 10-20 cm, thus within the range of detection by altimeters. Furthermore, series of AVHRR images have also revealed [1] that such eddies drift slow enough (2-5 km/day) that a sample rate of 10 days between consecutive SLA maps is rather adequate to survey their evolution.

First, the methodology is tested for three of such eddies that were imultaneously sampled by *in situ* measurements (CTD, drifters) and infrared imagery during ALGERS98 and ELISA cruises. Results, using our methodology, show a rather good agreement between our procedure and field observations but it is able to distinguish two interacting eddies which can not be distinguished from visual inspection.

Second, by applying this technique to the whole data set we can analyze the indivudal trajectories followed by such structures (fig. 3). Results show the presence of a clear circuit followed by eddies in the Algerian basin. They tend to do counterclockwise loops between 5-8º E . We can also appreciate that the circuit is composed of two loops with different size. In the larger one eddies may reach 38.5º N and a second loop where eddies remain trapped between 37-38º and are located between 6-7º E. Finally it can also be appreciated a third circuit, where

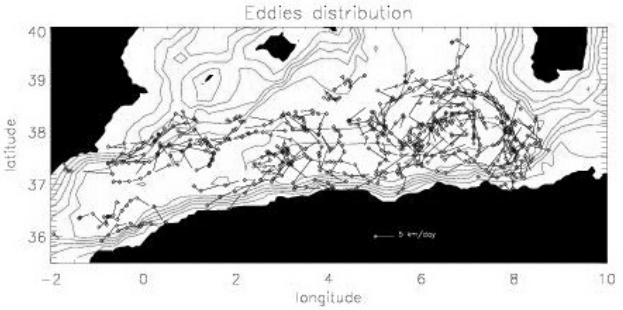

Fig. 3. Eddies distribution and velocities observed Sea Level Anomalies maps from October 12,1992 to September 30, 1999

eddies detach approximately at 3º E and drift westwards following the isobaths along the continental slope south of Ibiza Island.

Sumarizing, the simple technique presented here is able to detect and track, on a regular basis, the evolution of eddies within the Algerian basin by only using altimetric maps. This constitutes a first step to understand the dynamics and behaviour of such eddies. When applied to a rather long series of data we could obtain the main circuits followed by such structures. Results evidence that bottom topography and beta effect probably are the two key elements that determine the dynamics of such eddies but further analysis and comparison with numerical simulations need to done to conclude.

Acknowledgments. This is a contribution to GPS Radar Altimeter (GRAC) project funded by the Spanish R+D Plan and the European Union (2FD97-0588). Altimetric maps for the period October 1992 to October 1997 were elaborated and provided by CLS (Toulouse, France) under contract (MAS3-CT96-0051) of the MATER (Mass Transfer and Ecosystem Response) project funded by the European Comission. Altimetric maps for the period October 1997 September 1999, also produced by CLS, where kindly provided by Giles Larnicol. ALGERS98 and ELISA surveys were also funded by the MATER project.

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THE BLACK SEA THERMAL STRUCTURE

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Abstract

A peculiar thermal structure of the Black Sea is characterised by a gradual increase of temperature interrupted by a quasi-isothermal layer from 500 to 650-m. A stationary one-dimensional model is applied to explain the existence of this layer. It is shown that the total upward heat flux from the Black Sea thermocline notably exceeds the value of the geothermal heat revealing the dependence on thermal properties of the Bosphorus inflow. The geothermal heat is important below the quasi-isothermal layer where the inflow is a cold water pattern compared with the bulk water mass.

Key words: Black Sea, temperature, vertical profile, models.

Introduction

Vertical distribution of the potential temperature in the Black Sea below the core of the Cold Intermediate Layer is characterised by a gradual increase, approximately, down to 500 m. From 500 m to about 650 m, the potential temperature is quasi-uniform, both in the vertical and horizontally [1]. Spatial variations within the layer do not exceed 0.005°C. The layer, same as the pycnocline, is dome shaped with. The potential temperature vertical gradients within the layer are close to zero or have small negative values in the centre of the sea, and have small positive values over continental slopes.

The structure and a comparative role of the sources of heat in maintaining the observed temperature stratification in the interior of the basin are not immediately clear. At the exit of the strait, the Marmara Sea water constitutes a source of heat. However, over the shelf, the effluent comes into direct contact with the Black Sea waters. Through mixing with the Cold Intermediate Water, the temperature of the Marmara Sea water decreases from 14°C at the exit of the strait to about 8°C at the shelf edge [2].

What is an average integrated effect of the upper layer on the thermal regime of the effluent? Ozsoy *et al*. [3] have shown that, due to entrainment, the flowing down fluid can become cooler than the waters of the thermohalocline, and relatively cold (less saline) isopycnal intrusions are well noticeable in the depth range 100 – 500 m. However, a continuously cooled thermocline could not be stationary. On the other hand, observations do not reveal any trends in the thermohaline properties of the Black Sea on a century scale [4] suggesting stationarity of the system. Our paper is an attempt to resolve this contradiction, and to explain the peculiar thermal structure of the Black Sea in the framework of a one-dimensional stationary model. The objective of the work is to estimate contribution of different sources of heat in the formation of the Black Sea water column thermal structure.

Formulation of the model. We consider a stationary one-dimensional model based on mass, salt and heat balances for the Black Sea. The uppermost layer of the sea is excluded from our consideration. This does not need a special justification because inputs of salt occur only below a certain depth. The lower boundary of the uppermost layer is set at the upper boundary of the Bosphorus inflow. Since the Black Sea is characterised by steep continental slopes one may suggest that the considered processes take place in a basin with vertical boundaries and a plane bottom.

The domains of the plume and of the interior are distinguished in the basin. The influence of the plume on the interior is realised in the form of a source or sink of water distributed over the vertical. At the upper boundary we set a source of water with the volume transport of the Bosphorus inflow. This source of water determines vertical velocity in the interior domain. In the vertical, the system consists of three layers. In the first layer, the interaction of the water masses of the plume and of the interior occurs as pure entrainment of the ambient fluid to the inflow. The second layer models the thermohalocline, intermediate and deep layer. The interaction between the plume and the interior in this layer is characterised by disintegration of the plume through the formation of isopycnal intrusions. A separate examination of the fluxes in the third layer is necessary to tune the model. This layer is the Bottom Homogeneous Layer. Thus, the third phase of the plume – interior interaction is characterised by a flow down of a 'remainder part' of the plume into BHL, and its subsequent mixing within the layer by thermal convection. To sustain stationarity of the system the amount of salt that penetrates into BHL is set in agreement with the outward salt flux across the upper boundary of the layer. The conditions of continuity of heat, salt and water fluxes hold at the boundaries between the layers.

The vertical exchange in the interior domain of the basin has two components. The advective transport occurs due to the existence of the vertical velocity, , determined, in its turn, by the lateral source of water. The diffusive transport is maintained by the mechanism of turbulent diffusion in the pycnocline and intermediate layer, by double diffusion at the top boundary of BHL and by convective mixing in BHL. Conceptually the exchange processes modelled here were basically described by Ozsoy *et al*. [3].

Results

The approach to the solution of the problem was found useful to reveal the role of the geothermal heat flux in the formation of the thermal structure of the deep part of the water column of the Black Sea. It is shown that the Marmara Sea water downflow is a warm water pattern above 500 m. Below, the plume penetrates further downward as a cold water pattern. Thus, the lateral source of heat, together with the geothermal heat flux, determines the thermal regime of the Black Sea.

The calculated total vertical heat flux out of the Black Sea thermohalocline is, approximately, 17 times the value of the geothermal heat flux. Consequently, on average, the plume warms up the interior domain of the sea. Estimating the upward heat fluxes at 500 m we got a negligibly small value, 20 times less than a value for the geothermal heat flux. Consequently, the geothermal heat is almost entirely spent below 500 m in compensation for the negative lateral heat flux. Model results thus shed light on the nature of the conspicuous quasi-isothermal layer observed in the Black Sea in the layer, approximately, from 500 to 650 m.

Acknowledgments . This is a contribution to INTAS project # 99-01710.

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THE AEGEAN - LEVANTINE EDDY RESOLVING MODEL (ALERMO): IMPLEMENTATION AND CLIMATOLOGICAL RUNS

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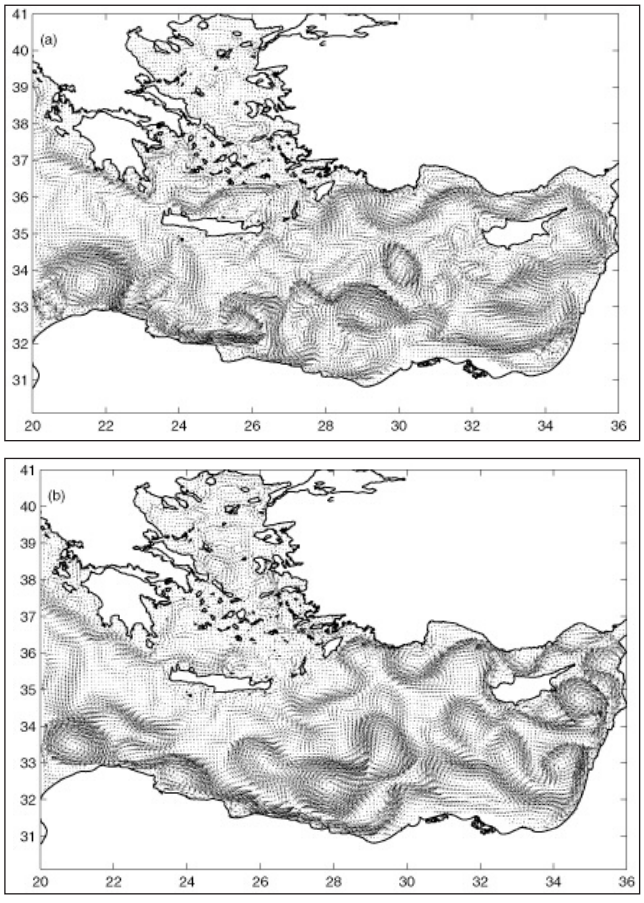
Abstract

Within the MFSPP project, an eddy resolving ocean model of the Aegean and Levantine basins (ALERMO) has been developed. This model acts as an intermediate between the basin scale OGCM and the high-resolution shelf models within the same project. In this paper we present the development of the model, the nesting technique with the basin scale OGCM as well as results from its climatological runs.

Keywords: models, Levantine basin.

The numerical model

The ALERMO model is based on the Princeton Ocean Model (POM), a primitive equation, 3-D circulation model [1]. The model has a bottom - following vertical sigma coordinate system, a free surface and a split mode time step. Potential temperature, salinity, velocity and surface elevation, are prognostic variables. The ALERMO model has one open boundary located at 20° E (see fig.1). The computational grid has a horizontal resolution of 1/20°x1/20° and 30 sigma layers in vertical with a logarithmic distribution near the surface resulting in a better representation of the surface mixed layer. ALERMO includes parameterization of the Dardanelles outflow and rivers runoff. It is forced with climatological wind stress, total heat flux and evaporation/precipitation fields. The wind stress and evaporation fields are derived from the ECMWF 1979 - 1993 meteorological parameters data set, while precipitation is obtained from Jaeger [2] monthly precipitation climatology. The total heat flux fields used here, are diagnosed from the OGCM climatological model run. Correction terms (in terms of weak relaxation to SST and SSS climatologies) are also used to account for imperfect knowledge of the heat flux, evaporation and precipitation fields.



Fig, 1: a) Winter subsurface circulation pattern b) Summer subsurface circulation pattern.

Nesting technique

Nesting is a finite-difference technique to simulate a high-resolution domain embedded in a coarse resolution model. In our case, the fine resolution model is ALERMO which is one-way nested along its western boundary (located at 20°E) with the global Mediterranean OGCM [3] constraining volume transport to be conserved between the two models. The condition for the normal barotropic velocity at the open boundary is a modified Flather [4] condition that efficiently allows interior disturbances (possibly due to mismatches between coarse and nested values) to pass out through the lateral boundary. On the other hand, the tangential barotropic velocity at the open boundary as long as baroclinic velocities are directly prescribed from the OGCM. To update the temperature and salinity at the open boundary we use an upstream advection scheme whenever the normal velocity is directed outwards from the modeling area. In cases there is inflow through the open boundary, temperature and salinity are prescribed directly from the interpolated OGCM temperature and salinity profiles. Finally, for the free surface elevation at the open boundary we have adopted a zero-gradient condition.

Discussion of model results

In fig.1a and 1b we present the subsurface (30m) winter (mid February) and summer (mid August) circulation patterns corresponding to the 2nd year of the climatological integration of the model. The circulation patterns suggest that the model can successfully reproduce all the main general circulation characteristics of the area (Mid Mediterranean Jet, Asia Minor Current, Rhodes cyclonic gyre, Mersa-Matruh and Shikmona anticyclonic gyres). Both winter and summer circulation patterns are very rich in mesoscale structures, which are mainly intensified during the summer period. Important seasonal variability characterizes the easternmost Levantine basin and the southern central Levantine. In the former we see the recurrence of the Shikmona anticyclone between winter and summer while in the latter the Mersa-Matruh gyre is showing large variations in strength, form and position. The Mid Mediterranean Jet (MMJ) is well formed and shows seasonal variations in its pathways. During winter it flows along the northern border of the Mersa-Matruh gyre. Along its eastward pathway there are several meanderings taking place which in some cases result in anticyclonic eddy detachments to the north. During summer the MMJ remains hugged to the African coast up to 29oE while the Mersa-Matruh gyre appearing as a three-lobe structure is completely to the north of the jet. During this period, Mersa-Matruh expands spatially and strengthens. As a result the Rhodes gyre is pushed to the north.

Acknowledgements

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A CLIMATOLOGICAL ATMOSPHERIC FORCING DATA SET FOR USE WITH GENERAL CIRCULATION MODELS OF THE MEDITERRANEAN SEA.

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Abstract

A comprehensive climatological atmospheric forcing data set for the Mediterranean Sea area is being presented. This data set is suitable for use in ocean circulation models of the Mediterranean Sea or parts of it. The values of the various heat budget components have been checked against previous studies and the total mean annual heat loss is equal to –7.2 W/m^2, a value very close to the generally accepted one for the Mediterranean Sea.

We present here the procedures followed in order to prepare a climatological atmospheric forcing data set to be used by general circulation models of the Mediterranean Sea. This data set consists of heat fluxes fields and wind stress components on a monthly basis, derived from the ECMWF 1979 – 1993 6-hour re-analysis atmospheric parameters on a regular 1° x 1° grid.

The calculation of climatological wind stress fields is based on the transformation of 6-hour ECMWF wind velocity data to x and y components of wind stress. The drag coefficient is calculated every 6 hours as a function of wind speed and air-sea temperature difference through a polynomial approximation given by [1]. SST data are taken from Reynolds 1° x 1° monthly 1979 – 1993 data base [2] and are linearly interpolated every 6 hours while air temperature data are taken from ECMWF 1979 – 1993 re-analysis data. The air density is calculated as a function of air temperature and relative humidity.

The x and y component of wind stress time series (at 6-hour intervals) are then averaged in time in order to form monthly climatological fields for the Mediterranean region. In

fig.1 we show the wind stress field for a typical winter and summer month. We should mention here that the monthly wind stress fields produced with this particular method from the ECMWF re-analysis wind velocity data, compare very well with the results of [1] for the Mediterranean region.

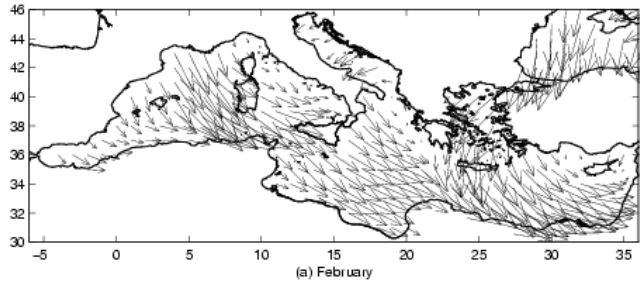

Figure 1 . Wind stress field for a typical winter (upper part) and summer (lower part) month, in the Mediterranean Sea.

The results of the different bulk formulae are summarized in Table I in terms of annual mean values. The formula of May [3] for the longwave radiation combined with Kondo scheme [4] for the calculation of latent and sensible heat flux give a strongly positive (+28.9 W/m2) heat budget for the Mediterranean. If instead we use the Bignami formula [5] for the calculation of longwave radiation the heat budget drops to +17.3 W/m2 (Kondo – Bignami set). Finally, the best set of formulae which gives a negative annual heat budget for the Mediterranean (-7.2 W/m2) is the neutral Budyko scheme [6] for the calculation of latent and sensible heat fluxes along with the Bignami formula for the longwave radiation (Budyko – Bignami set)

Table 1. Annual mean values of heat budget components obtained using various bulk formulae.

Formulae	Q_s (W/m^2)	Q_B (W/m^2)	Q_e (W/m^2)	Q_h (W/m^2)
Reed	201.67			
May		78.76		
Bignami		90.33		
Neutral Budyko			106.18	12.42
Kondo			82.81	11.16

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ECOSYSTEM RESPONSE TO THE ATMOSPHERIC FORCING IN THE SOUTHERN LIGURIAN SEA IN 1997–1999

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Abstract

A coupled hydrodynamic-biological model — *MODECOGeL* [1, 2] — is applied to the southern Ligurian Sea. The model is forced with a high sampling meteorological data measured from an automatic weather station located in STARESO (Calvi, Corsica). Two simulations (from October 1997 to September 1998 and from October 1998 to September 1999) have been performed with the model. The results corroborate the general pattern of phytoplankton seasonal dynamics observed in SeaWiFS remote-sensed data and, in particular, the higher phytoplanktonic biomass observed in 1999 is well reproduced by the model [3].

Keywords: Ligurian Sea, models, blooms

Introduction

The biological production heterogeneity of the Ligurian Sea is closely associated with local and regional hydrodynamical factors, especially those responsible for a high variability of the mixed layer depth in such a strongly stratified environment. This area is typically oligotrophic and therefore, any supply of nutrients is extremely important for the primary production. Moreover, the overall system is dominated by a marked seasonal cycle as a result of the meteorological signal, with high phytoplankton biomass observed during cold windy winter-spring period. The intensity of winter-spring phytoplankton bloom also performs a significant interannual variability. The difference between two seasonal cycles (from October 1997 to September 1999) illustrates the response of phytoplankton dynamics to local meteorological conditions. We develop here a model in order to explain the observations obtained from satellite data [3], especially the higher phytoplanktonic biomass found in 1999. Considering that the establishment and decay of the thermocline are strongly dependent on the atmospheric conditions, the model will be forced by surface wind stress and heat fluxes computed from real meteorological conditions, a high rate sampling meteorological data allowing simulations that give confidence in the mixed layer dynamics [4].

Model

The coupled **MODECOGeL** model, implemented, calibrated and validated for the northern Ligurian Sea using long term (1984–1988) experimental data from the French Frontal program surveys, is thoroughly presented in [1][2]. The hydrodynamic model is a 1D version of the multi-levels, turbulent closure, G.H.E.R. (***G****eo****H****ydrodynamics and* ***E****nvironment* ***R****esearch*, University of Liège, Belgium) model. The ecosystem model is a 12 state variables one based on the L.O.B.E.P.M. (***L****aboratoire d'****O****céanologie* ***B****iologique et d'****E****cologie du* ***P****lancton* ***M****arin*, University of Paris VI, Villefranche-sur-mer, France) works. It takes into account 12 state variables based on size-classes. It is worth attention that, while the annual average of wind intensity was higher during the year 1997/1998 than in 1998/1999 (5.07 m/s versus 4.94 m/s), the year 1997/1998 was characterized by higher winds during autumn, spring and summer while during the year 1998/1999 the winter was windier. The winter winds are particularly important for the deepening of the mixed layer.

Results and discussion

Among the results of the model, we will focus on distributions of turbulent kinetic energy (Figures 1a and 1b) and temperature (Figures 1c and 1d) for both periods (97/98 and 98/99). The observation of the turbulent kinetic energy indicates that winter mixing was clearly more intense in 1999, where the mixed layer deepened down to 400 m at the end of February. The beginning of the stratified period started in May. This effect was faster in May 1999 (windier than May 1998) while the surface warming was higher in May 1998. As soon as the end of May, this tendency was reversed. In 1999, the summer (less windy) was characterized by a higher surface temperature and a sharp thermocline. This one was less deep than in 1998. The end of September 1998 was marked by a strong wind event followed by a drop of the mixed layer depth and the thermocline. The complete destratification took place sooner in winter 1998/1999 as compared to winter 1997/1998 because of a windier winter.

Figure 2 shows the time-depth distribution of nitrate and chlorophyll for both years. It appears clearly that the 1999 bloom is higher than the one in 1998. At the light of physical results one can explain the higher phytoplanktonic biomass in 1999. The year 1999 shown a very strong winter mixing – as compared to 1998 – that could allow an important nutrients supply in the surface layer, giving rise to an intense spring bloom. An important nutrient input constitutes storage for the summer and should allow, in favourable meteorological conditions, to ensure a summer more intensive phytoplanktonic production despite of the strong stratification. On the other hand, during winter 1997/1998, the less intense mixing is not sufficient to bring up high nutrients concentration into the euphotic layer, resulting thus in a weaker phytoplanktonic production.

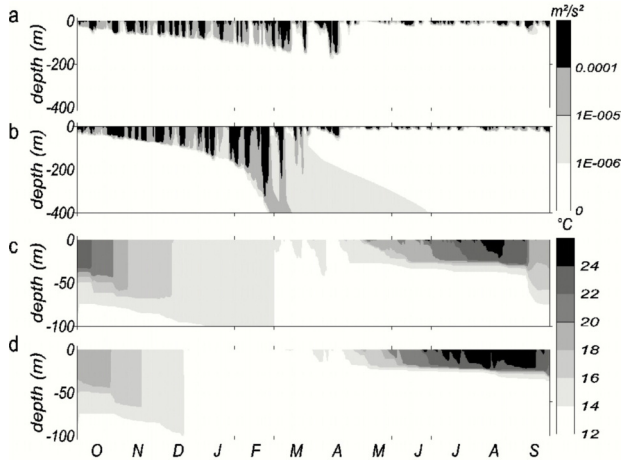

Figure 1. Time-depth evolution of the physical variables computed by the model. Turbulent kinetic energy (a) in 1997-1998 and (b) in 1998-1999. Temperature (c) in 1997-1998 and (d) in 1998-1999.

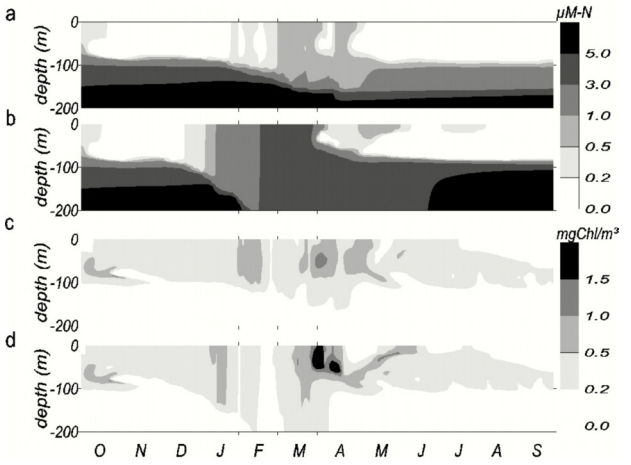

Figure 2. Time-depth evolution of the biological variables computed by the model. Nitrate (a) in 1997-1998 and (b) in 1998-1999. Chlorophyll (c) in 1997-1998 and (d) in 1998-1999.

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A NUMERICAL STUDY ON THE CAUSES OF THE EASTERN MEDITERRANEAN TRANSIENT : THE ROLE OF THE NORTHERN AEGEAN AND THE BLACK SEA WATERS

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Abstract

We investigate the role that the Northern Aegean Sea and the Black Sea waters might have played in triggering the Eastern Mediterranean Transient. Our results indicate that neither a decrease (even a total absence) of the low salinity Black Sea waters and/or a simple cooling of the Northern and Southern Aegean can be considered responsible for the production of the EMT in the Southern Aegean Sea.

Keywords : Aegean Sea, Circulation models, Deep waters, Eastern Mediterranean

Introduction

In the late 80's and early 90's an abrupt climatic change (the EMT) occurred in the Eastern Mediterranean Sea, by which the deep water formation site moved momentarily from the Adriatic Sea to the Southern Aegean Sea (Cretan Sea). [1], [2], [3], [4], [5]. The origins and causes of the EMT have been the object of some controversy. Some [2], [3], stress the combined role of the salinity increase in the Cretan Sea during the late 80's and the very cold winters of 92-93 which triggered the very large amount of high density waters produced in the Cretan Sea, others [4], claim that the EMT was solely caused by extra cooling, and the observed salinity increase is a consequence and not a forerunner of the event, while finally [5] based on data analysis of water masses at various years, claim that the EMT was triggered in the Northern Aegean where dense waters were formed due to low temperatures and possibly reduced inflow of the low salinity Black Sea waters in to the Aegean which then influenced the Southern Aegean Sea. We further investigate the question of the EMT with a series of numerical experiments focusing mostly on the eventual role of the Black Sea waters and the Northern Aegean Sea.

The numerical model

We use an implementation of the POM model with a horizontal resolution of 1/20 of a degree (~ 5.5 km) in both horizontal directions with 30 sigma levels in the vertical. The model is initialized with the MED4-MODB data set and is forced with monthly values of a 'perpetual year' forcing atmospheric data set derived from the 1979-1993 6-hour ECMWF reanalysis data. The model includes a parameterization of the Dardanelles outflow with a salinity of 28.3 psu and a mean volume of 10000 m^3/sec. The results of the 3rd year of the climatological run are kept as out reference experiment to which all other subsequent runs are compared.

Numerical experiments

We conducted a series of 5 numerical experiments (including the reference run). With these experiments out intention is a) to investigate the possible effects of the Black Sea waters and b) to examine the role of extra cold winters in the area. See table 1.

Table 1: Description of numerical experiments conducted and corresponding forcing applied

Experiments	Dardanelles	Extra cooling in degrees Celsius	
		N. Aegean	S. Aegean
1	Yes	0	0
2	No	0	0
3	No	-2	0
4	No	0	-2
5	No	-2	-2

The switching-off of the Dardanelles outflow is of course an extreme condition which we nevertheless impose to validate their impact in winter dense water formation in the Northern and Southern Aegean Sea. The extra cooling is applied by decreasing the air temperature by 2° Celsius from January up to March in each consecutive year which results in an SST decrease of 0.5° C approximately. We believe this to be more realistic than the 2° C drop in SST used in [4] which in fact implies a much more important decrease of atmospheric temperatures (of the order of 8° C). All above experiments were run for three years following the climatological run and the results of the last year are compared to climatology.

Results and discussion

In experiment 2 we observe an increase in deep waters densities in the Northern Aegean (by 0.05 sigma-t units), which is further enhanced in experiment 3 (0.1 sigma-t units). A very small increase (0.01) of density is observed in the Western Cretan sea. No EMT produced. In experiment 4, we obtain slightly lighter waters in the Northern Aegean compared to experiment 3 and a relatively important increase of densities in the Western Cretan Sea by .05 (29.28). Still no EMP produced although a small volume of dense waters starts to appear in the Western Cretan Sea. Finally the experiment 5 results are an almost perfect combination of experiment 3 and 4 with no synergies observed.

From all the above we conclude that without the salt preconditioning observed in the Cretan Sea (not simulated in any of our experiments) the EMT is not realistically produced. In our various experiments we have tried various forcings that might be responsible for the EMT with the exception of one which is the very important salinity increase observed in the data of the Cretan Sea prior to the occurrence of the EMT. We ended up not producing the EMT. In contrast to [3] where this effect was simulated and the EMT successfully produced. We conclude that the salt preconditioning (either due to increase of evaporation and/or increase of salty water inflow from the Levantine basin due to circulation pattern changes as mentioned in [3], play a major crucial role in producing the EMT.

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INTERANNUAL VARIABILITY OF THE CIRCULATION IN THE BALEARIC CHANNELS (1996-2000)

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Abstract
Two well differentiated flow regimes have been observed in the Balearic Channels during 1996-2000, linked to the presence (1996 and 1999-2000) or not (1997-98) of large amounts of Winter Intermediate Water (WIW). In some years, large WIW eddies can in fact drastically modify the channel circulation. This points out the connection between the water exchange through the channels and the winter climatology in the northern Mediterranean where mainly WIW are formed (1).

Key-words: Intermediate waters, circulation, hydrography, Balearic Sea.

Introduction

In the framework of the MATER project (UE-Mast III - 1996-99), we monitored the hydrodynamics in the Balearic Channel during 1996-98. Sixteen hydrographic surveys were carried out and five mooring lines were deployed (2). Part of this research has been continued in the frame of the Spanish project CIRBAL during 1999-2001 to further investigate the interannual variability of the channel circulation.

Circulation regimes

During 1996, the predominant winter flow regime was dominated by the southward Northern Current (NC) carrying large amounts of northern waters into the Ibiza Channel. This flow decreased during spring as wind forcing in the north relaxed (3), and a large, deep anticyclonic eddy (AC96) was observed, trapped to the north of the Ibiza Channel, partly deflecting the NC toward the Mallorca Channel. This eddy was composed of a large amount of WIW. In summer, the NC almost vanished, allowing moderate northward inflows of Modified Atlantic Water (MAW) through the Ibiza Channel. The NC was entirely deflected into the Mallorca Channel due to the combined obstruction effect of eddy AC96 and MAW inflows in the Ibiza Channel. Eddy AC96 was eroded during summer and, in fall, the re-intensified NC was detected flowing in the Ibiza Channel again.

A different circulation regime was observed during 1997 and 1998, characterized by low amounts of WIW. This time, the main core of the NC was almost systematically found in the Ibiza Channel. No major persistent eddy was observed to the north of this channel. Only sporadic anticyclonic eddies and meanders, due to the instability of the NC, were found travelling southward with the current. Thus, only during short periods of several days, while one of these eddies crossed the sill of the channel in its narrowest part, obstructing the water exchange, the NC was retroflected behind the eddy toward the Mallorca Channel. The seasonal variation of the NC was observed again, its weakening in summer allowed the northward progression of MAW through the Ibiza Channel. However, the Mallorca Channel represented the preferential pathway for the northward spreading of these waters. MAW inflows were generally moderate, but from January to June 1998, they were strongly enhanced by large anticyclonic eddies lying in the Algerian Basin to the south of the channels (4).

In 1999, a moderate amount of WIW was observed again to the north of the Ibiza Channel. Also, as in 1998, a large anticyclonic Algerian eddy lied to the south of Ibiza driving MAW into the Ibiza Channel. The blocking effect of WIW and MAW inflows for the NC forced its deflection toward the Mallorca Channel. A vigorous Balearic Current, fed by southern (MAW) and northern (NC) waters, thus was flowing over the Balearic slope forming marked meanders, possibly due to an instability of the front between light (southern) and dense (northern) waters.

In 2000, CTD data collected in the Mallorca Channel evidenced the presence of WIW there. It is thus very likely that WIW was also present in the Ibiza Channel. Satellite imagery revealed numerous eddies in the Gulf of Valencia to the north of the Ibiza Channel, and, most probably, they impeded the southward progression of the NC. This interpretation was confirmed by the trajectory followed by a drifting buoy which was deployed (01/06/2000) off Cape Creus and recovered one month later (05/07/2000) in the Mallorca Channel. WIW lenses were observed in the Ibiza Channel during a survey in September and again as late as in November.

Conclusion

The analysis of this multi-year data set evidences that WIW eddies can significantly alter the flow regime in the Balearic Channels. Large amounts of WIW, as those dectected in 1996, 1999 and 2000, which reach the channels in early spring, seem to favour eddy activity at the edge of the NC and the formation of eddies (as eddy AC96) which are too large and deep for drifting through the Ibiza Channel. Thus, they remain trapped to the north of the channel until fall and partially deflect the NC eastward. This blocking effect is enhanced by the northward spreading of southern waters through the channel, a characteristic of the spring-fall period also. The eddy activity seems to be reduced with smaller amounts of WIW (1997 and 1998): eddies are smaller, shallower, and likely less numerous, and can cross the sill. As a consequence, they do not induce any long-term deflection of the NC. The northward inflows of southern waters alone are not energetic enough for forcing the deflection. All these observations are in good agreement with numerical simulations of the Balearic Sea (5). In conclusion, our analysis points out the importance of eddy formation, linked to the unstable character of the NC, for the water exchange through the Balearic Channels, and for the meridional tranport of properties in the western Mediterranean. It also establishes the link between eddy activity and the interannual variability of WIW formation in winter. Historical data show that during the period 1985-2000, quite large amounts of WIW were present in the Balearic Channels almost all years except in 1997 and 1998. This would suggest that the deflection of the NC forced by WIW eddies before reaching the Ibiza Channel is the 'normal' flow regime from spring to fall (following, hence, normal or cold winters) whereas the direct southward path of northern waters through the eddy-free channel during this period is an 'exceptional' flow regime (following, hence, very mild winters).

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THE ROLE OF OPTICAL PROPERTIES IN THE KASTELA BAY DYNAMICS

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Abstract
Optical properties in the coastal area of the Adriatic Sea have changed with respect to the conditions that reigned several decades ago. Numerical experiment was performed including different optical conditions for the heat transfer, which resulted in different vertical thermohaline structures for the two water types.

Key words: numerical model, Kastela Bay (Adriatic Sea), optical water types

Introduction

The part of heat energy transfer is affected by optical properties of the sea (transparency), which however in the last decades showed decreased trends, due to the man-made pollution in most of the shelf areas. The hypothesis is that optical conditions of the heat transfer may have significant dynamical effect. Therefore the optical water types (according to Jerlovs' (1) classification) characteristic for the earlier period in the Kastela Bay (coastal area in the Middle Adriatic) and for the type prevailing recently (2) were used in the numerical hydrodynamical model. As the first approximation, the whole Bay was taken to have the same optical type (Ib or III).

The non-linear levels model was used, described in details in the paper by Bone (3). Here, optical water types Ib and III were introduced, by a spectrally simplified representation of a single coefficient for the respective water type. Extinction coefficients were taken for the short-wave (VIS) and long-wave (IR) ranges respectively, according to Paulson and Simpson (4). Heat transport was defined with the "bulk" method, whose empirical coefficients were taken according to Large and Pond (5). Other coefficients in the model were used from Haurwitz (6) and Pyne (7).

Climatological mean value (9 m^3/s) was taken for the Jadro river input. Meteorological conditions are from 23.01.1978 as follows: the eastward wind direction with the speed 10 m/s; air temperature 14°C; relative humidity 70 % and cloudiness 2/10. The control point of the model was in the middle of the Bay, which is the location of the long-term oceanographic station. Horizontal grid step was 300m, and vertical step1m. The tides were taken according to Mosetti and Manca (8) for Split.

Results and discussion

In the numerical simulation, at the surface layer (Fig 1) for the reference point in the Bay, temperature increased when switching from type Ib to III, before the equilibrium state was established, after two

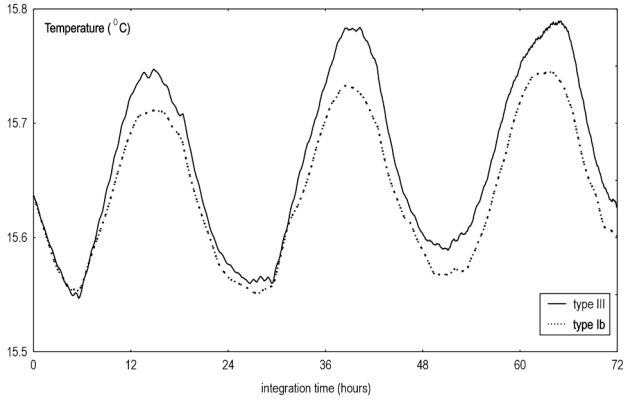

Figure 1. Temperature course with the integration time for the optical water types Ib and III in the surface layer.

days.

The temperature course changed regularly throughout the day but had increased temperature trend with the integration time. Stronger heating in the surface layer was obtained in the optical type III.

The highest temperature differences between the two water types are observed in the vertical temperature profiles (Figure 2) in intermediate layer at the end of the integration period, which demonstrates

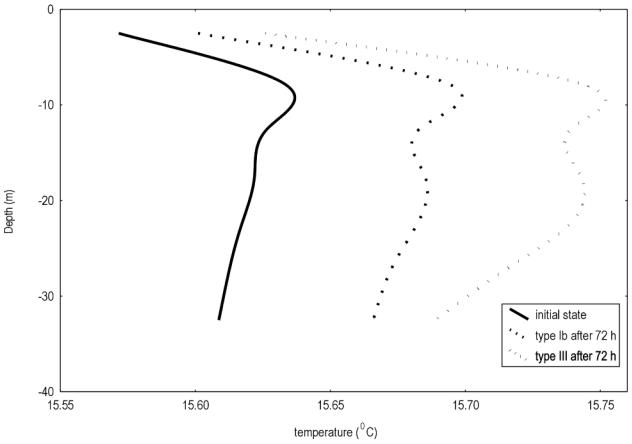

Figure 2. Vertical temperature structures after 72 hours of integration time for optical water types Ib and III.

accumulation of solar energy in the intermediate and surface layer.

Vertical salinity profiles does not differ between the two optical water types. Density changes accordingly to increased temperature in the whole layer for the type III, but more in deeper layers. Vertical profile of v current component is stronger in type III relative to the type Ib, while u component remained unchanged.

Conclusions

Long-term trend of decrease in transparency in the last thirty years can be recognized as a change in optical water type. Introducing global radiation and different optical water types in the model, had significant consequences in the Kastela Bay temperature profiles, currents and density, but did not change the salinity field.

The less transparent optical water type (III) kept more thermal energy in the intermediate layer, leading to the more stratified conditions.

Since transparency has decreasing trend in most of the coastal areas, further investigation should include optical water types and all the consequences that they may cause, like the trends of the heat budget, changes in dynamical stability and currents etc.

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A REASSESSMENT OF THE MEDITERRANEAN RIVER RUNOFF

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Abstract

An estimation based on field measurements of water flow from 69 rivers has shown that the Mediterranean drainage basin (some 4,135,000 km^2) has the ability to provide 570 km^3 (0.23 myr^{-1}) of freshwater. During the second part of the 19th century the construction of thousands of small and big dams has reduced this natural freshwater flow almost to the half. This reduced value corresponds to 0.11 myr^{-1}, which is comparable to the Black Sea net outflow .

Keywords: Mediterranean, rivers, freshwater, water-balance

Introduction

The Mediterranean drainage basin covers an area of about 4,135,000 km^2, incorporating more than 160 rivers, with catchment areas larger than 200 km^2. Overall, there are only a few rivers with drainage basins larger than 50x10^3 km^2: the Ebro (Spain); the Rhone (France), the Po (Italy), the Moulouya (Algeria), and the largest river Nile (Egypt).

The freshwater inflow controls the overall water balance of the basin being one of concentration, whereby evaporation excess precipitation and runoff by some [1] 0.6 myr^{-1}. A recent river runoff estimation [2] gives a value of 0.2 myr^{-1}; this denotes the importance of the river inputs, as they account for one third of the water deficit. Thus, any changes in the river runoff would affect substantially the freshwater budget, which is linked strongly with the overall functioning (thermohaline circulation, dense water formation) of the Mediterranean Basin system [3]

In the present investigation, based on field measurements, the overall river inputs is quantified and the significance of the smaller rivers is revealed. The effects of the dam construction on the magnitude of the natural freshwater flux are examined and the freshwater contribution into the Mediterranean water budget is re-assessed.

Data and Methods

In order the overall water load to be calculate, the Mediterranean rivers and their catchment have been divided into 5 geographical regions (PR), considering their geographical locations and climatological conditions (Fig. 1). Subsequently, the water yields (m^{3}km^{-2}) for each of the 5 PR was estimated. This estimation is based upon the calculation of the weighted average of the corresponding water yields from field-measurements of the water fluxes of 69 rivers discharging along the Mediterranean coastline. Subsequently, the mean (weighted) value for each PR was calculated, using the known water yields and the weighted area of the watersheds corresponding to the measured water fluxes (Table 1).

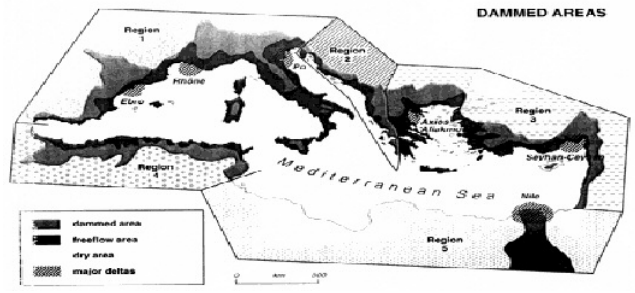

Figure 1: Physiographic regions (1-5) and corresponding dammed areas. Key: (1): the area covered by the field measurements (in parenthesis the percentage relatively to the total area is given; (2): the number of rivers associated with field measurements (in parenthesis the total number of rivers is given); (3): in parenthesis the percentage relatively to the total freshwater load is given.

Results and Discussion

The Physiographic region PR^{-1} supplies annually the largest amount of fresh water (254 km^3), whilst the lowest fluxes are associated with PR^{-4} (12 km^3). The overall (potential) annual freshwater load estimated to be some 570 km^3 (0.23 myr^{-1}). But within the second half of the 19th century the construction of almost 3000 dams [4] has reduced the (natural) drainage basin area of the Mediterranean by 78%. Furthermore, an analogous reduction has been caused in the overall water supply within each physiographic region, in response to dam construction. Thus, the overall estimation of the freshwater load retained behind the dams accounts accordingly some 297 km^{3}yr^{-1} which corresponds to 52% of the total water volume i.e only 273 km^{3}yr^{-1} reach the ocean.

Table 1. Estimation of the annual freshwater yields and loads before and after damming

	Water yield (10^3 m^3/km^2)	Area[1] (10^3 km^2)	Rivers[2]	Water load (km^3)	Dammed Area (10^3 km^2)	Water load after damming (km^3)
PR-1	517.50	299.1 (75%)	30 (83)	254	~225	137(54%)3
PR-2	1050.00	48.4 (81%)	11 (19)	63	~31	31(49%)
PR-3	440.00	71.8 (21%)	11 (36)	150	~125	94.5(63%)
PR-4	55.25	150.6 (71%)	16 (21)	12	~145	3.6(30%)
PR-5	30.00	3035 (99%)	1 (5)	91	~2800	7.3(8%)
Total			**69(164)**	**570**	**3326**	**273 (48%)**

If we add to this figure the net Black Sea outflow, which according to a recent estimate [5] is around 260 km^{3}yr^{-1}, the resulting sum corresponds to an annual total runoff of 0.21 m. It has also been estimated [6] that the divergence of the vertically integrated horizontal water vapour fluxes to be around 0.66 myr^{-1}. A subtraction of 0.52 myr^{-1}, the estimated net inflow from Gibraltar strait [1], yields an implied effective runoff (Med. Rivers + Black Sea) around 0.14 myr^{-1} a value slightly less than the one estimated in this work.

Finally we would like to stress that the fresh water contribution of the major river systems (drainage basins >104 km^2) is shown to be smaller than what was assumed in earlier studies, as it represents only the 37% of the total influx. For exapmle the R. Nile before dumping contributed only the 16% of the total annual freshwater input.

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THE EFFECT OF THE BORA ON THE ADRIATIC SEA: A COMPARISON WITH TWO THREE-DIMENSIONAL OCEAN MODELS

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Abstract

This paper refers to the comparison of two three-dimensional (3D) numerical models for the Adriatic Sea when the atmospheric forcing is represented by a simple bora wind. Starting with the same initial condition and considering the basin closed at the Otranto Strait, after five days of simulated time both models reproduce quite well some characteristic phenomena induced by this wind (for instance, the upwelling along the Albanian coast and the horizontal gradient of the sea level in the northern areas). Since some differences are noticed for other features (i.e. the horizontal velocity field and the absolute value of the above mentioned gradient) further studied are required.

Keywords: Adriatic Sea, Models.

Echoing a recent paper addressed to the Lake Michigan [1], two 3D ocean models have been applied to the Adriatic Sea for the better understanding of the effect of meteorological forcing (in the present case, the bora wind) on the marine circulation. The first model is the DieCAST - z-level coordinates, "rigid lid" approximation. The second one is the POM - sigma coordinates, free surface. Since the terrain-following coordinate system is more convenient for coastal processes as upwellings while the z-level system is more appropriate for areas characterized by strong bottom variations, a comparison between the two models is particularly useful for the Adriatic because it is a semi-enclosed basin with relevant topographic changes. Moreover, recalling that the bora induces intense upwelling phenomena along the Albanian coast and noticeable sea-level variations in the northern coastal areas, this basin needs particular care when a particular numerical model is chosen for describing the most relevant features of its dynamics. In the following we describe briefly the main results of this study.

After five days of simulated time with a constant and simplified bora affecting the whole basin [2], both models give similar horizontal patterns for the temperature and salinity fields. They produce a strong upwelling along the Albanian coast although the DieCAST shows less computational noise with respect to the POM. This statement is confirmed by the vertical distributions of temperature (Fig. 1 a,b), salinity, zonal and meridional velocities for a transect at the latitude of 41N. Vertical distributions of meridional velocity are quite similar for both models until five days of simulation. However, some differences are evident along Albanian coast if the simulations are carried out for ten days (Fig. 1 c,d). Regarding the surface velocities, the POM shows large sub-basin gyres (Fig. 2) quite different from the DieCAST that produces large scale meanders (Fig. 3). This difference appears remarkable in the southern Adriatic where the above mentioned upwelling appears. Finally, the comparison between the equivalent surface anomaly (DieCAST) and the free surface (POM) shows similar structures (Figs 2, 3). In particular, both models produce the well known sea level gradient between Venice and Trieste, though the DieCAST underestimates such a parameter because its inherent approximation for the surface pressure.

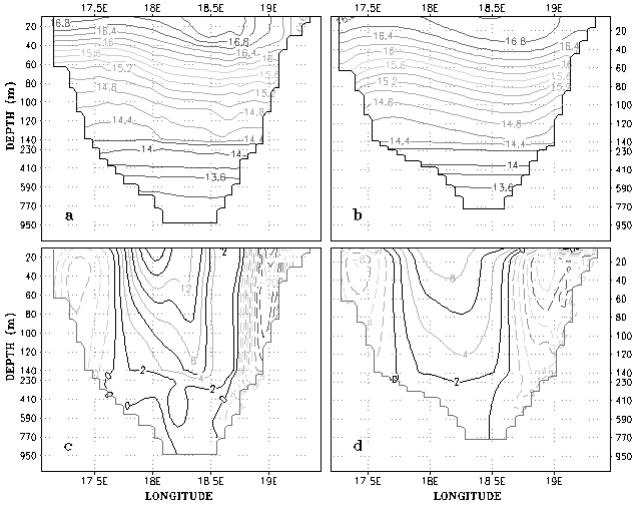

Figure 1. Zonal cross section at 41N of temperature distribution simulated by (a) POM and (b) DieCAST after 5 days. Zonal cross section at 41N of meridional velocity simulated by (c) POM and (d) DieCAST after 10 days.

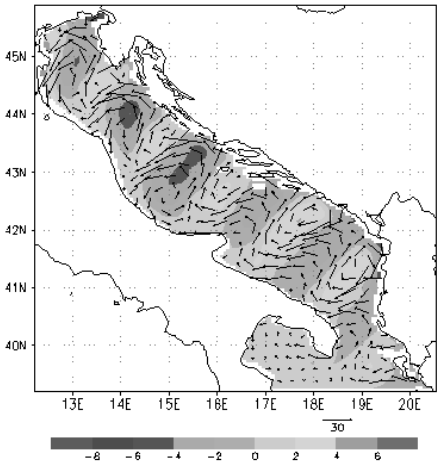

Figure 2. POM: simulated sea surface currents and free surface elevation.

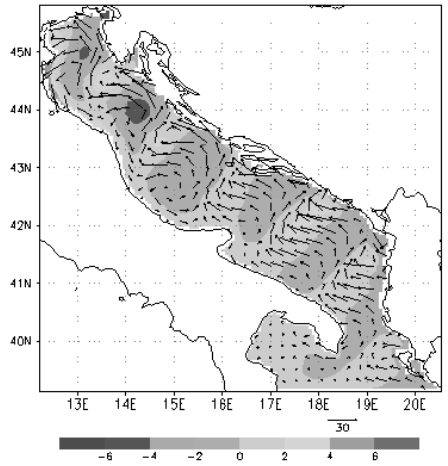

Figure 3. DieCAST: simulated sea surface currents and equivalent free surface anomaly.

In conclusion, although the two models are based on different numerical schemes and different turbulence closure parameterizations, their use for the Adriatic Sea seems to produce similar features with the exception of the sea level values in coastal areas and the current patterns. Based on this preliminary results, further studies are now scheduled keeping in mind the comparison of model simulations with experimental data sets.

Acknowledgment

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PRELIMINARY RESULTS OF CURRENT AND TEMPERATURE MEASUREMENTS COLLECTED IN THE CHANNEL OF SARDINIA FROM JULY 1999 TO APRIL 2000

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Abstract

Current and temperature data were collected in the channel of Sardinia with 12 currentmeters set on 5 moorings at intermediate and great depths during a 8-month experiment. Improving our understanding of the circulation there is essential since this is a key area where, in particular, most of the dense water formed in the Western Mediterranean (in the Gulf of Lions) is expected to flow eastward (before sinking in the deeper part of the Tyrrhenian sea), while a mixture of the densest Eastern and Western Mediterranean waters is expected to flow westward.

Key-words : currents, temperature, strait and channel, Eastern Mediterranean, Western Mediterranean.

Experiment description

Five moorings were deployed across the Channel of Sardinia (from 38°06' N-09°18' E to 38°32' N-08°47' E, i.e. along an MFSPP XBT-transect) in July 1999 and recovered in April 2000 with the INSTM[2] R.V. "HANNIBAL". Moorings, named M1 to M5, were spaced ~10 miles apart (Fig.1) and equipped with Aanderaa currentmeters set at 500 and 900 m (M1 and M5), 1000 and 1400 m (M2 and M4), 500, 1000, 1400 and 1900 m (M3) with a 1 hour sampling interval. This mooring array is thus more complete than the one previously analysed by Bouzinac *et al*. [1] in the same area.

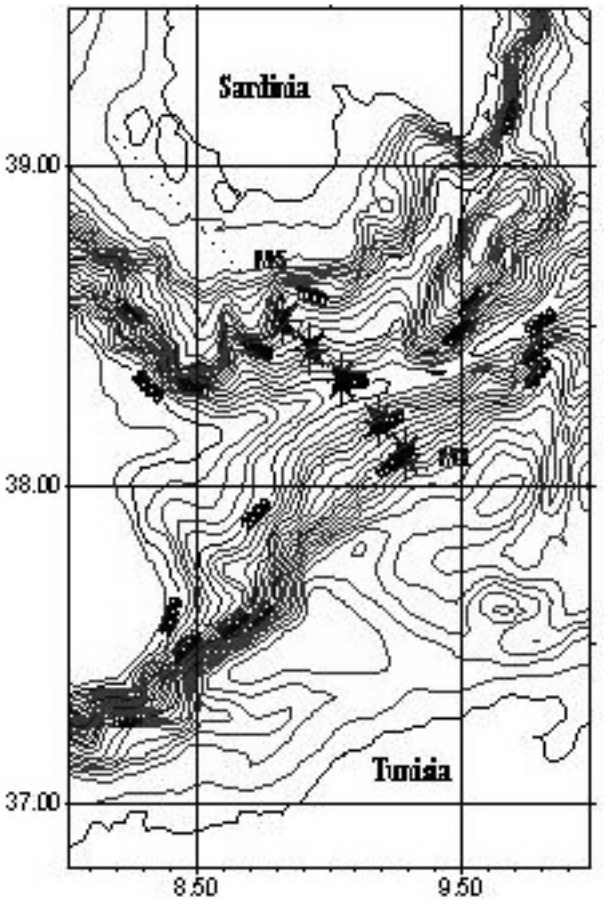

Fig.1: Moorings location and 100-m spaced isobaths

Data and data processing

Instrumental problems have delayed the data analysis but several results have already been obtained that will be completed in the forthcoming months. First, and in order to check the validity of some automatic and hand-made corrections to instrumental problems, a tidal current analysis has been made (Fig.2) and successfully compared with results already obtained in the Algerian basin [2]. All statistical computations have been made.

Preliminary results

Progressive vector diagrams (Fig.3) combined with related temperature record (ie by displaying each point of the PVDs with a colour representative of temperature, but this kind of figure can't appear in this present paper) clearly illustrate the fact that, as expected, intermediate and deep

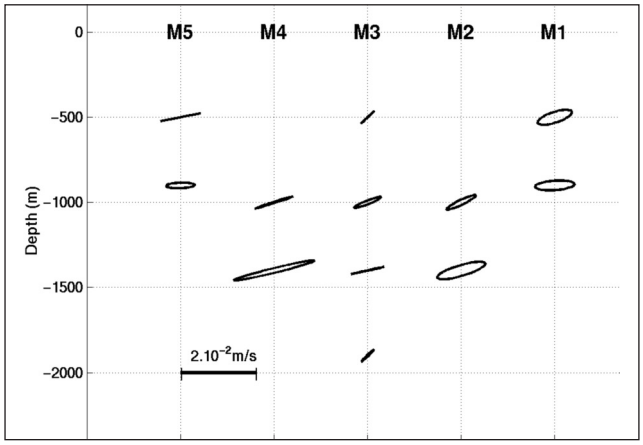

Fig.2: Ellipses for M2 at each point of the five moorings

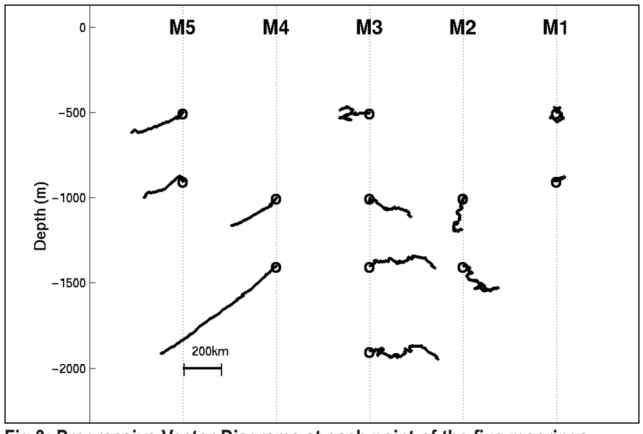

Fig.3: Progressive Vector Diagrams at each point of the five moorings

waters are relatively cool and flow eastward along the Tunisian slope while they are relatively warm and flow westward along the Sardinian slope. Comparisons with XBT data support the relatively large variability of the temperature distribution across the channel, as already evidenced by Sammari *et al*. [3].

An empirical orthogonal functions analysis is on hand to try specifying the characteristics of thevarious flows, determining whether the eastward and westward flows are correlated or not.

Acknowledgements

We warmly thank the crew of the INSTM[2] R.V. « Hannibal » for their kind welcome and active participation during the campaign.

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THE D18O VARIABILITY OF SOUTHEAST MEDITERRANEAN WATER MASSES (OFF THE ISRAELI COAST)

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Abstract
The annual and seasonal variability of salinity, temperature and oxygen isotopic composition ($\delta^{18}O$) of the southeastern Mediterranean water-masses (off the coast of Israel) was studied during two consecutive years (June'96 – May'98). The $\delta^{18}O$ values of the Levantine Surface Water varied between 1.3 and 1.7‰VSMOW, without a distinct seasonal pattern. The variability in $\delta^{18}O$ values during summer is due to changes in evaporation rates. While during winter, the combined effect of winter overturn and evaporation rates, as well as rainfall and its $\delta^{18}O$ signal, modify the surface-water $\delta^{18}O$ values. The intermediate and deeper waters have nearly constant values of ~1.5‰ and ~1.3‰ respectively throughout the year.

Key-words: oxygen isotope composition, water masses, southeastern Mediterranean

Introduction

The Mediterranean is a semi-enclosed sea characterized by an anti-estuarine thermohaline circulation resulting from the excess of evaporation over precipitation plus river runoff. North Atlantic surface water that enters the Mediterranean moves eastward and spreads from Sicily Straits through the southeastern Mediterranean (SEM) undergoing progressive modifications due to air-sea interaction. The water becomes warmer and saltier and reaches the EM as Modified Atlantic Water (MAW) (1-3). During the summer, a shallow ephemeral water-layer, defined as the Levantine Surface Water (LSW) is formed (4,5). The surface water layer displays a high annual-interannual variability related mainly to the position of atmospheric pressure cells (6). Recent studies (2,6-8), have shown that the EM thermohaline circulation has changed considerably since'87. Until `87 the Levantine Intermediate Water (LIW) was formed in the Rhodes Gyre and the Deep Water (DW) originated in the south Adriatic Sea. After that, and due to changes in large scale freshwater balance, the Cretan/South Aegean Sea became an additional source of DW.

Because of the sensitivity of the EM to large amplitude interannual variability (6) we initiated this study that aims to determine the $\delta^{18}O$ seasonal and annual variability of SEM water-masses as well as their temperature and salinity characteristics.

Sampling and Methodology

Water samples were taken during twelve consecutive bi-monthly cruises (June`96 May`98) on board of the R/V *Shikmona*. The upper 700 m were sampled at a permanent station (32°28.23'N; 34°36.61'E), ~30 km off the Israeli coast. During each cruise, continuous vertical profiles of T, S and O_2 concentration were measured by a Sea-Bird SBE 9 + electronic CTD. Water sample were taken from 1.7-liter Niskin bottles mounted on a General Oceanics Rosette and were stored in darkness at ~4°C for the $\delta^{18}O$ analyses. The $\delta^{18}O$ measurements were carried out using a VG SIRA-II mass spectrometer. The values are reported in ‰VSMOW. The analytical precision is 0.01‰, and the reproducibility is better than 0.1‰.

Results and Discussion

$\delta^{18}O$ variability in surface water

The results show that the $\delta^{18}O$ values of the LSW varied repeatedly between 1.3 and 1.7‰VSMOW, without a distinct seasonal pattern. The stable isotope signal of the surface layer is very sensitive to local and short-scale climatic events of days and weeks. During summer, the $\delta^{18}O$ variability is influenced mainly by the evaporation rate. During winter, the system is more complex and the variability is the result of the combined effect of evaporation rate, rainfall $\delta^{18}O$ value and rainfall amount, as well as the winter overturn rate (thickness of the mixed layer). During rain/snow storms, the $\delta^{18}O$ values of the LSW dropped to ~1.4‰. In other winter events, higher $\delta^{18}O$ values of ~1.6‰ resulted from the overturn and mixing of the surface layer with the denser underlying LIW.

The seasonal and interannual d18O variations with depth

Unlike the frequent variability of the surface-water $\delta^{18}O$ values, the LIW and DW had nearly constant values of ~1.5 and ~1.3‰, respectively, that generally correspond to the salinity and temperature profiles (Fig. 1). Between October and December `96, exceptionally high $\delta^{18}O$LIW values of up to ~1.8‰ occurred between ~200-400 m water depth, probably reflecting an extreme formation event of intermediate water at the northern part of the Levantine basin. This $\delta^{18}O$ increase indicates a change in the freshwater forcing or a redistribution of salinity in the northern EM similar to the dry climatic event that occurred between `87 and `95 (3,7,8).

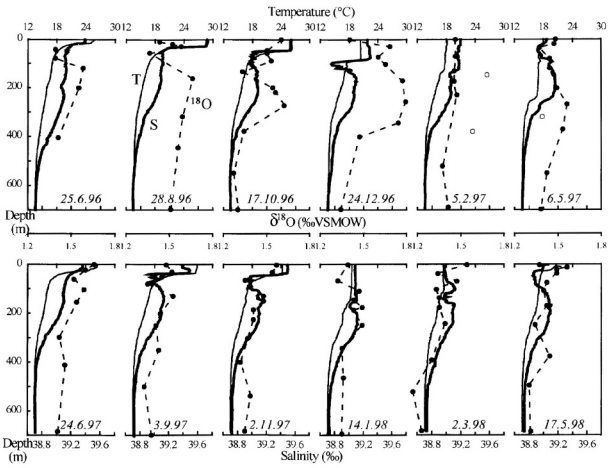

Fig. 1. d18O, temperature and salinity variations during the studied period.

Conclusions

The eastern Mediterranean water-masses (off the Israeli coast) have a distinct oxygen isotopic signature controlled simultaneously by several physical processes related to the atmospheric forcing. The $\delta^{18}O$ variations of the surface water results from local and short-scale climatic events of days and weeks. Changes in evaporation rates, rainfall amount and its $\delta^{18}O$ value, and the winter overturn rate may play an important role in shaping the $\delta^{18}O$ signal during the winter. Because the LIW and DW masses originate in the northern EM, abrupt evaporation/precipitation changes in the surface waters at the source area could be detected by the $\delta^{18}O$ values of these water masses.

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ECOHYDRODYNAMICS RELATED TO THE CALVI CANYON (CORSICA): A NUMERICAL STUDY.

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Abstract

A 3-D, high resolution model is used to investigate the impact of the Calvi canyon on the ecohydrodynamics in early spring conditions. Numerical runs are performed to simulate the nitrate distribution. Results show that the canyon topography generates high downwelling (upwelling) in the western (eastern) part of the canyon. Downwelling is larger than upwelling within the canyon leading to a net downward nitrate transport there, while upstream and downstream of the canyon there are regions of upwelled water richer in nitrate. Simulations are performed for NE, upwelling favorable, wind conditions where data of nitrate concentration are available for model validation.

Keywords: Upwelling; Coastal models, Continental slope; Primary production.

Introduction

Submarine canyons appear to be preferential sites for shelf-slope exchanges and vertical motion, features which can have important implications on the dynamics of plankton ecosystems. The deflection of deeper offshore currents up canyon can induce a nutrient transport into the euphotic zone, on the continental shelf, leading to the enhancement of primary production. Observations in the Calvi coastal area highlighted a complex flow structure with an anticyclonic gyre in the western part of the Calvi Bay and an offshore flow downstream of the canyon head[1]. A high horizontal gradient of nitrate concentration is observed across the canyon axis. In the present study a numerical modeling approach is used to estimate the impact of the canyon hydrodynamics on the ecological processes in the area.

Model

The study is based on the GHER 3-D baroclinic nonlinear primitive equation model using a *k-l* turbulent closure and a double-sigma coordinate system (1). The model has been applied in weakly stratified conditions corresponding to a typical early spring pre-bloom situation. A run is first performed in negligible wind conditions to reach the topography induced steady state circulation, and then in the case of a NE upwelling favorable wind. The initial conditions for nitrate distribution are determined by available measurements on the shelf.

Results

Results show that upstream of the canyon the flow is deviated onshore in shallow depths and the resulting negative relative vorticity generates a closed anticyclonic circulation in the western part of the Calvi bay, while over the canyon the flow acquires positive potential vorticity due to the depth increase and a cyclonic circulation is formed. Downwelling is generated on the western side of the canyon, whereas upwelling of lower intensity is generated on the eastern side (Fig. 1a). Nitrate concentration at 20 m depth (Fig. 2a) is everywhere lower than the initial one, consistent with a net downward motion within the canyon. On either side of the canyon there are regions of upwelled water of higher nitrate concentration. The region downstream of the canyon presents the highest values (3-4 times higher than the initial value). Simulations performed with a NE wind (10 m/s during 24 hours), show an increase of cyclonic vorticity and of vertical velocities over the canyon with upwelling almost compensating downwelling motion (Fig. 1b). Nitrate distribution pattern presents higher values over the canyon with respect to the no wind case. Increased upwelling and wind driven turbulent mixing lead to a nitrate transport through the nitracline. The regions of upwelled nitrate downstream and upstream of the canyon are now confined on the slope domain. A drastic increase of upwelling velocities and of nitrate concentration (6-7 times higher than in the no wind case) is simulated within and around the Bay (Fig. 2b) in agreement with field observations (2) (Fig.3). A phytoplankton bloom often occurs within the bay with a chlorophyll concentration maximum generally observed some days after the passage of a NE wind. On the other hand, observations do not show such efficient nitrate enrichment of the Bay during SW wind events.

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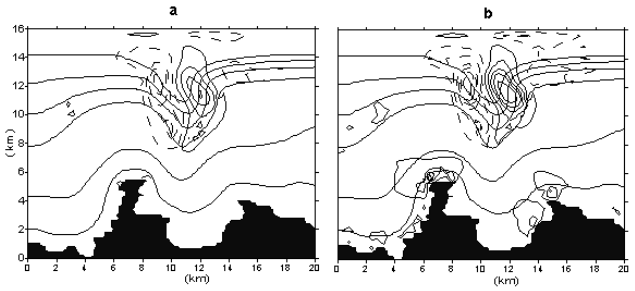

Fig. 1: Mean vertical velocities (m/s) in the upper 50m for the no wind (a) and for the NE wind (b) case. The thick solid and dashed lines indicate upward and downward flow, respectively. The contour interval is 0.0005 m/s. The 50-, 100-, 200-, 300-, 400- and 500-m isobaths are plotted with thin solid lines.

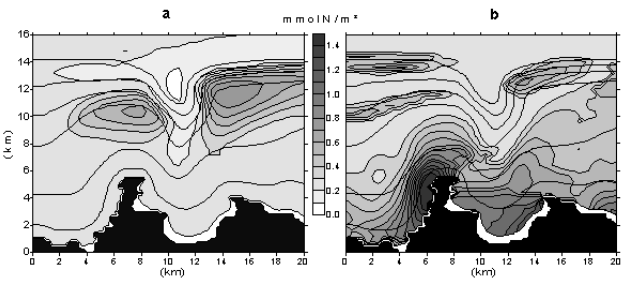

Fig. 2: Horizontal nitrate distribution at 20m for the no wind (a) and for the NE wind (b) case.

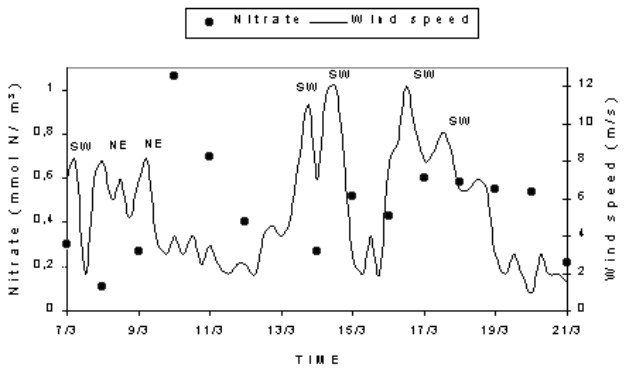

Fig. 3: Time variations of measured surface nitrate concentration (dots) and wind intensity (solid line) measured in the western part of the bay (7-21 March 1988). Headings indicate NE and SW wind event (intensity higher than 7 m/s during at least 12 hours).

AN ANALYSIS OF DIFFUSION CHARACTERISTICS IN THE HARBOUR AREA (SPLIT HARBOUR, ADRIATIC SEA)

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Abstract

An experiment, including measurements of physical, chemical and biological properties, was conducted in the Split harbour area (Middle Adriatic) in order to investigate the diffusion there. After the tracer (RHODAMINE-B) had been ejected into the sea, the oil spill was followed using three theodolites from the land and by photographing the area. The horizontal diffusion coefficient, calculated from the simple one-dimensional Okubov model, had values between 0.3 and 1.1 cm/s. Seasonally, the diffusion coefficient had higher values during summertime, while during winter it had lower values as a result of the influence of current field.

Keywords: Adriatic Sea, coastal process, sewage pollution

Introduction

Split harbour is placed on the east coast of the Middle Adriatic. The harbour is covering 0.6 km^2, with a mean depth of 5.4 m. The south entrance communicates with Bra_ Channel with maximum depths of about 70 m. The depth falls from the entrance (12-15 m), to shallow parts on the northern side (less than 2 m).

In the Adriatic Sea the diffusion studies were rare, and in one [1] the experiment was held in the area near Dubrovnik (South Adriatic). There were used two models to parametrize the diffusion: i - Joseph-Sendner approximation [2] gave the values of diffusion parameter between 0.07 and 0.10 cm , while ii - Neuman-Pierson [3] approximation gave the diffusion parameter between 0.9 and 1.9 cm/s.

Data collection

The experiment was organized in 1996 during three different seasons: in February when typical vertical isotherm is formed, in July with strong vertical stratification, and in November/December when the sea cooling is in progress. The measurements comprised the collection of CTD at 23 stations, oxygen at 7 stations and current data at 2 stations, whereas diffusion measurements were performed at three stations (D1, D2 and D3, located inside the harbour) in the way that 50 l of sea water, containing 30 g of the tracer RHODAMINE-B and diluted by 300 ml methanol and 100 ml acetone, were ejected into the sea. After the ejection, the oil spill was monitored and measured using 3 theodolites stationed on the high positions on the buildings in the harbour. Moreover, the oil spill was photographed regularly in time. The experiments were held during calm winds in order to minimize the influence of winds, waves and currents.

It should be pointed out that the experiment was organized with lots of difficulties, because the Split harbour is the second major port in the Croatian part of the Adriatic. Consequently, the ship and ferry traffic was very intensive and influenced the experiment organization. For example, the first idea was to lay two AANDERAA current meters at the entrance of the harbour, what was done during February. But, local ferries didn't pay attention to them at all, so they simply destroyed one of them and moved the other one for almost 50 km by the propeller (fortunately we have found it).

Results

The analysis of diffusion will be based on the theory developed by Okubov [1,3], and it is based on the equation for instantaneous source. It introduced diffusion coefficient a by using the parametrization done by Joseph and Sendner [2]. Thus, the diffusion is stronger the diffusion parameter is lower and vice versa.

The diffusion experiment was performed three times: on 13 February, 4 July and 9 December 1996. The diffusion parameter is calculated from the data of the spot area from two near-time geodetic measurements, and is given in Table 1.

In February at station D1 spot stretched very quickly and disappeared after 11 minutes, while at D2 and D3 remained at least 20 minutes. The influence of currents was manifested as extensive along-current stretching. Diffusion parameter had values from 0.28 cm/s at D3 (strong diffusion caused by strong currents) to 0.77 cm/s at D2 (the currents were weaker).

In July the oil spot remained between 14 and 17 minutes, with diffusion parameter values between 0.34 cm/s (at D1) and 1.12 cm/s (at D2 and D3). The influence of currents is obvious at D1, increasing the diffusion process, while at D2 the values are more realistic and representative for the summer period.

Table 1. Diffusion coefficient a measured in February, July and December 1996 at stations D1, D2 and D3.

STATION	Time slice (min)	[a]February (cm/s)	[a]July (cm/s)	[a]December (cm/s)
D1	3 - 7	0.47	0.39	0.71
	7 - 13	-	0.34	0.65
	13 - 17	-	-	0.60
D2	3 - 7	0.77	1.12	0.88
	7 - 13	0.51	0.81	0.80
	13 - 17	-	-	0.73
D3	3 - 7	0.28	1.04	0.95
	7 - 13	0.28	0.82	0.7
	13 - 17	-	0.74	-

In December the diffusion had the values between 0.60 cm/s and 0.95 cm/s. The currents at measuring points were relatively weak, so that the quality of data was high with the diffusion parameter span lower than during February and July. The oil spot remained at least 17 minutes at all stations.

The span of diffusion parameter is lowest at station D2, which is positioned inside the small shallow sub-basin at the top of the harbour, so the currents were weaker here. Consequently, the quality of the results is the best. On the contrary, at D1 and D3 the ventilation is higher as a result of stronger current fields.

The diffusion was directly influenced by currents, being higher when stronger currents occurred (lower diffusion parameter a). During winter it had the values between 0.28 and 0.95 cm/s, while the summer values were between 0.34 and 1.12 cm/s. Currents were lowest at station D2, so there was the lowest diffusion span (between 0.51 and 1.12 cm/s). These results can be useful for the future works on diffusion, especially in the Adriatic Sea where only a few such experiments were made.

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ISTRIAN COASTAL COUNTERCURRENT IN THE YEAR 2000

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Abstract
The Istrian Coastal Countercurrent (ICCC) appeared in March and August 2000, when a mucilage event occurred in the northern Adriatic. The ICCC intensity was lower than in some years in the past when mucilage and/or anoxia events were observed (1977, 1989, 1991, 1997). However, transverse transport of freshened waters was in the year 2000 registered already in March, despite the unusually low Po river discharge. This indicates a reduction of the water exchange rate between the northernmost part and the rest of the Adriatic, which favours the development of undesirable phenomena.

Keywords : Adriatic sea, mucus aggregates, currents

Introduction

Changes in the circulation pattern have been assumed to play an essential role in the development of undesirable phenomena (extended mucilage and bottom anoxia events) that were periodically observed in the northern Adriatic (e. g. 1, 2). Originally, it was held that surface circulation in the region is cyclonic, with a northerly flow along the eastern (Istrian) coast. However, an analysis of relative geostrophic currents in the 1966-1997 period has indicated that countercurrent can also be established within the eastern coastal belt, up to 12 NM wide (2). This southerly current has been named the Istrian Coastal Countercurrent (ICCC). It was well developed in August and was intense (7-15 cm/s) or pronounced (up to 7 cm/s) in most of the years of the investigated period. Summer mucilage or autumn anoxia events in the northern Adriatic in the 1966-1997 period were observed in the years in which the ICCC was intense (in 1977, 1988, 1989, 1991 and 1997; 2).

In this paper the geostrophic currents in the Istrian coastal belt and the ICCC occurrence during the year 2000, when a mucilage event occurred in the northern Adriatic, are described.

Materials and methods

The geostrophic currents with respect to the 30-dbar surface between stations RV001 and SJ107 (Fig. 1) during the year 2000 were computed by the standard oceanographic method (2) using salinity and temperature data collected monthly at 0, 5, 10, 20 and approximately 30 m depths.

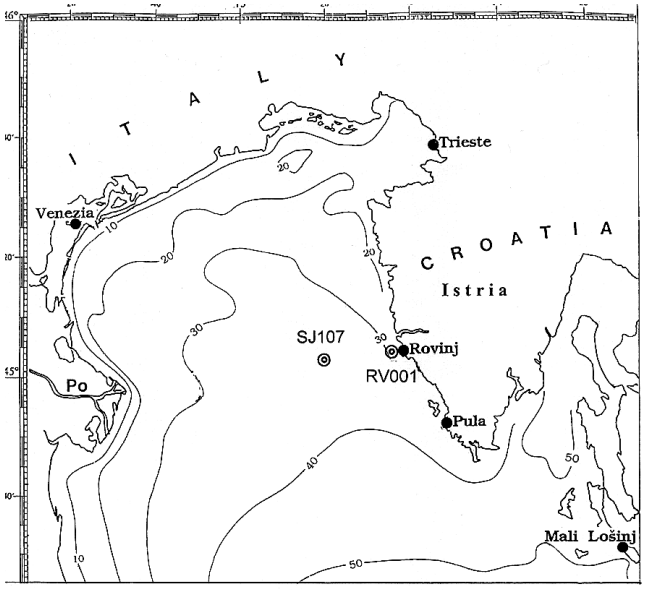

Figure 1. The northern Adriatic with the oceanographic stations.

Results and discussion

During the year 2000 the ICCC occured in March (7 cm/s), in late August (5 cm/s) and in September (4 cm/s; Fig. 2). Strong density gradients in northeastern Adriatic, resulting in the appearance of the ICCC, were caused by inflow of low saline water – presumably of the Po origin – in the area (CMR, unpub. results).

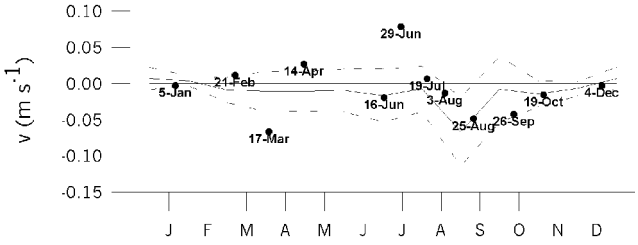

Figure 2. Geostrophic current speeds, computed relative to the 30-dbar surface, between the stations RV001 and SJ007 during the year 2000 (filled circles). Solid and dashed lines represent averages and standard deviations for the 1972-1992 period. Positive values indicate inflow into the northern Adriatic.

Generally, in winter the freshened Po-influenced waters are confined to the western coast, whereas during late spring and summer, when the river discharge rates often increase considerably, they can spread over larger areas of the northern Adriatic. However, their influence on the northeastern Adriatic significantly varies from year to year. Low salinity waters in the northeastern Adriatic in March 2000 give evidence that Po influenced the region by the end of winter, despite its discharge rate being significantly lower than the long term average for this month (CMR, unpub. results).

It has been hypothesized that the ICCC occurred in August in years in which a significant amount of freshened waters entered the northeastern Adriatic and was kept in the area within an anticyclonic gyre (3). That led to reduction in the water exchange rate between the northernmost part and the rest of Adriatic. An increased residence time of low salinity and nutrient rich Po-influenced waters would favour eutrophication processes and mucilage accumulation in the area. Data collected during the summer 2000 seemingly support the hypotheses, but they can be thoroughly verified only by a comprehensive research effort, designed to collect reliable data on water exchange rates, circulation patterns, and their influence on the ecosystem of the region.

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ONE-YEAR TIME SERIES OF FLUORESCENCE AND DYNAMICAL PARAMETERS IN THE ALGERIAN BASIN FROM SUMMER 1997 TO SUMMER 1998 (ELISA EXPERIMENT).

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Abstract

The ELISA (Eddies and Leddies Interdisciplinary Study off Algeria, 1997-1998) experiment was dedicated to study, in the eastern part of the Algerian Basin, the mesoscale (anticyclonic) Algerian Eddies (AEs), and their consequences on hydrodynamical and biological phenomena. It involved continuous monitoring of AEs with satellite images, 4 main cruises, and a network of 9 moorings. One of the moorings was equipped, besides currentmeters, with 4 autonomous CTD/Fluorometers probes (CTDF) between ~40 and 80m. The one-year CTDFs time series analysis allow to describe and explain most of the phytoplankton biomass variability, relating it either to AEs or to seasonal cycle.

Keywords: Algerian Basin, instruments and techniques, mesoscale phenomena, phytoplankton, time series

In the Algerian Basin the instability of the Algerian Current generates eddies [1, 2]. Only anticyclonic eddies can develop, hereafter called Algerian Eddies (AEs). Diameters range from 50 to 250km, vertical extents from few 100s of meters down to the bottom, lifetimes from few weeks to nearly 3 years, and their general trajectory is a counter-clockwise circuit in the eastern part of the Algerian Basin [3]. AEs impact on biological phenomena is important, as shown for a typical Algerian Current instability [4]. As well, in an old (>15 months) AE located close to the Algerian slope primary production values were found lower than those commonly accepted for the Eastern Mediterranean [5]. The AE location (alongslope/offshore) during the season also seems to be an important factor for the biological response [6].

The aims of the ELISA (Eddies and Leddies Interdisciplinary Study off Algeria) experiment (www.com.univ-mrs.fr/ELISA) were to study:

1) the general circulation of the water masses,

2) the origin, structure and trajectories of Algerian Eddies,

3) the biological response associated with mesoscale dynamical phenomena, and

4) the biological consequences of the mesoscale activity on the functioning of the Algerian Basin.

The means combined continuous satellite monitoring of AEs with NOAA/AVHRR infrared images, and between summers 1997 and 1998, 4 main cruises guided in near-real with NOAA/AVHRR images and a 9-mooring network. In order to properly describe the biological variability associated with the mesoscale dynamical phenomena over the whole year, we equipped one mooring (mooring E8, ~100km off the Algerian coast) with 4 CTD/fluorescence (CTDF) autonomous probes (SBE16 + Wetstar). We had the SBE16 specifically modified in order to ensure a representative fluorescence value by recording the mean of 5 consecutive fluorescence measurements (burst mode). A pumped system ensured that new water parcel was presented, and antifoulant-impregnated rings preserved from biofouling signal degradation. CTDF nominal immersions were 40, 50, 60 and 80m. However, when the mean current was strong, its combination with inertial oscillations would cause the mooring head to sink and behave like a vertical profiler (period ~19h30'), exploring the layer ~40-110m. Sampling rate was 1/15min (currentmeters: 1/1h). The CTDF were deployed from July 1997 to July 1998, recovered and cleaned twice in-between. Unfortunately, data return was not fully satisfying, especially since a design problem resulted in leaks and short circuits. However, the available CTDF data allow to clearly identify and describe the biological signature of an AE called 96-1 (see [3]), which stayed over the mooring for 3 months, as well as those of the propagating AEs 97-1 and 98-2. The maximum of fluorescence was recorded from early January till mid-February, and corresponded to the seasonal bloom.

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DEFINITIVE EVIDENCE OF MESOSCALE-INDUCED LEVANTINE INTERMEDIATE WATER (LIW) ENTRAINMENT IN THE ALGERIAN BASIN

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Abstract:

CTD and XBT casts in the eastern Algerian Basin are used to study the distribution and the entrainment of LIW (Levantine Intermediate Water) filaments from the Sardinian northward-flowing vein by the algerian eddies. We definitely conclude that there is no LIW vein flowing westward along the Algerian slope.

Key words: Algerian Basin, circulation, hydrology, mesoscale phenomena, vertical profiles

Even in the Western Mediterranean some aspects of the general circulation of the water masses are still debated [1]. Millot showed that the algerian eddies (AEs) can entrain filaments from the Sardinian northward-flowing LIW vein, which explains the presence of little-modified LIW in the interior of the basin, and thus refuted the existence of a LIW vein flowing westward along the Algerian slope [2, 3].

The ELISA experiment (Eddies and Leddies Interdisciplinary Study off Algeria, www.com.univ-mrs.fr/ELISA) was dedicated to study, in the eastern part of the Algerian Basin, the mesoscale (anticyclonic) AEs generated by the instability of the Algerian Current [4] and their consequences. AEs diameters range from 50 to 250km, vertical extents from few 100s of meters down to the bottom (~3000m), lifetimes from few weeks to nearly 3 years, and their general trajectory is a counter-clockwise circuit in the eastern part of the Algerian Basin [5, 6]. A total of 307 CTD and 346 XBT casts were realized during 4 ELISA cruises in 1997-1998. These data sets are used to study the LIW spatial distribution, and its relationships with AEs. The salinity distribution (figure 1) shows i) continuity between the (Sardinian) LIW vein and the filaments spiraling inside AEs when close to the Sardinian slope, ii) that all little-modified LIW lenses in the basin interior can be related to AEs entrainments, iii) that little-modified LIW is not located along the Algerian slope. The complementary XBT data allow to refine the LIW distribution. We definitely conclude that there is no LIW vein flowing westward in the Algerian Basin.

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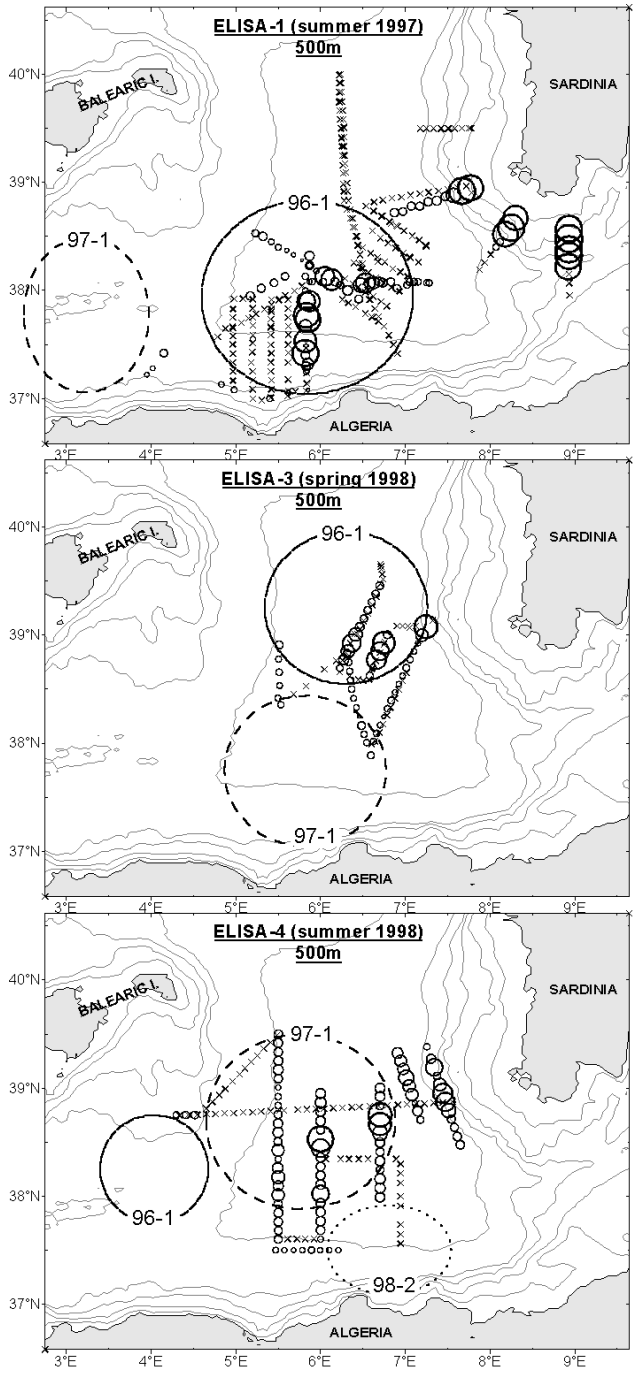

Distribution of salinity (O) at 500m using the CTD casts. Dots diameter increases linearly from 38.49 to 38.70. Positions of the complementary XBT (+) casts. Schematic positions of the AEs (named 96-1, 97-1, 98-2) at time of sampling.

THE RECENT STAGE (1998-99) OF THE EASTERN MEDITERRANEAN TRANSIENT

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Abstract
The shift of the formation site (1987-99) of the eastern Mediterranean deep and bottom waters from the Adriatic to the Aegean is the main element of the so called the "Eastern Mediterranean Transient". Observations indicate that the spreading of the older Aegean deep water that had been deposited as bottom water in the Cretan Passage (1991-95), has progressed further towards the East and the West. Moreover, the Aegean still functions as a source of deep water that outflows mainly from the eastern Cretan Straits, but it is no longer dense enough to reach the bottom of the adjacent basins, thus ventilating layers between 1500-2500 m.

Keywords: Deep waters, Hydrology, Eastern Mediterranean, Aegean Sea

Since the beginning of the 20th century up to the mid-80s, the deep conveyor belt of the Eastern Basin presented rather constant characteristics [1, 2]. Since 1987, abrupt changes in the thermohaline circulation and water properties basin-wide were initiated, namely the "Eastern Mediterranean Transient" (EMT). The Aegean Sea, the new and effective formation site of the deep and bottom waters [3, 4, 5], has provided the eastern Mediterranean with waters warmer (θ>13.3°C), more saline (S>38.7), richer in CFC-12 (>0.5 pmol/kg) and denser (σ_θ >29.2) than the previously existing deep and bottom water mass (EMDW) (σ_θ~29.18). Several hypotheses concerning possible causes of this unique thermohaline event have been reported [6], but there is still lack of a consistent and quantified theory of the EMT. We describe the present state of the EMT based on the collected hydrological and tracer data in the frame of E.U/ MTP-II/MATTER project (1997-99).

The most important structure in the deep and bottom layers of the eastern Mediterranean in 1995 was the dome-like shape of the young (O_2> 4.5 ml/l, CFC-12 >0.5 pmol/kg), relatively warm (θ > 13.6 °C), saline (S > 38.75 psu) and very dense (σ_θ >29.2) waters of Aegean origin, namely the Cretan Deep Water (CDW), that occupied a large area centered at the Cretan Passage [3]. The massive invasion of CDW caused an uplift of the 'old' EMDW in the water column and this water layer is recognisable in the temperature, salinity, dissolved oxygen and tracer minima (θ < 13.7 °C, S <38.8 psu, O_2< 4.3 ml/l and CFC-12<0.3 pmol/kg) at depths between 800-2500m in the Levantine Basin and 600-1500m in the Ionian Basin. Four years later the spreading of the Aegean water into the surrounding areas has progressed even further. The present structure indicates a change in the Aegean contribution resulting in the appearance of two dense-water cores; on top of the aforementioned Aegean dense waters (σ_θ >29.2) in the bottom layers (2500 m to bottom) there appear slightly less dense waters (σ_θ <29.2) within the 1500-2500m layer, along the Cretan Arc outside the Aegean Sea and in the eastern Ionian, while in the Levantine is totally absent. In particular, the most intense signal of this change is found in the Cretan Passage, to the south of Crete, where all the parameter distributions now show inversions. The old bottom Aegean dense waters have lost salt (ΔS~0.04 psu) and heat ($\Delta\theta$~0.11°C), probably mixed with other older EMDW of Adriatic origin, as the dome of the CDW water has been partly drained to fill the Levantine and Ionian Basins. Accordingly, the density decreased by less than 0.01. The fact that the near bottom CFC-concentrations in both basins did not increase substantially between 1995-1999 furthermore indicates that the subsequent advance of CDW at the bottom has been supplied from the earlier outflows but has not been refilled by similarly dense water output from the Aegean which should have led to increased CFC-12 concentrations. Secondly, the new observed Aegean core caused a significant increase in salinity (ΔS~0.11 psu) and temperature ($\Delta\theta$~0.3°C) resulting in an increase of density up to $\Delta\sigma_\theta$ ~0.02, along with increase in oxygen and CFC-12, within the 1500-2500dbar depth range, when compared with the properties of the waters occupied the same layers in 1995. The latter were the product of mixing of the old waters that were uplifted by the first very dense Aegean outflow [7] with the outflowing Aegean waters. It seems that this new Aegean outflow comes from the eastern Straits of the Cretan Arc and spreads westward towards the Ionian Sea. These more recently ventilated waters from the Aegean obviously did not obtain sufficiently high densities to reach the bottom but are settling at shallower depth between 1500-2000 dbar. However, the uplifted old waters occupy now a thinner layer 500-1000m above the aforementioned new Aegean layer, representing deep temperature, salinity, oxygen and CFC-12 minima in the vertical. Comparison of the hydrological parameters between November 1998 and June 1999 indicates weakening of the new Aegean signal in the layers 1500-2500 dbar. In particular, the temperature decreased up to 0.1°C, salinity up to 0.04 psu and the density up to 0.005.

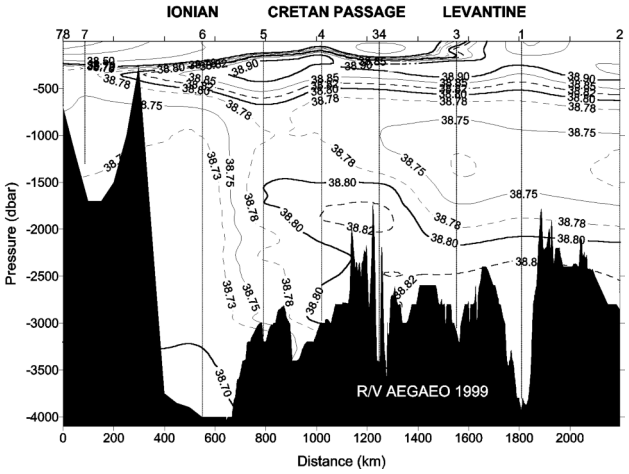

Figure 1. West-East Salinity transect in the Eastern Mediterranean

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RESULTS FROM ECOMALAGA PROJECT: HYDROLOGICAL AND BIOLOGICAL SEASONAL CYCLES AND TRENDS IN THE MALAGA BAY AND ALBORAN SEA.

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Abstract

From October 1992 to the present, the IEO has collected systematically (one survey each season of the year), hydrological (CTD profiles) and biological data (nutrients, oxigen, chlorophyll and zooplanktonic biomass) in the Málaga Bay. Preliminary results dealing with the possible existence of seasonal cycles and trends are presented. Short time scale variability superimposed on these cycles can be considered as a white noise due to the sampling interval (around 3 months). This noise presents as much variance as the low frequency variability we want to study, diminishing the significance of our results. We try to improve these results through the use of EOFs, as spatial structures are expected to have lower variance than single stations. To the view of our preliminary results we try to find the average distribution patterns of the variables analysed and, if existing, the relation between their variability and that of the whole Alboran Sea.

Introduction.

Málaga Bay is located in the northern shore of the Alboran Sea which is the first Mediterranean basin receiving the Atlantic waters coming from the Strait of Gibraltar.

The upper layer of the Alboran Sea is filled by Atlantic low salinity (S<36.6) waters, extending over the more saline Mediterranean waters. This water mass is more or less modified and extends to a different depth depending on the geographical location within the Alboran Sea. The classical circulation pattern shows the Atlantic current surrounding and feeding two anticyclonic gyres in both the western and eastern basins. Due to the geostrophic adjustment of these structures, isopicnals sink toward the centre of the gyres, where the Atlantic layer reaches its maximum depth (around 200m), and slope up toward the edge of the gyres, decreasing the thickness of this layer. As a consequence, the Atlantic current is associated to an intense thermohaline front that makes it clearly visible in infrared satellite images (1). Figure 1a shows a scheme of this circulation pattern, a more detailed description of the water masses and circulation of the Alboran Sea can be found in (2). Figure 1b is a zoom of figure 1a showing our area of study.

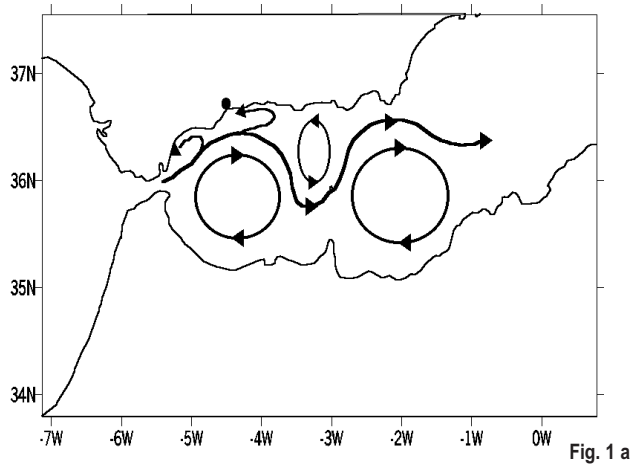

Fig. 1 a

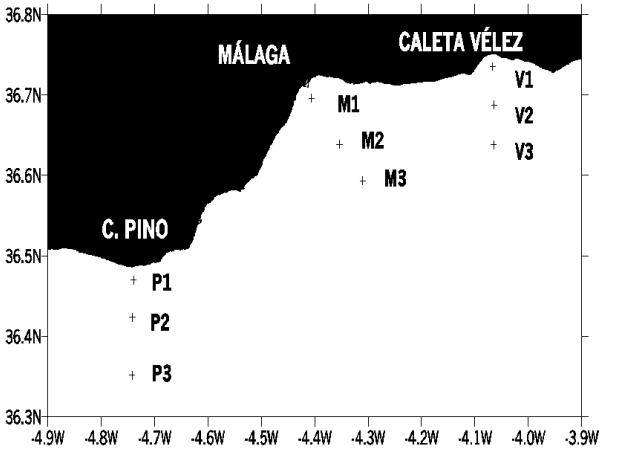

Fig. 1 b

According to this scheme, hydrological conditions in the Málaga Bay, depend on the dynamics of the Alboran Sea and will be very sensible to its time variability. If we accept, as a starting point, the scheme of figure 1a, the Atlantic current will flow through our westernmost transect (see fig. 1b, stations P1-3), and the rest of Málaga Bay (transects M and V) will keep out of the direct Atlantic influence and under a cyclonic circulation. An increase in size of the western Alboran gyre (WAG), will leave the whole Bay under Atlantic conditions, while a southward drift of the Atlantic jet will have the opposite effect. The study of the time variability in our area can also be an indicator of that of the whole basin.

In order to study the long term variability of the hydrological conditions (ranging from seasonal to inter-annual), as well as different biological and enviromental variables within the Málaga Bay and its relation with the dynamics of the Alboran Sea, the Instituto Español de Oceanografía (IEO) has supported the project ECOMALAGA since October 1992 to present (and still going on). For this propose, nine stations distributed along three transects (P,M and V in figure 1b) are systematically sampled four times each year (spring, summer, autumn and winter surveys). During each surveys, we accomplish CTD profiles and take sediment samples, water samples to evaluate nutrient and chlorophyll concentrations, and oblique trawls with Bongo net.

Preliminary results.

Our initial hypothesis is that most of our time series contain time variability at different time scales. The length of them (6 years for biological variables, and 8 for hydrological ones) do not aloud for the moment to study (in a statistically significant way) inter-annual variability. For this reason we focus our attention on the seasonal cycles plus shorter time scales. We propose a model in the form of a mean value a linear trend and a seasonal signal plus a noise containing the shorter time scale variability. Hypothesis about the noise superimposed on the deterministic part of the model are usually important in order to establish the significance of the model fit. We assume that differences between the values predicted by the deterministic part and the actual value (noise) are due to phenomena such as upwelling (wind driven or due to southward drifting of the Atlantic current), or to the instabilities associated to the Atlantic jet. Non of these phenomena are expected to have a time scales larger than several days or weeks, and so we suppose that deviations from the model are statistically independent. This is quite reasonable if we consider that in the best cases we have four samples per year. Our results evidence that the short time scale is likely to present as much variance as that associated to the low frequency (mainly seasonal) so diminishing drastically the significance of our estimates. A possibility of reducing variance in our time series is not to study the time series arising from each of the stations. Instead of this, we study the variability linked to spatial structures arising from EOF analysis.

Though in some cases it is possible to establish the seasonal cycles unambiguously (temperature and salinity) it is not so clear in others as chlorophyll concentrations. Surface temperature exhibit a clear cycle with maximum values at mid August. This maximum is delayed around a month at 50m, reflecting the heat diffusion into the sea. More interesting is a minimum of salinity found in autumn, which could be linked to the instability of the Alboran circulation in this season.

Nutrient concentrations are maximum in winter surveys. Chlorophyll, on the other hand, does not have a clear behaviour, and we will have to wait until new data are collected to establish if maximum values are found in winter or spring. The possibility of a winter bloom has already been suggested by (3) using pigment satellite data.

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AN ESTIMATION OF WATER MASS FRACTIONS IN THE MIDDLE AND SOUTH ADRIATIC

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Abstract

The paper offers an estimation of water mass fractions in the Middle and South Adriatic by applying least-squares tracer analysis method on the temperature, salinity and dissolved oxygen data collected during six along-Adriatic cruises. Dense water formation is investigated too, confirming two major types of generation: (1) shelf-type occurring dominantly in the North and Middle Adriatic, and (2) deep-convection type occurring in the centre of the South Adriatic Pit.

Keywords: Adriatic Sea, hydrography.

Introduction

The Adriatic Sea has been recognized quite early as a source basin of dense water [1,2]. During strong and cold winter outbreaks shelf-type of generation appears on the North Adriatic shelf having depths lower than 100 m [3,4], whereas deep-convection type occurs in the deep circular South Adriatic Pit [5,6]. The Adriatic water masses thus generated flow toward the Otranto Strait and Ionian Sea where they contribute to the formation of the bottom or near-bottom waters [7].

Data and method

Temperature, salinity and dissolved oxygen data were collected along the central profile extending from the Jabuka Pit to the Otranto Strait during the cruises of February 1962, September/October 1974, April/May 1975, February 1976, July 1976 and January 1980. The data were analysed by applying the least-squares tracer analysis method [8], which uses concentration of several tracer variables to find the mixture of source water types that best describes the composition of a water sample. The analysis performed here resulted in fractions of 4 characteristic deep (dense) water types in the Adriatic: North Adriatic Dense Water – NADW, Middle Adriatic Deep Water – MADW, South Adriatic Deep Water – SADW and Modified Levantine Intermediate Water – MLIW.

Results

Figs. 1 and 2 show the fractions of SADW and MLIW in the Middle and South Adriatic. Primarily, the persistence of the South Adriatic gyre can be observed here. For example, MLIW entered the Adriatic in February 1962, passed near the Croatian coast and reached north-west parts of the South Adriatic Pit, whereas SADW had higher fraction values in the pit centre revealing the doming of isopycnals and upwelling that occurred there. The same feature can be traced also in the cruises of September/October 1974, April/May 1975 and July 1976, but the centre of the gyre has been positioned closer to the Palagruza Sill, as MLIW pushed the gyre northwestward.

During the strong episode of deep convection which occurred in February 1976 dense water reached down to 800 m, and therefrom expanded towards the Otranto Strait. In addition, shelf-type of dense

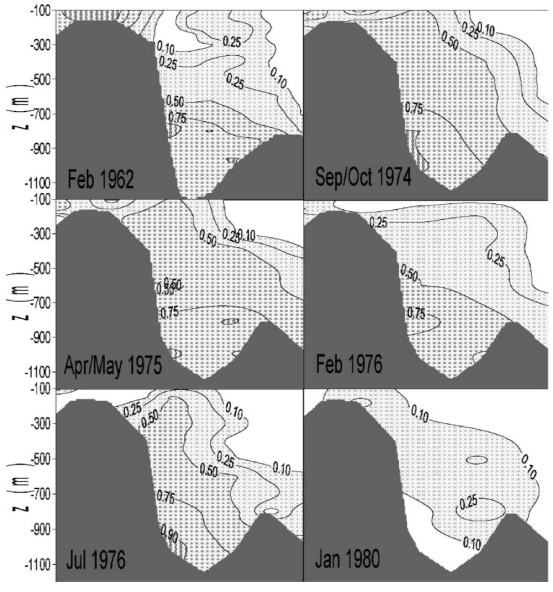

Figure 1: SADW fraction estimated for the central Adriatic section.

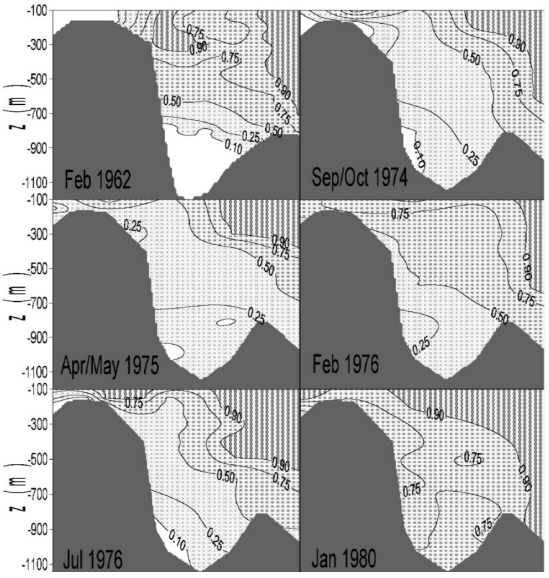

Figure 2: MLIW fraction estimated for the central Adriatic section.

water formation occurred in the North and Middle Adriatic during the same winter, as surface buoyancy losses were rather high in February whereas river discharges were low at the time. The North and Middle Adriatic water mass usually enters the South Adriatic as a subsurface vein on the Italian shelf, turbulently mixes and sinks in the area of Bari Canyon and fills the bottom of the South Adriatic Pit. Throughout productive years it can be also traced in the Otranto Strait, as observed during the July 1976 cruise with fractions higher than 10%. Simultaneously, SADW fractions were of even higher values (up to 35%), and both water masses contributed to the deep waters of the Ionian and Levantine basins.During the cruise of January 1980, which is known as ingression year, MLIW fraction dominated in the whole area, having value higher than 60% even at the bottom of the pit. The South Adriatic gyre was thus destructed and could not be detected in the density data.

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HIGH-FREQUENCY SEA LEVEL OSCILLATIONS OBSERVED AND MODELLED IN THE SPLIT HARBOUR (ADRIATIC SEA)

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Abstract

The paper deals with the high-frequency analysis based on the data of pressure gauge located in the Split harbour, collecting the data of sea and air pressure. The analysis included the spectral analysis and filtering, revealing harbour seiches having periods of 6.5, 3.0, 2.2, 1.6 and 1.15 min. The seiches were modelled and verified numerically. Furthermore, a strong peak was found on period of 11.9 min of air pressure data, highly correlated to the sea pressure with phase lag of about 90o and gain of about 14 cm/hPa.

Keywords: Adriatic Sea, sea level, atmospheric input

Introduction

The seiches in harbours and small basins can be of high importance when the ships are entering there, as they can produce a rather strong currents and large sea level displacements [1]. In the Adriatic, the investigations of seiches in small basing started early in the century [2], and periods of oscillation were estimated for a great part of the basin where tide-gauges were mounted [3]. Moreover, an extreme strong events were observed in some parts of the Mediterranean [4,5] and Adriatic [6], as a consequence of resonant air pressure forcing on sea levels near seiche period, so-called Proudman resonance [6], having sea-level amplitudes up to 3 m and producing and extreme damages on the infrastructure affected by the event.

Data and methods

Dataset analyzed in this paper is collected in the period August-October 2000, comprising air and sea pressure measured at the tide gauge placed near the entrance of the harbour within MedGLOSS project. Air pressure is measured every 2 minutes, whereas bottom pressure data resolution is 0.5 minutes. In addition, sea-level data measured at the old float-type tide gauge will be examined, as it is positioned far from the harbour entrance.

The methods of analysis applied here include spectral analysis [7] (40 degrees of freedom) in order to visualize energy peaks related to the seiche and other oscillatory movements in the harbour, high and band pass filtering on the resonance frequency (11.9 min), and finally analytical and numerical 2D barotropic modelling of the harbour seiches. The modelling is done by applying backward-forward numerical procedure and by assuming zero sea level displacement at the entrance of the harbour and zero horizontal velocity on the side walls.

Results

Power spectra, both of the bottom and air pressure, are given in Fig 1 (periods higher than 4 min). A number of energy peaks can be seen in the frequency range between 0.04 and 0.12 min^{-1} (8.3 and 25 min), but its origin cannot be precisely defined: they can belong to resonant oscillation forced by air pressure or to the seiches of some wider area. The first mode occurs at a period of 6.6 min, but with no strong energy as the tide gauge is positioned near the entrance of the harbour (nodal line). Higher modes can be detected on periods of 3.0, 2.2, 1.6 and 1.15 min, revealing higher seiche modes of the whole harbour or oscillation of some parts of the harbour. Applying 2D barotropic model on the harbour, the theoretical period of the uninodal seiche is calculated to be 7.3 min during the low tide, but it falls to 6.9 min when adding 0.7 m (tide + storm surge) on sea level in the harbour. Higher theoretical modes can be traced on periods of 5.1, 3.1, 2.2, 1.64 and 1.24 min, thus they reproduce the empirical period well.

An interesting peak can be traced both on the air and sea pressure spectra on frequency of 0.084 1/min (11.9 min). Thus, an intense oscillatory movement occurred in the atmosphere forcing sea level to oscillate, during the storm passage on 31 August / 1 September 2000. Gain between air and sea is –14 cm/hPa. Fortunately, the resonant oscillation was not placed in the frequency area with high energies, thus, no strong oscillation occurred in the harbour. Maximum amplitude of air and sea pressure can be estimated to be 0.3 hPa and 0.45 dbar (4.5 cm) by applying very narrow band-pass filter. Nevertheless, if the resonant movement occurs on the seiche or near-seiche periods, resulting sea level amplitude can rise enormously, as happened in a number of places [4,5] such as Vela Luka Bay [6], where the resonance appeared with maximum sea level amplitude of about 3 m.

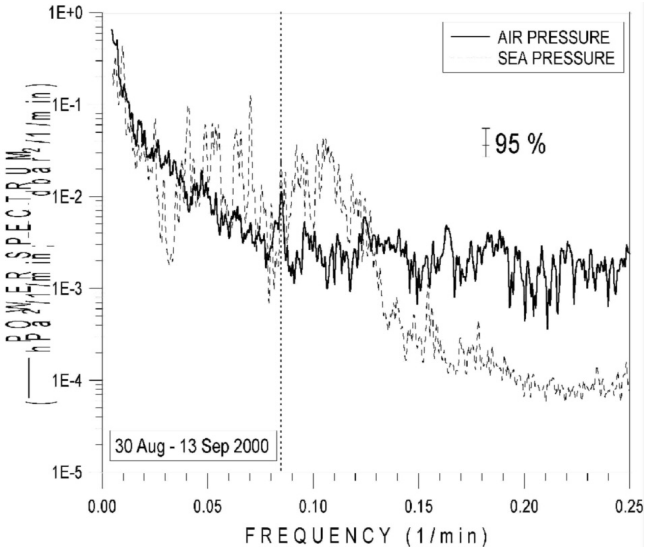

Figure 1: Power spectra of the air and sea pressure measured on the MedGLOSS tide gauge.

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SYNOPTIC, SEASONAL AND INTERANNUAL VARIABILITY OF THE WARM CORE EDDY SOUTH OF CYPRUS, SE LEVANTINE BASIN

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Abstract
The general circulation in the SE Levantine Basin have been known since 80s. A more detailed picture of one of the dominant flow features in the area, that of the warm core eddy south of Cyprus has emerged thanks to the CYBO and MFSPP projects results, from mid 90s until 2000. These renewed investigations definitive revealed that the anticyclonic eddy south of Cyprus is a permanent one undergoing synoptic, seasonal and interannual fluctuations.

Keywords:Levantine Basin, mesoscale phenomena, currents, open sea

Introduction

The SE Levantine Basin dynamics during 80s [1,2,3] shown a mesoscale flow structure with an anticyclonic eddy activity south of Cyprus. In early 80's Brenner (1989) describes this flow feature to be a persistent one, while in mid 80s the POEM group [2,3] identified it as a non permanent multipole anticyclonic gyre. This gyre encompassed by three anticyclonic eddies with the mostnorthen one to be considered as the Cyprus warm core eddy mentioned previously [1]. From 1995 until 2000 new in-situ experiments were carried out in the SE Levantine Basin, both in the frame of the CYBO-Cyprus Basin Oceanography and MFSPP-Mediterranean Forecasting System projects. These renewed investigations made possible to give strong evidences about the existence, the structure and the evolution of the anticyclonic warm eddy south of Cyprus, on a quasi synoptic, seasonal and interannual time scales.

Results and Discussion

Within the frame of the CYBO project, several seasonal oceanographic cruises were carried out in the SE Levantine Basin during late winter and summer periods, between 1995 and 2000. The cruises were aimed to obtain new deep *in-situ* data, from a telescopic grid of 80 stations. Moreover, in the framework of the MFSPP project, a total of 17 XBT cruises were carried out biweekly, between September 1999 and June 2000, along the VOS-Volunteer Observing Ships track Limassol-Port Said. This made possible to collect more than 350 temperature profiles in a quasi synoptic scale.

The overall scientific picture derived from the renewed investigations of the SE Levantine Basin within the CYBO project [4] reveals new mesoscale flow features, such the Cyprus Basin Cyclonic Eddy and the westward coastal current flowing along the SE Cyprus coastline. Moreover, the CYBO results reveal that the dominant flow phenomenon south of Cyprus, in the SE Levantine Basin is the warm core eddy, that is attributed to the Cyprus/Shikmona anticyclonic eddy (Fig.1). The eddy, whose influence extends to depths of about 400m, constitute an intense dynamic feature with velocities as high as 35 cm/s. A seasonal spatial extension, north-south, of the eddy was found to occur between 1995-1999, while the baroclinic instability of the MMJ caused the formation of a secondary smaller eddy west of the Cyprus anticyclonic eddy. Both features contribute to an even more complicate meandering flow bath of the MMJ in the Cyprus Basin.

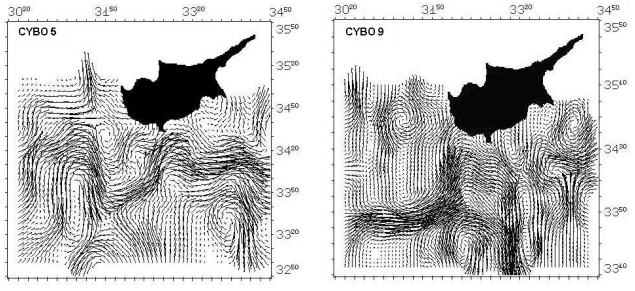

Fig.1 Circulation in October 1997 (CYBO-5) and May 2000 (CYBO-9)

The analysis of the XBTs transects show a well stratified surface water column down to 40-60 m depth, during autumn 1999 and early summer 2000. The in-situ SST from as high as 27-28.5°C in September 1999 (are higher comparable to the MEDATLAS climatology) was decreased to 17-18°C in February and March 2000. The surface cooling and the mixing processes in winter 2000, initiated a rapid increase of the upper homogenous water layer, from 100 m down to 320m, from January to March 2000, with temperature as low as 17-17.5°C (Fig.2). From April 2000 until the end of June 2000 the heating of the sea surface waters gradually re-established the stratification of the surface water, with temperature as high as 25°C. The temperature depression found along the above tracks is strongly associated with the Cyprus/Shikmona eddy. This is verified from the CYBO results, as well from the NRT operational forecasting experiments of the MFSPP.

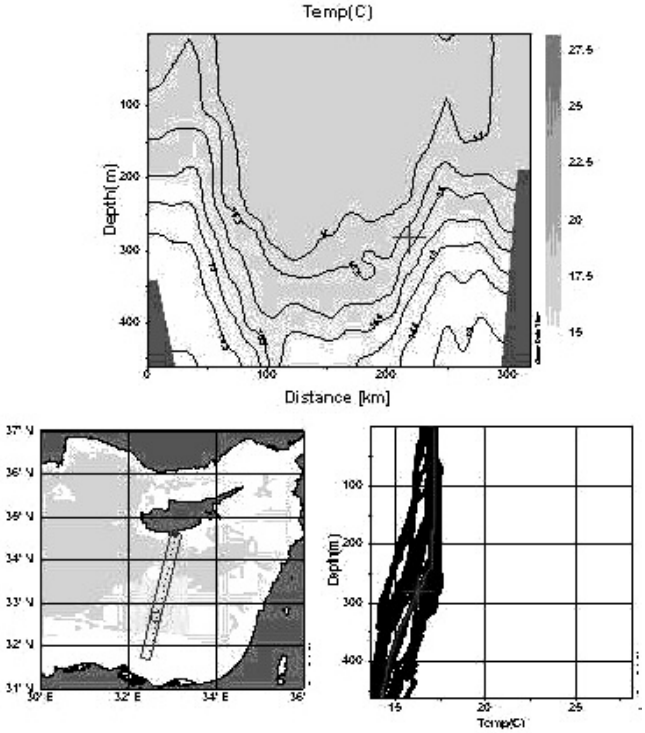

Fig. 2. Temperature section and composite profiles of along the XBT track Limassol-Port Said, MFSPP-VOS, March 2000.

Both studies give strong evidences that during 2000 the location of the Cyprus/Shikmona anticyclonic eddy was shifted for about 40-60 nm to the west comparable with the CYBO results obtained between 1995-1999 and those derived in 80s [1].

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MEDITERRANEAN FORECASTING SYSTEM: SUB-MODEL FOR THE CYPRUS AND NORTH-EAST LEVANTINE BASINS

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Abstract

A high resolution nested coastal/shelf model for the sea area in Cyprus and NE Levantine is implemented to fulfil the objectives of the MFS-Mediterranean Forecasting System pilot project. The Cyprus model is nested within the Aegean Levantine regional coarse grid model for fully prognostic runs. The project results show the feasibility of the approach for the development of the operational MFS.

Keywords : Levantine Basin, mesoscale phenomena, currents, open sea

Introduction

The Mediterranean Forecasting System is a multinational project, funded by the European Union, that is designed to produce NRT forecasts of the temperature, salinity and flow fields in the Mediterranean Sea [1]. The model results will provide invaluable input to marine environmental prediction models, such as pollutant models, used within the framework of the various contingency plans for response to marine pollution incidents. The system consists of a basin-wide monitoring capability, supplemented by a number of centres able to model the coastal shelf areas with state of the art hydrodynamic mod-elling, and complemented by an information network for exchange of observational data and model results.

The oceanographic models in the project are : 1) an Ocean General Circulation Model (OGCM) with 1/8°x1/8° resolu-tion over the whole Mediterranean Sea; 2) few Regional Models nested within the OGCM, with a 5 km resolution and 3) several nested models in various coastal/shelf regions, with 2-3 km resolution.

Results and Discussion

The Cyprus Coastal Model (CYCOM) is one of the coastal/shelf models for the waters in the NE Levantine Basin surrounding Cyprus (Fig.1). It is nested within the Aegean-Levantine regional model (ALERMO) which covers the Eastern Mediterranean Sea. Both CYCOM and ALERMO use numerical schemes that are modified versions of POM (the Princeton Ocean Model). The POM model [2] has been used within the framework of the MFSPP to simulate the flows in both region-al and coastal/shelf sea areas of the Mediterranean Sea. The MFS is to be interfaced with 3-10 days forecasts of atmospheric forcing pa-rameters from operational weather centres, but in the MFSPP, which is designed to establish the hierarchy of models and the communication network, the computa-tions have been based on the ECMWF perpetual year surface forcing.

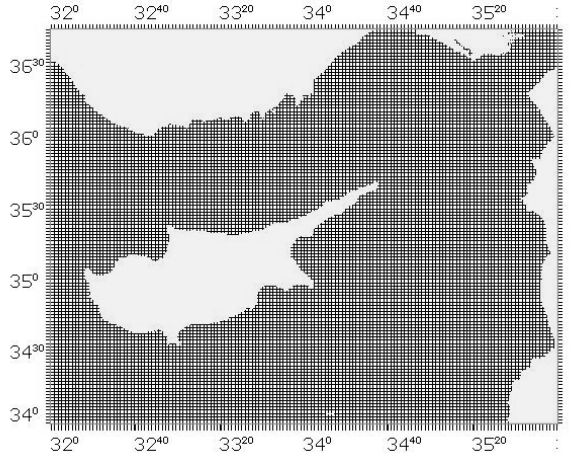

Figure 1. Cyprus model grid, 146x122x30 grid cells.

The CYCOM numerical algorithm uses an Arakawa C-grid and time splitting, with the barotropic mode com-puted with a step of 5 sec and the vertical structure and temperature and salinity fields updated with a step of 450 sec. Horizontal sub-grid mixing is modelled by an eddy viscosity defined by the Smagorinsky scheme while vertical mixing is treated by the turbulent energy scheme of Mellor and Yamada. The surface boundary conditions for temperature and salinity were taken to

$$\frac{K_H}{D}\left.\frac{\delta T}{\delta \sigma}\right|_{\sigma=0} = \frac{Q}{\rho C_p} + \frac{C_1}{\rho C_p}(T^* - T)$$

$$\frac{K_H}{D}\left.\frac{\delta T}{\delta \sigma}\right|_{\sigma=0} = W_s + C_2 (S^* - S)$$

include terms providing relaxation to climatol-ogy, in the form

where the heat and salt fluxes, Q and W_s, are com-puted using monthly ECMWF forcing (wind stress, solar radiation, back radiation, evaporation and precipitation). D the water depth, σ the sigma coordinate, K_H the vertical diffusivity, C_p the specific heat, T^*, S^* the climatological T, S fields and C_1, C_2 relaxation coefficients.

For T^* and S^* the monthly mean surface values from the MED6 database were used, modified according the method of Kilworth so that linear interpolation between successive values produces the observed monthly means.

The model domain has open boundaries on the west and south sides at which it is nested within the ALERMO regional model and it is essential that the mesoscale features generated in the Levantine Basin by the regional model should influence the model solution in the CYCOM shelf model. The ALERMO output of velocities, temperature and salinity were extracted at intervals of 10 days and interpolated spatially to the open boundary points of the CYCOM grid and also in time to each time step. The barotropic velocities normal to the boundary were imposed in the form of a Flather mixed radiation/specification condition while the tangential components as well as the baro-clinic components of velocity were strictly imposed on the shelf model. The temperature and salinity were imposed from ALERMO at points where there was inflow while at outflow points these variables were computed simply by advection from the inside of the shelf region.

A principal demand for the success of the nested models is that the results of the shelf model should reproduce the dominant features found by ALERMO for the Cyprus Basin. To the west of Cyprus the flow in both models is dominated by a strong northerly jet which forms the eastern extension of the Rhodos cyclonic gyre, and is at the same time the northerly branch of the Mid-Mediterranean Jet. This jet bi-furcates SW of Cyprus and the other branch flows eastwards, actually south of the CYCOM model region, and enters this region in the SE corner as a northward current. It again branches, partly flowing westwards where it forms a cyclonic activity south of Cyprus and partly continuing northwards into the Lattakian Basin. With some seasonal variations, the current flows from the Lattakian basin, round the NE tip of Cyprus and turns westwards into the Cicilian Basin where it is known as the Asia Minor current, and is known to transfer warm waters as far west as the Aegean Sea. In this basin the main jet follows a meandering path, flowing north of a significant cyclonic eddy lying off the northern coast of Cyprus, with generally anti-cyclonic activities to both east and west of it. The nested models show consisteny between the coarse and fine grid results, as well as reproducing the main features that are known to exist in the CYCOM model region.

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MEDGLOSS NETWORK

AN OVERVIEW OF THE MEDGLOSS 2000 COORDINATION MEETING AND PROGRESS UPDATE

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Abstract

This paper provides a summary of decisions and recommendations of the Joint IOC and CIESM Workshop and Coordination Meeting of the MedGLOSS Pilot Monitoring Network of Systematic Sea Level Measurements in the Mediterranean and Black Seas held during May 15-17, 2000 in Haifa, Israel and of the progress made since then. The full proceedings were published in IOC meeting report 176 (1).

Introduction

The Workshop and Coordination Meeting of the MedGLOSS Pilot Monitoring Network of Systematic Sea Level Measurements in the Mediterranean and Black Seas, was held at the Israel Oceanographic & Limnological Research (IOLR) headquarters at the Tel Shikmona promontory hill in Haifa, during May 15 through May 17, 2000. It was jointly sponsored by the International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) and the Intergovernmental Oceanographic Commission (IOC) of UNESCO. Participants representing the following organizations in 12 countries bordering the Mediterranean and Black seas attended the meeting: Morocco (Institut National de Recherche Halieutique), United Kingdom (Proudman Oceanographic Laboratory), Spain (Puertos del Estado and Instituto Espanol de Oceanografia), France (EPSHOM and CLS Space Oceanography), Italy (Istituto Talassografico CNR and Universita Degli Studi di Bologna), Malta (Malta Council for Science & Technology), Croatia (National Hydrographic Institute), Greece (Hydrographic Service of Hellenic Navy), Romania (Romanian Marine Research Institute), Ukraine (Marine Hydrophysical Institute), Turkey (General Command of Mapping and Hydrographic Service of Turkish Navy), Israel (Israel Oceanographic & Limnological Research and Survey of Israel). Due to unforeseen personal problems four countries which expressed wishes to participate and commitment to join MedGLOSS did not participate in the meeting (Russia, Egypt, Bulgaria, Cyprus). The Cyprus delegate arrived just after the meeting at IOLR and received a copy of the draft documents prepared. The Russian organization (HydroMeteoCentre of Russia) submitted written presentation. The MedGLOSS sponsoring organizations CIESM and IOC were represented at the meeting by Dr. Frederic Briand, CIESM Director General and by Dr. Philip Woodworth, Chairman of the IOC GLOSS Group of Experts. This meeting was a further step advancement of the earlier initiatives taken by CIESM and IOC for the study of the sea level in this region. Responding to these forecasts on sea level rise due to global warming by the the "greenhouse effect", a worldwide sea-level monitoring network named Global Sea-Level Observing System (GLOSS), itself a component of the Global Ocean Observing System (GOOS), was initiated by the Intergovernmental Oceanographic Commission (IOC) of UNESCO in 1985. Among its monitoring stations one of its categories includes regional densified subset networks, which can provide quality sea-level data at GLOSS standards which will strengthen data reliability, fill data gaps at neighboring stations and add boundary conditions information for regional studies of regional sea-level changes, water circulation and air-sea interaction processes.

The main meeting objectives were (a) To bring together professionals involved and interested in the operation of the MedGLOSS pilot network for a discussion of the present state and future active operation of the MedGLOSS sea-level pilot network; (b) To exchange and update knowledge on sea-level and sea level benchmark monitoring equipment and data analysis; (c) To discuss the present state of the MedGLOSS pilot stations and their historic data availability and the needs for data rescue; (d) To decide upon the active implementation and operation of the MedGLOSS pilot network; (e) To coordinate the data transfer and utilization among the MedGLOSS members as well as with other international projects and bodies such as the MFS, the MEDGOOS and BLACKGOOS.

MedGLOSS meeting decisions

The following constitute the major decisions unanimously agreed:

a. The MedGLOSS programme initiated by IOC and CIESM is considered very important to the national and international society for monitoring of sea-level rise due to forecasted climate change, for monitoring of long term plate tectonic movements and for providing boundary conditions and ground-true data to operational oceanography modeling and nowcasting in the Mediterranean and Black Seas.

b. The participants agreed that the MedGLOSS pilot network will consist of 40 selected monitoring stations (2 additional stations to be installed in Morocco and in Cyprus). Of these 21 will operate in near real time mode providing at least twice a day data for operational oceanography (strait fluxes, surges, satellite altimetry calibration, etc.), while 32 of them (with long historic records) will act in delayed mode, providing data at least every 6 months for long term monitoring and prediction (Table 1 and Fig. 1).

Table 1 – List of Proposed MedGLOSS stations pilot network and their operation status

MDL-modeling, PRE-prediction, LT-long term monitoring, SF-strait fluxes,XEV-extreme events,NRT-near real time, DLY-delayed mode

No.	StationName	Latitude deg	Longitude deg	Main Objective	Operation Mode
1	Ceuta	35.900	-5.317	SF	NRT / DLY
2	Gibraltar	36.117	-5.350	SF, LT	NRT
3	Malaga	36.900	4.433	LT	DLY (NRT)
4	Alicante	38.210	-0.290	LT	DLY
5	Barcelona	41.385	2.177	Storm Surges	DLY
6	Palma	39.583	2.633	seiches	NRT
7	Marseille	43.300	5.350	LT	NRT
8	Aspretto	41.933	8.817	Altim. Calib.	DLY (NRT)
9	Genova	44.400	8.900	LT	DLY (NRT)
10	Napoli	40.833	14.250	LT	DLY
11	Otranto	40.133	18.500	SF	DLY
12	Brindisi	40.633	17.933		DLY
13	Ravenna	44.500	12.283	LT	DLY
14	Medicina	44.478	11.632	LT	-
15	Trieste	45.650	13.750	LT, XEV,PRE	DLY (NRT)
16	Split	43.507	16.442	LT,XEV	NRT
17	Dubrovnik	42.667	18.067	LT	NRT
18	Porto Empedocle	37.283	13.533	Sicily SF	DLY
19	Cagliari	39.200	9.167	LT	DLY
20	Porto Maso	35.909	14.519	SF,seiches, LT	DLY
21	Alexandropoulis	40.850	25.883	LT	NRT
22	Thessaloniki	40.617	23.033	LT	DLY
23	Skopelos	39.132	23.723	LT	DLY
24	Chios	38.376	26.140	MDL, PRE	DLY
25	Piraieus	37.940	23.639	MDL, PRE	NRT
26	Rhodos	36.433	28.233	MDL, PRE	NRT
27	Souda	35.500	24.050	MDL, PRE	NRT
28	Kalamata	37.017	22.133	MDL, PRE	NRT
29	Preveza	38.950	20.767	MDL, PRE	NRT
30	Antalya	36.833	30.617	MDL, PRE	NRT
31	Bodrum	37.036	27.429	LT	NRT
32	Mentes	38.414	26.732	LT	DLY
33	Erdek	40.383	27.850	LT	DLY
34	Istanbul	41.004	28.976	SF	DLY
35	Burgas	42.501	27.487	LT	DLY
36	Constanta	44.167	28.667	MDL, PRE	NRT
37	Katcively	44.416	34.050	MDL, PRE	NRT
38	Tuapse	44.100	39.067	LT	DLY (NRT)
39	Paphos	34.783	32.401	LT, MDL	DLY
40	Hadera	32.467	34.917	LT, MDL	NRT
41	Ashdod	31.811	34.635	LT	NRT
42	Alexandria	31.217	29.917	LT	DLY
43	Nador	35.167	2.950	MDL, PRE	DLY (NRT)

c. All MedGLOSS stations have to measure and provide data according to the international standards defined for GLOSS stations. Minimum data will include hourly averaged values of sea-level and atmospheric pressure.

d. All near real-time stations need to have their reference bench marks measured by GPS missions at 1-2 year intervals, while those selected also or only for long term monitoring, need installation of permanent GPS monitoring stations at or near the bench marks.

e. Rescue of existing historic sea-level data (digitization) at the pilot stations should be given assistance and considered of high priority.

f. The participants expressed their appreciation to IOC and CIESM for

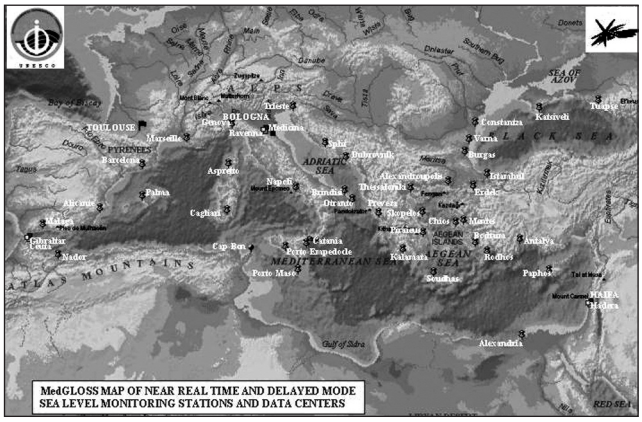

Figure 1 – Updated MedGLOSS pilot network sea level stations and data centers

supporting the meeting, and to CIESM also for funding upgrading of sea-level stations in a number of countries. In view of the relatively modest funding needs for upgrading of equipment, maintenance and operation of the monitoring stations and historic data rescue, the national research financing bodies should be contacted by IOC and CIESM to assist their national organizations participating in MedGLOSS in the long term performance of these tasks, for the benefit of the national and international communities. However, additional funding would be seeked via international research programs and from the MedGLOSS programme sponsors, IOC and CIESM.

g. MedGLOSS pilot network will operate from one focal point, agreed to be at the Israel Oceanographic & Limnological Research, Haifa, which will gather the sea-level data from the MedGLOSS sea-level stations, quality verify, absorb in a basin wide data base and disseminate the data to the participating organizations and to other international organizations and programmes such as the PSMSL, WMO, MFS, etc. Upon full implementation of MedGLOSS in all Mediterranean and Black seas countries, additional support centers will be selected, to aid the focal center with quality verified data.

h. A Memorandum of Understanding draft will be circulated by Dov Rosen, MedGLOSS coordinator, to the MedGLOSS participating organizations, to be signed upon approval, which will coordinate the MedGLOSS pilot network operation and the data rights and transfer to third parties outside MedGLOSS, according to the purpose of data use (commercial, scientific).

i. Formal active operation of MedGLOSS pilot network will start on 01 October 2001.

MedGLOSS progress update

Following the recognition of the need for upgrading key sea-level stations, CIESM decided after the last CIESM Congress to fund the upgrading and connection to the MedGLOSS pilot network of a number of key stations of CIESM member countries, with the assisstance of the Israel Oceanographic and Limnological Research Institute (IOLR), Israel. The stations originally selected for equipment upgrading were in Romania, Croatia, Malta, Egypt, Tunisia and Morocco and lately also in Cyprus. The upgrading started by the installation of the first in December 1999 in the port of Constantza, Romania, followed by the next station installation in June 2000 in the port of Split, Croatia, and the third station installation in Portomaso, Malta in February 2001. Two additional stations were proposed to be installed in Tunisia and Egypt. Tunisia decided to perform the upgrade by self funding, purchase and installation of the equipment selected. For this purpose, all necessary documentation was transferred to the Dr. Cherif Sammari of Tunisia. Discussions were conducted with the National Institute of Oceanography and Fisheries, Egypt for a the installation of a station in the port of Alexandria. So far they have not materialized in an implementation plan for the Alexandria station, but it is hoped that this would be achieved soon. The installation of a sea level station in Nador port, Morocco was agreed with the Morocco authorities by CIESM. The funds were provided for ordering the equipment and coordination of the installation started by the local authorities and the coordinator. By the end of 2000 final confirmation of the site in the port of Nador was received from the port authorities for the installation of the station. At present the equipment purchased is ready and expected to be installed in late fall 2001, during suitable weather conditions. Finally, the installation of the equipment for a sea level station in Paphos, Cyprus agreed with the Cyprus authorities is planned to be performed at the beginning of September 2001.

The real time transmission from all selected pilot network sea level stations for near-real time transmission was delayed to 1 October 2001, expecting that by then both existing and new station will be ready for coordinated data transmission. In addition to the implementation of the MedGLOSS meeting decisions, additional plans for 2001 are:

(a) Adaptation of tide forecasting software package TASK developed at POL to WINDOWS system by IOLR and POL;

(b) Adaptation of ISRAMAR software package for MedGLOSS data gathering and transmission and display to WINDOWS system by IOLR;

(c) Adaptation of the residual sea-level forecasting developed by the Puertos del Estado to the Central and Eastern Mediterranean and to the Black Sea.

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SEA LEVEL VARIATIONS IN MELLIEHA BAY, MALTA

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Abstract

Sea level variations in the northwestern coastal area of Malta are studied by a set of 2-minute sampled observations in Mellieha Bay. These measurements constitute the longest time series of simultaneous water level and meteorological parameters in the Central Mediterranean. Tidal and non-tidal oscillations are analysed over a wide range of frequencies. Large amplitude fluctuations, known locally as the 'milghuba', carry substantial energy in the long wave frequency band 0.2–5cph. Strong seasonal non-eustatic fluctuations in the MSL are characterised by a high in the last months of the year followed by a typical sharp fall to a minimum in February/March.

Keywords: sea level, tides, waves, time series

The Maltese Archipelago, consists of a group of small islands aligned in a NW-SE direction, located close to the southeastern margin of the Sicilian shelf. The islands are located at an oceanographically strategic position for studying the influence of the Sicilian Channel in the exchange flow between the two principal basins of the Mediterranean Sea. The sea level data in the small Mellieha embayment (≈ 1.5x3Km) cover the period June1993-December1996 (43 months). These measurements constitute the first set of digitised sea level recordings in the Maltese Islands and were collected as part of an ongoing research programme that will now form part of MedGLOSS. Submitting the data to a tidal harmonic analysis by a least square procedure [1] based on 61 constituents yields a maximum range of only 20.6cm, on average, with a predominance of the semidiurnal constituent (M2=6.04cm, 55°; S2=3.77cm, 62°; K1=0.7cm, 53°; O1=0.78cm, 56°) and a Form Number of 0.15. The contribution of the solar radiation tidal input is high (S_2 is 62.4% of M_2), which is typical of the Mediterranean. The main diurnal constituents K_1, O_1 and P_1 are relatively weaker in the region of the Maltese Islands compared to the Sicilian shore to the North. These diurnal constituents cause the minor diurnal inequalities.

Spectral analysis on the full data set is performed by using a Kaiser-Bessel spectral window with 50% overlap. Different window sizes are used for the lower and higher frequencies to permit an optimal resolution of the long-period and short-period components respectively. Three main frequency bands are noted: (i) the low frequency (long-period) band (LB) in the range 0 - 0.8cpd (T(hours)>30); (ii) the tidal frequency band (TB) in the range 0.8 - 4.8cpd (30>T(hours)>5); (iii) the long wave frequency (short-period) band (SB) in the range 4.8cpd and upwards (T(hours)<5). The energy distribution at different frequencies is expressed as a percentage of the total energy in the records (Table 1). The low frequency signals carry 57.3% of the total energy. This explains that variations in atmospheric pressure associated with mesoscale meteorological phenomena produce a predominant effect on the sea level in the synoptic and sub-synoptic time scales. However, the response of the sea is non-isostatic [2] and carries the signature of oceanographic conditions in the region as well as that of non-local forcing resulting from intra-basin differences. Tidal energy inputs (35.8%) mainly result from the semi-diurnal component (32.7%). The high frequency (>4.2cpd) inputs, are due to long period waves in the form of coastal seiches, and contribute by 6.6%. This figure is an average of the seiche energy over the whole time span covered by the data series and greatly underestimates the real energy carried by these large amplitude oscillations which occur as transient events lasting only for relatively short spans of time (from a few hours to a couple of days).

Table 1. Percentage energy distribution in Mellieha Bay.

Frequency Band	%
Low frequency (<0.8cpd)	57.3
Diurnal (0.8-1.2cpd)	3.0
Semidiurnal (1.8-2.2cpd)	32.7
Quarter diurnal (3.8-4.2cpd)	0.06
High frequency (>4.2cpd)	6.6
Other	0.36

The phenomenology and generation of these non-tidal short period sea level fluctuations, known by local fishermen as the 'milghuba', are extensively covered in [2]. These oscillations have now been observed to occur all along the Northern coast of the Maltese archipelago. From the Malta Channel Experiment [2] it is inferred that the longer period signals are associated to longitudinal, latitudinal and mixed stationary modes that develop on the highly irregular shaped continental shelf. The higher frequency coastal seiches are characterised not only by eigenmodes pertaining to inlets and bays on the coastal perimeter, but also by open sea modes in the nearshore shelf areas.

The seasonal signal in the MSL, studied by monthly averages, is characterised by a sea level maximum which generally occurs in October, while a minimum occurs in March (Fig. 1). The maximum range between the extreme levels can reach up to 0.35cm. However, the differences in size and phase of the fluctuations as well as the occurrence of fast variations (such as the sharp rise in sea level in May 1996) are indicative of considerable interannual variability. Comparison with sea level data covering the period May 1990 to May 1991 in the Grand Harbour (only within a few kilometres of distance from Mellieha Bay) show that during that year the rise to maximum sea level in October was more gradual, while the minimum occurred in January rather than March.

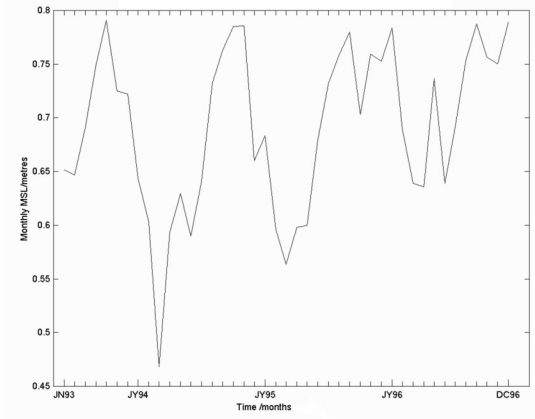

Figure 1. Seasonal fluctuations of monthly MSL in Mellieha Bay (Jun93 / Dec 96).

The seasonal signal is also present, though less energetic, in the atmospheric pressure. However, with the Inverse Barometer correction, the MSL still retains a large part of its variability. Other factors besides air pressure must thus be responsible. Seasonal winds and the piling of water onshore as a result of storm surges can greatly contribute to the seasonal sea level variations [3]. The MSL variations in Malta are however found to be practically unrelated to the wind. Sea water temperature and baroclinic phenomena such as steric effects can also be important factors. Using an ECMWF climatology of net surface heat fluxes for the Mediterranean, it is found that steric effects produce changes in the MSL that have the right phase compared to observations, but which are only about half in size to the actual variations [4]. A great part of the seasonality observed in Malta is thus believed to be non-local in nature and to predominantly carry the signature of differences in meteo-marine conditions in the two main Mediterranean basins. The simultaneous basin-wide sea level observations within MedGLOSS will be useful to assess the extent to which this seasonal variability can be attributed to adjustments in the mass balance of the whole Mediterranean Sea.

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SEA LEVEL OBSERVING SYSTEM IN THE WEST-WESTERN MEDITERRANEAN. IN THE PURSUIT OF THE LONG-TERM CHANGES IN SEA LEVEL. CONTRIBUTION TO MEDGLOSS

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Abstract

The sea level observing system presented in this paper is operated under the responsibility of the Instituto Español de Oceanografía (IEO). It cover not only the strait of Gibratar: Ceuta (35º 00'N, 05º 36'W) in the African Coast, Tarifa (36º 00N, 05º 36'W), Algeciras (36º 07'N, 05º 19'W) in the European Cost, but also two other stations close to the strait: Cádiz (36º 32'N, 06º 17'W) in the Atlantic and Málaga (36º 43'N, 04º25'W) in the Mediterranean. Furthermore, the station in Palma de Mallorca (39º 33'N, 02º 38'E) is also included in this system and Ciudadela will be operative very soon. All the station fulfil the GLOSS requirement and European Sea Level Observing System [1, [2] and even in the stations of Ceuta and P. Mallorca there are (will be) installed a permanent GPS, under the IGN responsibility, for a continuos land monitoring [3]. The time series cover the period (1944-1999), except for P. Mallorca, but there are some lags. At present, the complete period can not be used for the long-term change because there exist some inhomogeneities in the time series, then it is not possible to know that in this part of the Mediterranean the trend reduction after 60's [4, 5] have been occur, but the present analysis shows lower trend than in the Atlantic and even in some stations the trends are negatives. During this decade (90's), the sea level has been increased somewhat more than in the 80's in most of the stations.

Key-words: Sea Level, Time series, Global Change, Western Mediterranean.

Technology and methodology

At this time, the complete sea level observing system, consist in 6 permanent tide gauge stations, 1 (or 2) permanent GPS stations and two Data Centres, in the IEO and IGN respectively, fig. 1. Concerning to the sea level, the measurement equipement is a mechanical float gauge with a digital output system facility in addiction to the graphical output. The data are received in the Data Centre in near real time by modem. The stations around the peninsular coast are linked to the National Geodetic Levelling Network. The mean sea level in P. Mallorca and Ceuta are the references for the Levelling Network of the Island of P.M. and the City of Ceuta respectively. The locations of these two stations are very strategy for the spatial sea level topography. For that reason, these stations are included in MEDGLOSS. The sea level data are received in the Data Centre and a systematic quality control is performed at annual basis, by using the USLC software [6]. Later on in order to found the inhomogeneities in the whole series, the Alexandersson's homogeneity test, SNHT [7], has been performed station by station. Then, with the reference homogeneous station for the region, the Craddock's test (1979) it is performing and the vertical land movements will be remove by using the correction given by Peltier [8],[9], for the final results.

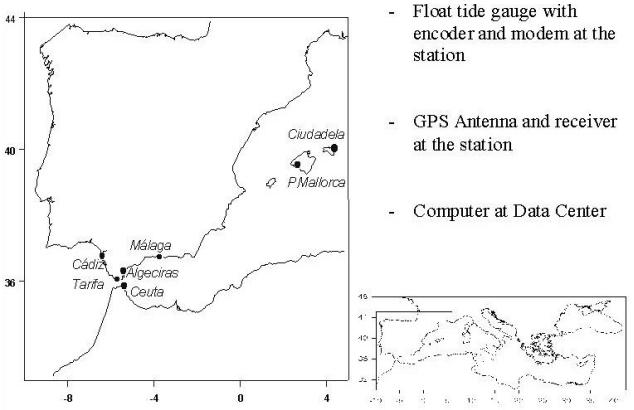

Fig. 1. Network. Geographical position and technology.

Discussion of the time series

In fig. 2, the Alexandersson's test shows: two inhomogeneity indicators in Málaga (1961,1978), one in Algeciras (1956, 1990), two in Tarifa (1957, 1991). The dates when the inhomogeneities occur are corresponding, mainly, with changes in places or equipement according to the historical notes of each station. The trends have been calculated for the homogeneity periods as presented in fig. 3 and table 1. The Craddock's test is been processing taking into account the results of the previous analysis and the historical notes, for cross-checking.

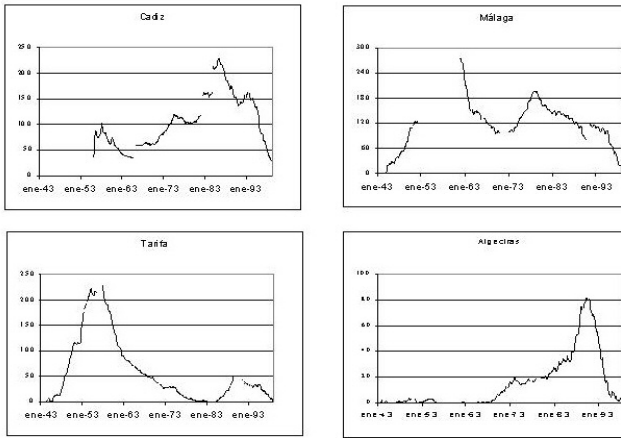

Fig. 2. Alexanderson test. Pointer of inhomogeneity

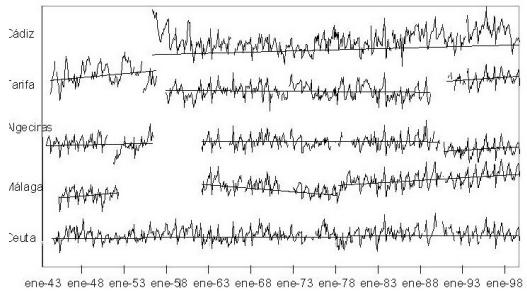

Fig. 3. trends by station and by period.

Table 1. Mean sea-level trend by period and stations.

Station	Period	trend mm/yr	station	Period	trend mm/yr
Cádiz	Feb 56-Dec 99	2.18	**Ceuta**	Mar 44-Dec 99	0.55
Tarifa	Jan 44-Aug 56	7.52	**Málaga**	Jan 45-Feb 52	7.47
	Oct 57-Mar 91	-0.62		Jan 62-Apr 78	- 6 .66
	Apr 91-Dec 99	5.80		May 78-Dec 99	4.99
Algeciras	Jan 43-Mar 56	1.81			
	Jan 62-Dec 90	-0.06			
	Jan 91-Dec 99	4.90			

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MEDGLOSS PRESSURE GAUGE IN THE SPLIT HARBOUR: INSTALLATION AND PRELIMINARY ANALYSIS OF THE DATA

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Abstract
The paper reports on the installation procedure and some preliminary results based on the data collected at the MedGLOSS pressure gauge installed in the Split harbour in June 2000. Some problems related to the levelling procedure are discussed. In addition, applicability of the sea level data is stated, and some preliminary results based on the data is presented.

Keywords: Adriatic Sea, sea level, tide gauge

Introduction

MedGLOSS program (Mediterranean Global Sea Level Observation) was initiated 5 years ago [1], in order to join together various national services dealing with the measurements of sea level around the Mediterranean. Besides the network of existing tide gauges operating along the coast and situated mostly along the northern part (mostly based on the mechanical float-type devices operating in the stilling wells), a few of newer pressure gauges were installed after 1999, in particular in the Split harbour in June 2000. Herein will be presented some applicability of the sea level data, installation procedure of the gauge placed in Split harbour and some preliminary examinations based on the pressure data collected there.

The data collected by the Split station will be useful within the climatological studies in the Adriatic, particularly those dealing with the global sea level rise, which is coming into focus over the last two decades [2]. Sea levels on the time scale of several days (storm surges) are also of typical interest nowadays; an example strongly emerges when considering the flooding in the North Adriatic [3,4], particularly in the Venice lagoon (so called "acqua alta"). In addition, free oscillation of the sea level, especially occurring within the semi-enclosed basins and harbours, can endanger the safety of navigation [5].

Pressure gauge at Split harbour

Pressure gauge in the Split harbour was installed in June 2000, on the pier close to the lighthouse placed at the harbour entrance. Such position was chosen because of the requirements needed for the proper work of the instrument, namely: (1) the sea is deep enough (minimum 3 m below the Chart Datum) to put down the pressure sensor deep enough to avoid the influence of the sea level oscillations in general, (2) central unit has to be placed close to the sensor in a well protected location (here it is placed within the rocky walls of the lighthouse), and (3) the place has to be protected in general from any other source of eventual damage (sea traffic, people, …).

The equipment of the new stations includes an underwater pressure sensor of Paroscientific Inc. manufacture, type Digiquartz Intelligent sensor, model 8DP060-1 with an RS-232 communication cable; Setra atmospheric pressure sensor, type 470, Garmin GPS II Plus Personal Navigator unit with serial output and remote antenna for accurate time recording, computer (Pentium II 350MHz computer with Windows 98 and 6 MB disk and US Robotics 32,000 baud rate modem), connections and power supply unit.

When installed, connection of the gauge to the geodetic reference network was done by classical geodetic methods. As the old float-type tide gauge is placed approximately 1 km from the new one, Geodetic Datum on the pressure gauge was acquired by using the existing geodetic benchmarks on the way from the old gauge to the new one. However, an error of 12 cm occurred as a result of the errors within the geodetic network related to its oldness, but it is fixed by assuming that the Chart Datum is the same at both locations.

The data are qualitatively analysed by using day-to-day analysis. Thus, after more than 6 months of working, it can be said that the pressure gauge worked properly in that time, without any problems. Moreover, the study of harbour seiches and resonance is performed4, as a rather strong synoptic disturbance occurred over the area, exciting very strong sea level response on the periods lower that 1 hour and having amplitudes up to 40 cm. An example of filtered high-frequency series is displayed in Fig. 1.

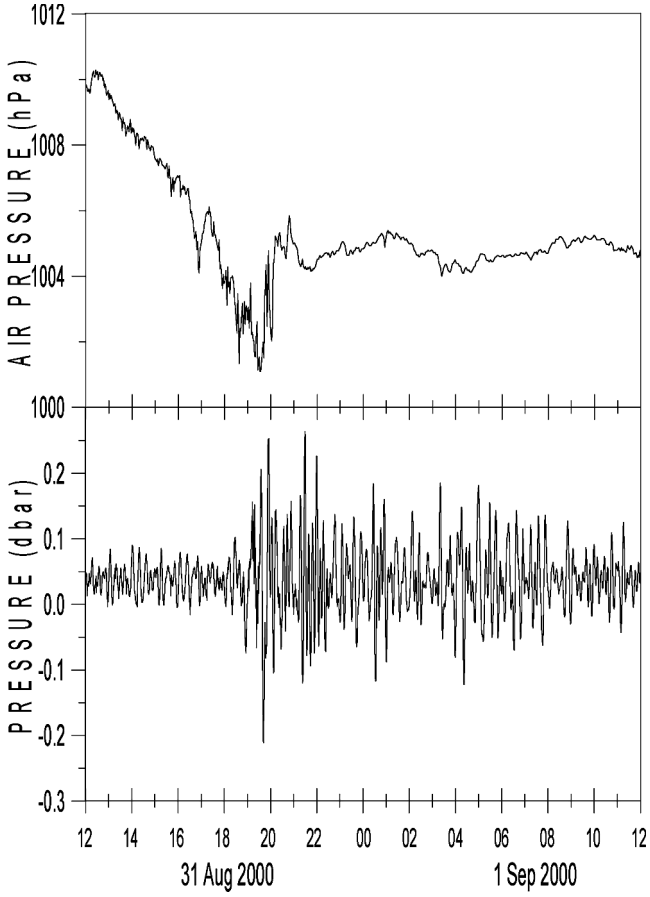

Figure 1. Time series of air pressure and high-pass filtered sea pressure time series (cut-off frequency around 1 h) of the data collected during the passage of strong synoptic disturbance.

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CHARACTERIZATION OF PHOSPHORUS SPECIES DISCHARGED TO THE S.E MEDITERRANEAN BASIN FROM LANDBASED SOURCES

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Abstract

Particulate phosphorus species were differentiated in water discharged to the SE Mediterranean basin. Despite the discharge of $1770x10^3$ MT y^{-1} of suspended matter to the SE Mediterranean, the area is still phosphorus limited. Variations in the quality of discharged water do not permit the appearance of a predominant phosphorus fraction. Iron bound phosphorus (P_{fe}) was enriched in the Nile discharge while elevated P_{org} levels were discharged from highly productive delta lakes and wastewater outfalls. Bioavailable phosphorus (P_{ex} and P_{org}) represents 16-67% of the particulate phosphorus pool.

Key words: Phosphorus, chemical speciation, coastal waters, Levantine basin

Introduction

Phosphorus is a key element in the biogeochemical cycles of the marine environment. Its availability in seawater is important in controlling its productivity. The SE Mediterrenean basin is the largest seawater body where primary production is phosphorus-limited. This unusual limitation may be due to inorganic processes adsorbing phosphorus onto labile iron hydroxides carried by Saharan dust and River Nile particulate matter. In estuarine or estuarine-like ecosystems, characterized by the transition from fresh to salt water environments, an understanding of the factors that regulate the biomass and production requires insight into the behaviour of the different forms of the targeted element rather than the total concentration. Since sequential extraction techniques are most promising for separating and quantifying various reservoirs, the aim of the present study is to evaluate the concentration levels of the main phosphorus forms in suspended matter and reconstruct a phosphorus input rate to the SE Mediterranean basin from landbased sources. It should help in understanding phosphorus biogeochemical cycling and its effect on the present day productivity.

Material and Methods

Water samples were collected from the major landbased sources discharging to the SE Mediterranean basin off the Egyptian coast. These include: Nile delta coastal lagoons opening to the Mediterranean (sites 1, 3, 5 and 7), a major sewage outfall off Alexandria city (site 2), the River Nile (site 4) and a major agricultural drain (site 6). Total phosphorus (P_{tot}) [1] and phosphorus forms [2] were determined on dried suspended matter obtained by centrifugation.The five steps SEDEX scheme was used to separate the following phosphorus pools: exchangeable + loosely-bound (P_{ex}); iron bound (P_{fe}); authigenic + biogenic apatite + $CaCO_3$ bound P (P_{au}); detrital apatite + other remaining inorganic phases (P_{det}) & organic (P_{org}) [2]. The method is suitable for measuring concentrations <0.005 wt %P. The method was tested for efficiency, specificity, matrix effect and reproducibility. Phosphate extracted from suspended matter was measured spectrophotometrically [3]. Simultaneously, suspended matter was tested for carbonate, organic content (Loss On Ignition) and chlorophyll a.

Results and Discussion

The amount and type of water discharged from the different landbased sources as well as its average TSM content are presented in Table 1. The SE Mediterranean waters off the Egyptian coast receives $18.3x10^9$ m^3 of fresh, brackish and wastewater (mainly sewage) annually from different landbased sources. About 20% of this amount are discharged from the Nile while 28% are derived from Lake Manzalah, the largest and most productive Nile Delta lake (Table 1).

Table 1. Amount and characteristics of water discharged to the SE Mediterranean.

Location	Landbased Discharge Points						
	L. Mariut	KBPS	L. Edku	R. Nile	L. Burullus	Gh. drain	L. Manzalah
TSM(mg/l)	26.9	53	87.7	138	113	105	31.5
POC/TSM %	79	68	33	53	32	26	83
Chl a (µg/l)	4.2	8.6	2.3	1.1	0.9	0.8	10.9
Discharge*	2.3	0.2	1.4	3.5	2.2	3.5	5.2
Water type	S+B	S	B	F	B	B	B
CO3/TSM %	18	31	54	44	62	58	22

KBPS= Kay Bey Pump Station *$x10^9 m^3$ y^{-1} S=Sewage B=Brackish F=Fresh

The concentrations of different particulate phosphorus species as well as their contribution to P_{tot} are presented in Table 2. P_{ex} contributed to about 2-22% of P_{tot}. P_{ex} concentrations are proportionally related to particle size. Pex decrease gradually by increasing salinity seawards from landbased sources.Variations in P_{ex} concentrations depend on alteration in redox conditions and adsorption capacity. When semi-reducing conditions prevail, P_{ex} reached maximum levels. P_{ex} is the most bioavalable fraction especially when phosphorus concentration in the water column is low.

Phosphorus associated with Ca appears either as detrital fluoroapatite of igneous and metamorphic origin (P_{det}) or other forms as biogenic skeletal debris and $CaCO_3$ incorporated phosphate (P_{au}) [4]. P_{det} showed a negative correlation with P_{au}. Organic matter oxidation and sulphide occurrence enhance $CaCO_3$ dissolution leading to low P_{au} and P_{det} contribution to P_{tot} at locations 1 and 2. The extraction method can not discriminate between apatite forms, e.g., fish bone debris from igneous apatite-P. In the present study, at least 30-50% of the suspended phosphorus pool represents an insoluble phase and is ignored when looking for water column phosphorus enrichment.

Table 2. Average concentrations of particulate phosphorus fractions (µmol g^{-1})

Form	Landbased Discharge Points						
	Lake Mariut	KBPS	Lake Edku	River Nile	Lake Burullus	Gharb drain	Lake Manzalah
P_{ex}	2.16±0.7 (22)	0.65±0.3 (7)	0.4±0.2 (6)	0.34±0.2 (2)	0.6±0.1 (7)	0.±0.1 (6)	0.88±0.6 (6)
P_{fe}	0.3±0.1 (3)	0.3±0.9 (3)	1.8±0.3 (23)	5.2±1.1 (35)	2.69±0.3 (33)	2.66±0.2 (31)	1.670.5 (12)
P_{au}	1.9±0.4 (19)	2.1±1.1 (22)	2.7±0.9 (35)	3.6±1.7 (24)	2.1±1.1 (26)	1.9±1.6 (22)	4.3±0.9 (31)
P_{det}	1.21±0.7 (12)	0.8±0.3 (8)	1.1±0.6 (14)	1.7±1.0 (12)	1.9±0.7 (24)	2.4±1.6 (28)	0.9±0.4 (6)
P_{org}	4.31±2.81 '44)	5.84±1.1 (60)	1.66±1.3 (22)	3.94±1.2 (27)	0.8±0.2 (10)	1.15±0.9 (13)	6.37±2.09 (45)
P_{tot}	10.5±2.1	10.3±3.6	7.8±1.9	14.8±3.3	8.3±1.5	8.7±1.1	14.8±2.8

**Number between paranthesis is the % from the sum of species*

The release of P associated with reducible iron oxide in the low oxygen (<2-3.5 mg/l) and pH 6.8-7.3 bearing water, opposite to Lake Mariut and sewage outfall, lowered the concentration of P_{fe}. On the other hand, ferric oxyhydroxide particles, formed under oxic conditions, have a high adsorption capacity for phosphorus. The Nile water characterized by fine-sized particles and high Fe levels showed the maximum concentrations of P_{fe} (5.2 ± 1.1 µmol g^{-1}). The well-oxygenated waters (>5.5 mgl/l) and pH (8.1-8.3) render the P_{fe} fraction to be insoluble and non- reactive in the water column. Such a release leads to highly eutrophic coastal areas as indicated by their elevated chlorophyll a levels (4.2 and 8.6 µg/L, respectively). The gradient of P_{fe} decline at the mixing zone with seawater was much more pronounced than that of P_{au} and P_{det}. A high linear correlation (R^2= 0.74, $p<0.001$) appeared between total inorganic phosphorus and P_{ex} indicating that sequestering mechanisms, other than adsorption on compounds, are kinetically slow and unimportant and concern early diagensis for the inorganic phosphorus cycle.

P_{org} (range 0.8 ± 0.2 to 6.37 ± 2.9 μmol g^{-1}) is the most heterogenous phase due to its continuous modification by degradation processes constituting between 10 and 60% of Ptot. The coincidence between chlorophyll a concentrations and P_{org} suggested that most of the organic phosphorus is derived mainly from phytoplankton with little originating from macrophytes or that changes in phytoplanktonic growth and productivity are related to P_{org} remineralization. Organic phosphorus and organic carbon showed a significant correlation (R^2=0.85, p<0.001) suggesting a common origin. Most of previous studies did not clearly observe such a relationship since P_{org} is calculated by substraction from the P_{tot} [5]. For the coastal sediments off Alexandria, P_{org} makes up about 20.9±3.72% of P_{tot} with a mean concentration of 6.9±3.37 μmol g^{-1}[6]. P_{org} showed no clear trend in relation to salinity variations along the mixing zone.

The sum of all extracted P phases was not significantly different from P_{tot} (<6%). Carbonate rich samples showed lower differences between the sum of species and P_{tot} (<1-3%). Generally, the concentrations of the P fractions derived for the SE Mediterranean are low compared to those in other estuaries.

About 1770x10^3 MT y^{-1} of suspended matter are discharged to the SE Mediterranean.Most of this material drifts eastward to Tena Bay via longshore currents. Low speed currents along the Egyptian coast (range 11-50 cm s^{-1}) permit the fast settling of this material to the bottom.

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Introduction

The Aegean Sea is an area of high seismic activity associated with important geothermal gas venting in shallow waters ranging from 2 to 120 m depth (1). Fluids from the vents, bacteria, and particles produced in the vent ecosystem are advected by currents and create a plume that spreads laterally at a level of neutral buoyancy. The geochemical cycling and biological production in these shallow hydrothermal systems is still largely unknown, particularly with respect to their importance in the production and export of particulate organic material. The present paper reports on the chemical composition of the settling material collected in particle interceptor traps deployed along the SE coast of Milos (Aegean Sea, Figure 1), in one area known for its extensive geothermal activity in the seabed (A) and in another presumed to be free of any major vent influence (B). The distributions of aliphatic and aromatic hydrocarbons and sterols, as source and maturity chemical indicators, were determined in order to contribute to a better understanding of the above processes.

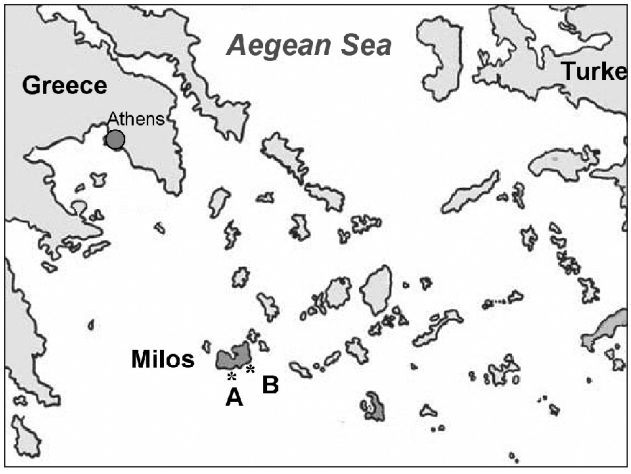

Fig. 1. Map of the Aegean Sea showing the location of the moorings. Site A is located in the vent zone off Paleohori Bay and site B beyond the influence of the submarine vents. Both moorings were located approximately 1 nautical mile offshore, and separated by a distance of about 3.5 nautical miles.

Materials and Methods

Moorings were deployed from June to September 1996, to collect during consecutive periods of 12 days settling particles at 60m over a bottom of 90m depth. Collected particles (50 mg ± 0.1), stored at –20ºC until they were processed in the laboratory, were freeze dried and extracted (3 times) by sonication with 5 ml of dichloromethane and spiked with cholestane, deuterated pyrene and 5α-androstan-3β-ol as analyte surrogates. The organic extracts were concentrated by rotary evaporation to 1-2 ml, dried over anhydrous N_a2SO_4, and fractioned by column chromatography (5 x 20 mm) with 0.5 g of 3% water-deactivated alumina. Four fractions were collected: (I) 6 ml of

GEOCHEMICAL CHARACTERIZATION OF PARTICULATE ORGANIC MATTER ASSOCIATED WITH HYDROTHERMAL VENT ACTIVITY IN THE COASTAL AEGEAN SEA.

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Abstract

Two particle interceptor traps were moored from June to September 1996 along the SE coast of Milos (Aegean Sea), in an area known for its extensive seabed geothermal activity. The settling particles collected differed between sites not only in quantity but also in their composition. In the area directly influenced by the warm water vents, the vertical flux of particulate material was almost one order of magnitude higher than that observed in the reference site, and its lipid composition (sterols) reflected a locally enhanced productivity, mostly associated to diatom blooms, which play a significant role in the accumulation and deposition of petrogenic hydrocarbons from the water column.

Key-words: Aegean Sea, thermal vents, particulates, chemical analysis

n-hexane (alkanes), (II) 5 ml of 1:2 *n*-hexane-dichloromethane (PAHs), (III) 5 ml of 1:1 dichloromethane-methanol (alcohols and sterols), and (IV) 5 ml of methanol. The different fractions were rotary evaporated to almost dryness, reconstituted with *iso*-octane, and spiked with 1-phenyldodecane, octachloronaphthalene and epi-choprostanol as internal standards, respectively, for alkanes, PAHs and sterols. The determination of the individual components of the different fractions was performed by capillary gas chromatography (30 m x 0.25 mm i.d. DB-5 fused silica) coupled to a Fisons MD800 mass spectrometer, under the conditions described elsewhere (3).

Results and Discussion

Particle fluxes were highly variable and clearly different at the two sites. During most of the sampling period, one or two orders of magnitude more particulates were produced and exported at vent site A than at control station B. Mean fluxes throughout the summer period at sites A and B were 2207 and 251 mg m^{-2} d^{-1}, respectively (2).

Although the traps were deployed within a total distance of 3.5 nautical miles, the settling particles differed between sites not only in quantity but also in their composition. Effectively, the difference in mean fluxes between sites was even more significant for POC than for total mass fluxes, with averages of 549 and 30 mg POC m^{-2} d^{-1} at sites A and B, respectively, indicating a higher contribution of abiogenic material in the latter. However, the particles collected at all sites during the observation period were largely related to pelagic production, and were mainly composed of zooplankton detritus. The sinking particles collected in summer at station A were mostly amorphous marine snow with very few fecal pellets. Bacteria were also more abundant in samples from the vent site A than in those at the site further away. Apparently, the higher fluxes in the vent site were a consequence of an enhanced production and export of organic material originating from the thermophilic ecosystem developed around the vents.

The profiles of aliphatic and aromatic hydrocarbons exhibited striking differences between particles of the two sites, A and B. The composition of sinking particles in station A, influenced by the thermal vent, exhibited an aliphatic fraction with a clear petrogenic fingerprint (Figure 2), whereas station B showed n-alkane distributions with a high even carbon number predominance in the C16-C24 range, which could be attributed to a biogenic (planktonic) origin (4).

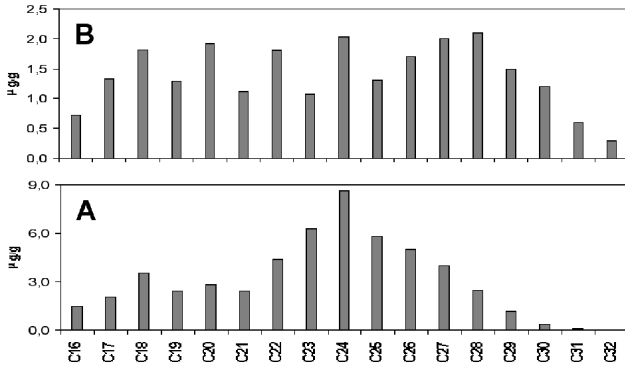

Fig. 2. *n*-Alkane distributions in particulates from stations A and B.

On the other hand, the aromatic fraction in particles from station A exhibited a high predominance of alkylated PAHs, whereas a more pyrogenic nature was observed in station B. The profiles in station B were consistent with atmospheric deposition of remote continental aerosols. In turn, the enhanced biological production in station A may have significantly contributed to the sedimentation of the more bioavailable petrogenic hydrocarbons accumulated by organisms and subsequently exported within fast sinking fecal pellets.

The sterol composition in the sinking particles also differed both in concentration and composition according to the sampling area. In fact, particles collected in the thermal vent affected area (A) exhibited remarkably unusual concentrations of 5β-stanols and related stanones, which were not detected or occurred at very low concentrations in the other area. The higher concentrations of sterols at station A is consistent with a higher productivity mostly associated to blooms of diatoms (Δ^5, $\Delta^{5,22}$ and $\Delta^{5,24(28)}$ stenols) in clear contrast with the oligotrophic conditions prevailing at the reference station B.

In summary, the Aegean Sea hydrothermal system has a strong but rather limited influence on the production of particulate organic matter and the transport of petrogenic compounds in the water column.

Acknowledgements

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INTEGRATED STUDIES OF CARBONATE CRUSTS FORMED THROUGH MICROBIAL ACTIVITY ON SUBMARINE MUD VOLCANOES

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Abstract

Authigenic carbonate crusts formed through microbial methane oxidation are widespread at seafloor cold seeps. They are a sink for methane carbon migrating from depth or being released from shallow gas hydrates and thus, partly regulate ocean atmosphere carbon fluxes. To investigate their formation we conducted an integrated microbial, mineralogical and organic geochemical study of authigenic carbonate crusts recovered from mud volcanoes of the eastern Mediterranean. Our results show that carbonate crusts are formed in an anaerobic environment through anaerobic methane oxidation. This process is mediated by diverse consortia of prokaryotes which include previously uncharacterised methanotrophic archaeabacteria.

Keywords : Eastern Mediterranean, Mud volcanoes, Bacteria, Geochemistry, Mineralogy

Introduction

In the Eastern Mediterranean, mud volcanoes form when tectonically over-pressured and methane-charged mud is extruded at the seafloor and re-deposited as mud breccia. Seven such structures at depths between 1600 and 2000 m were explored with the *Nautile* submersible during the Medinaut cruise in 1998. An important discovery was that the central parts of the mud volcanoes actively seep methane to the bottom waters and are covered by carbonate crust pavements formed by precipitation of aragonite and lesser quantities of high-Mg calcite and dolomite in the shallow pore water of mud breccia deposits (1,2).

Materials and Methods

In order to understand the geochemical and microbiological processes that lead to carbonate crust formation, two carbonate crusts recovered with the *Nautile* submersible from the Napoli and Amsterdam mud volcanoes were investigated. We combined mineralogical (X-Ray diffraction) and stable isotope studies of the authigenic carbonate phase (2) with lipid biomarker analysis (GC, GC-MS, HPLC), compound-specific carbon isotope measurements (3) (GC-irm-MS) and 16SrRNA gene surveys conduced on the organic matter extracted from the crusts.

Results and discussion

The carbonate cements have unusually low concentrations of ^{13}C indicating methane as the major source of carbon. Measured velues of $\delta^{18}O$ of the Eastern Mediterranean crusts are considerably higher than those expected for carbonates precipitating from modern eastern Mediterranean bottom waters. Although this could reflect precipitation at lower temperatures, no significant temperature anomaly was measured during the Medinaut cruise. The ^{18}O-enrichment is possibly due to precipitation from ^{18}O-rich water derived from the decomposition of gas hydrates that are present in the studied mud volcanoes (1). Other possible sources of ^{18}O are the seepage of relic brines of Messinian age that are present in the sedimentary succession of the eastern Mediterranean and high temperature fluid-rock interactions.

Prior to carbonate crust formation, methane is oxidised and, at cold seeps, this process is mediated by aerobic and/or anaerobic chemosynthetic microorganisms. Simple chemical considerations predict that aerobic methane oxidation produces acidity, favouring the dissolution of carbonates, rather than their precipitation. Furthermore, pore water chemical profiles in marine sediments suggest that most of the rising methane could be consumed in the absence of oxygen. Knowledge of the nature of the microorganisms which are involved in methane consumption in anoxic environments, however, is incomplete (3,4).

No evidence for the occurrence of aerobic bacteria performing methane oxidation was found in the crusts, relevant diagnostic biomarkers being virtually absent among lipids. In contrast, abundant and highly diverse ^{13}C-depleted biomarkers specific of archaeabacteria indicate that methane is assimilated by a diverse community of archaea. Organic geochemical analyses also indicate that methane oxidation is mediated by sulfate reducing bacteria.

Bacterial 16S rRNA gene surveys confirmed the absence of aerobic methanotrophic bacteria. Archaeal 16S rRNA gene surveys identified a great diversity of archaeal lineages, most of which are novel and previously uncharacterised. In agreement with lipid analyses, bacterial 16S rRNA gene surveys identified sequences of sulphateˆreducing bacteria. These observations are consistent with the presence of a consortium of prokaryotes composed of methane-consuming archaea and sulphate reducing bacteria which is held responsible for the anaerobic oxidation of methane in a variety of marine settings (5).

Conclusion

Recent studies show that gas hydrate destabilisation following bottom water temperature increase had profound effects on past global climate. Authigenic carbonates formed through anaerobic methane oxidation at cold seeps have the potential of recording such events. The microbial processes we describe provide the easiest explanation of their formation and could dominate at cold seeps worldwide. Highly diverse microbial communities are involved supporting recent propositions that microorganisms play a fundamental role in mineral precipitation.

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FATE OF PERSISTENT CHEMICAL WARFARE AGENTS IN A BENTHIC ECOSYSTEM OF THE SOUTHERN ADRIATIC SEA

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Abstract
In this study we analyze the status of health of a benthic ecosystem affected by chemical warfare agents (CWAs), loaded in weapons that were dumped in southern Adriatic Sea during and after WWII. Following a multidisciplinary approach, samples of sediment, water and fish were collected both in the area of study and in a reference site. Analysis have been carried out to determine the contamination and biotoxicity of water and sediments by CWAs. Stress index were developed in order to evaluate the toxicological effect of CWAs in fish and macroscopic analysis of liver, spleen and skin were utilized to assess the health status of fish. The results provide a initial worrying picture of the benthic ecosystem healthiness even though more work is needed.

Keywords: Adriatic Sea; bathyal, ecotoxicology, monitoring, pollution

Introduction

Among war material of any sort, chemical weapons were dumped in the southern Adriatic Sea during and after WW II. An evidence is the fact that from 1946 until 1996 more than two hundred Apulian fishermen have been hospitalised because of being severely by chemical injured by chemical warfare agents (CWAs) (1, 2). Bis-(2-chloroethyl) sulpide (Cl-CH_2CH_2-S-CH_2CH_2-Cl), a CWA commonly known as "mustard gas" or yperite ("H", Levinstein process) and dichloro-(2-chlorovinyl)arsine (Cl-CH=CH-As$(Cl)_2$) ("lewisite") they are among the twenty-four different CWAs that were contained in bombs, grenades and drums dumped in different sites of the southern Adriatic Sea at depths in the range of 150 ÷ 1000 m (Fig. 1). Eighteen of these compounds pose major risks to the concerned benthic ecosystem because their physical-chemical properties make their noxiousness persistent in sea water. Hydrolysis products, such as 1,4-thioxane (S-CH_2CH_2-O-CH_2CH_2) and bis(2-hydroxyethyl)sulfide (HO-CH_2CH_2-S-CH_2CH_2-OH) from yperite and 2-chlorovinylarsenious acid (Cl-CH=CH-As$(OH)_2$) and 2-chlorovinylarsenious oxide (Cl-CH=CH-As=O) from lewisite, have shown to be even more toxic than their parent products (3).

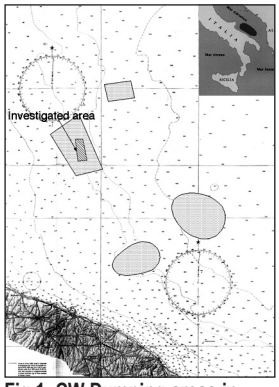

Fig.1. CW Dumping areas in southern Adriatic Sea

Methods and Materials

In June 1999 a survey was carried out on a ten square nautical miles rectangle of the sea-floor. This site was chosen from one of the four different dumping zones that the authors discovered in the southern Adriatic Sea (Fig. 1). A digital DATASONIC CHIRP SIS 1000 side scan sonar and sub bottom profiler coupled with a magnetometer (mod. G880 GEOMETRICS) were employed for the localisation of "targets" on the sea-bottom at depths in the range of 200 - 300 m. The analysis of the recorded courses allowed the ranking of 102 targets and the choice of the ones considered as representative. Nine aerial and two artillery bombs were observed by means of a remotely operated vehicle (mod. SEASURVEYOR SEA EYE 215) that was specially equipped to collect samples of sediment and water. In three cases, the CWAs contained in the observed rusted shells were clearly visible both from holes and fractures of the bomb body as well as on the surrounding sea-floor (hard substrata made by coarse sediments enriched with fine particles).

By means of the R.O.V, macrozoobenthos (*Thenea muricata, Abra sp., Cidaris cidaris, Echinus acutus*) and demersal fishes (*Helicolenus dactylopterus* and *Conger conger*) were observed to behave apparently normally while they were very close to what was considered as an yperite-based partially hydrolised product.

Sampling surveys were carried out to collect demersal fishes both in the area of risk and in two areas located in the southern Tyrrenian Sea supposed to be unaffected by war material dumping.

A multidisciplinary approach was used to investigate the noxiousness of the CWAs on the benthic environment. Sediments and fish tissues (muscle and liver) were analysed by means of GC-MS full scanning in order to detect yperite and lewisite products traces. Water and sediment samples were tested by means of MICROTOX® and tissues (liver, brain, muscle and gills) of *Conger conger*, *Helicolenus dactylopterus, Raja asterias, Raja clavata, Trigla lyra* and *Trigla lucerna* were analysed to detect traces of arsenic by means of AAS and to measure some "stress indices" (CYP-450 1A, Ech). Furthermore, a health assessment index (HAI) was assigned to each individual, according to the number of macroscopic alterations observed. Histopatological analysis were performed on liver and spleen of the same fishes.

Results and Discussion

Sediment samples revealed the presence of some decomposition products of yperite and of bis-(2-chloroethyl) disulpide (impurity product of Levistein's process): 1,4-tioxane; 1,4-dithiane; 1-oxa-4,5-dithiapane; 1,2,5-Trithiapane. Sediment samples analysed with the MICROTOX, test showed biotoxicity both in the solid phase and in the interstitial water.

Arsenic levels in *Helicolenus dactylopterus* (8 individuals) collected from the area of study were significantly higher (Mann Withney *U* test, $p<0,05$) compared to those found in the 6 individuals of the same species collected from the control site (Fig. 2).

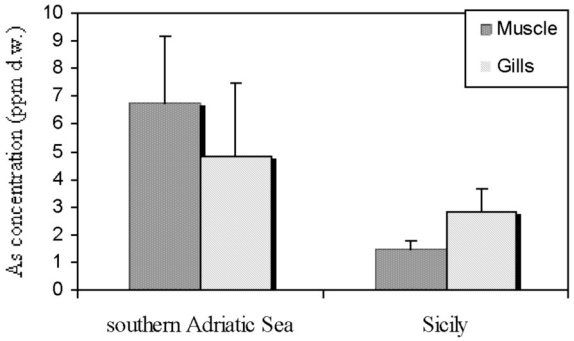

Fig. 2. As concentration (ppm d.w.) in specimens of *H. dactylopterus* collected

Moreover the enzyme activity of *Helicolenus dactylopterus* involved in detoxifying processes in liver tissues (CYP-450 1A) and the physiological activity of enzymes in brain and muscle tissues (AchE) showed significant differences compared to the controls values.

The "Health Assessment Index (HAI)" (4), counted 15 out of 18 individuals of *Helicolenus dactylopterus* as damaged whilst in the control site only 11 out of 21 specimen of *H. dactylopterus* showed significant macroscopic alterations. Histological analysis revealed evident damages (steatosis, fibrosis, granuloma, and atrophy of linphatic centres) in liver and spleen tissues of 16 individuals among the 18 *H. dactylopterus* analyzed.

The analytical results indicate that the leakage of CWAs from the rusted bomb shells is likely to produce negative effects on the concerned benthic ecosystem. In order to assess the environmental risk, more data and a wider biological sample size are needed. At the moment, the Italian Ministry of the environment is taking into consideration this request.

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PAHS IN SUPERFICIAL SEDIMENTS AFFECTED BY RAW SEWAGE IN A MOROCCAN MEDITERRANEAN COASTAL AREA (AL HOCEÏMA)

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Abstract
In the framework of an EC Avicenne initiative co-funded project, the authors investigated the distribution of some organic pollutants in superficial sediments subjected to urban raw sewage pollutant inputs in Al Hoceïma (Morocco, Western Mediterranean Sea). The sampling design has foreseen collecting samples of superficial (0-20 cm) sediments by means of box-corer, gravity corer and grab. 27 stations were sampled to characterize sediment texture and to quantify the PAHs concentration. Results show that these pollutants are dispersed in a wide area by strong long-shore currents.

Key words: coastal systems, PAHs, sewage pollution, Western Mediterranean

Introduction

In the framework of an EC Avicenne initiative co-funded project, the distribution of polycyclic aromatic hydrocarbons (PAHs) in superficial sediments subjected to urban raw sewage pollutant inputs in Al Hoceïma (Morocco, Western Mediterranean Sea) was investigated.

The area was chosen along the Moroccan coast in the Alboran Sea basin (Western Mediterranean Sea) near Sabadia and Al Hoceïma Bay; Al Hoceïma Bay is located on the extension of lower valley of Nekkor (Middle Rif's belt). Sedimentation is mainly terrigenous in the central area of the bay while, on the external sides is mainly bioclastic sedimentation (1); the morphological features of the continental shelf in the area indicate, on the outer side, some sectors with variable slope of the sea floor.

Methods and Materials

15 superficial sediment samples coming from the marine area in front of Sabadia al Hoceïma and 2 samples (SM3 e SM5) in front of the sewage output were collected. In the Al Hoceïma Bay, instead, in the eastern zone of investigated area, 8 superficial samples and 2 cores (Fig. 1) were collected to understand about vertical contaminant distribution. The first 6 cm length of each core was sub-sampled into 1 cm-thick layers while the remaining part was sub-sampled into 2 cm-thick layers. All the samples were then homogenised and frozen at -20°C prior to the analyses.

Grain size and PAHs analyses were performed according to Romano et al.(2).

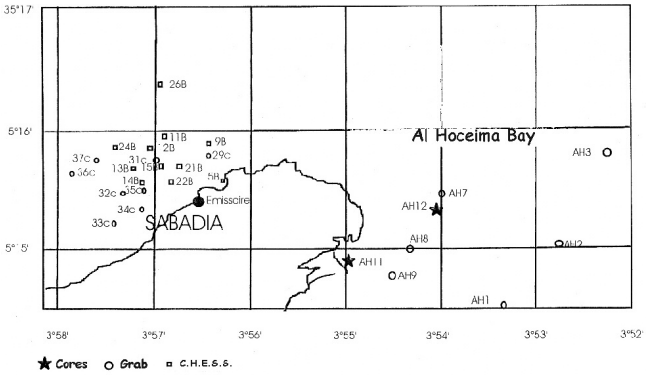

Figure 1. The investigated area and sampling points

Results and Discussion

In the western zone of the area, grain size results show only sandy sediments with an high biodetritic fraction (3%-4.6 %). It was coarse and frequently were found much organogenic detritus probably worked by the transport and long-shore current; the fine fraction is absent in almost all the samples, except for the MM 24B sample (13.8%), localized at the end of the first slope (50 – 60 m).

In the eastern zone (Al Hoceïma Bay), instead, superficial sediment is mainly terrigenous with a low sand fraction (3%-17%), and no biodetritic fraction. Only AH 9 and AH 11C samples have respectively 31% and 21.8% of sand. In both areas sediment distribution don't seems to be related to the bathymetry.

PAHs concentration levels measured in the western area are generally low in all the samples with the only exception of station 25B (549 ng/g) that is was located on the outer side of the area. In the eastern zone the levels are below the detection limit (<1 ng/g).

The vertical trend of the core AH 11C shows a decrease of the sandy fraction until 14 cm from the top while in the last two levels the sandy and gravelly fractions increase.

In the core AH 12C, instead, the sandy fraction increases with depth and, at the same time, there is a decrease in the clay fraction. There is only one exception in the (4-5 cm) level with a high value of clay content (62%).

In both cores the PAHs concentrations decrease with depth with the higher values in superficial layers of AH 12C; in particular, in this core is observed the same trend in the fine fraction (Fig. 2).

In conclusion, our results identify two areas with different sedimentological characteristics in which sedimentation is strictly conditioned by continental shelf morphology and the coastal hydrodynamic regime. The western area has a coarse and biodetric sediment deposition and the eastern area, Al Hoceïma Bay has a terrigenous sedimentation. PAHs contamination is low and strictly correlated with the fine fraction.

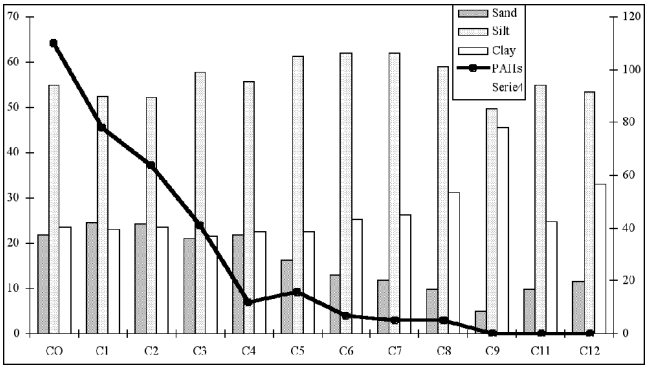

Figure 2. Grain size (%) and PAHs trend (ng/g) in AH11C core.

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SURVEILLANCE DES NIVEAUX DE CONTAMINATION CHIMIQUE ET RADIOLOGIQUE EN MÉDITERRANÉE BASÉE SUR L'UTILISATION DE STATIONS ARTIFICIELLES DE MOULES

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Résumé

Des transplants de moules sont utilisés pour évaluer les niveaux de contamination chimique et radiologique biodisponible le long des côtes méditerranéennes françaises. Les conditions de mises en œuvre (sélection du lot de moule, état physiologique, période de stabulation) permettent d'obtenir des modèles de régression linéaire reliant la concentration tissulaire en contaminant et un indice biométrique représentatif de la physiologie des organismes. Ces modèles permettent, à l'échelle du réseau, d'ajuster les résultats à un individu standard et de les comparer indépendamment de l'hétérogénéité physico-chimique et trophique des sites expérimentés.

Mots clefs : surveillance, bioaccumulation, bivalves, modèles, éléments traces.

Introduction

Le réseau RINBIO, développé en partenariat avec l'Agence de l'Eau Rhône Méditerranée Corse (RMC) et l'Institut de Protection et de Sûreté Nucléaire (IPSN), a pour objectif d'évaluer les niveaux de contamination chimique et radiologique biodisponible dans chaque unité du référentiel géographique du Schéma Directeur d'Aménagement et de Gestion des Eaux (SDAGE) du bassin RMC. Comme les « Mussel Watch », il se base sur les capacités bioaccumulatrices de la moule (1), mais utilise la technique des transplants pour s'affranchir de la faible disponibilité de stocks naturels de coquillages et de la bathymétrie des sites échantillonnées. Les caractéristiques physico-chimiques et trophiques des sites de stabulation influencent cependant la biodisponibilité et la spéciation du contaminant, mais également le métabolisme et la croissance des tissus de la moule dans lesquels il est pour ainsi dire dilué (2). Une méthode utilisant les relations entre les concentrations en contaminants et la croissance tissulaire (3) a été développée pour ajuster les résultats et permettre leur comparaison à l'échelle du réseau.

Matériel et méthode

38 stations ont été disposées d'avril à juillet 1998 en mer ouverte (bathymétrie des 20 et 30 mètres) et en lagune, en Languedoc Roussillon, Provence Alpes Côte d'Azur et en Corse. Les cinétiques de décontamination étant plus lentes que celles de contamination (4), les moules de 18 à 24 mois (50 mm) sont originaires d'un site connu pour ses faibles niveaux de contamination. Les contaminants chimiques sont analysés dans la chair totale des moules selon les protocoles du Réseau National d'Observation (5) : Pb, Cd, Cu, Hg, Cr, Ni, As, DDT+DDD+DDE, PCBs (CB28, CB31, CB35, CB52, CB101, CB118, CB138, CB153, CB 180) HAP (Benzo (b) fluoranthène, Benzo (k) fluoranthène, Benzo (a) pyrène, Benzo (ghi) pérylène, Indéno (1,2,3-cd) pyrène, Fluoranthène) Sur 19 échantillons prélevés en mer, les radionucléides sont analysés selon le protocole de l'IPSN (6). Pour chaque échantillon, le poids sec de coquille (PC) et le poids sec de chair (PS) sont mesurés pour calculer un indice de condition (IC = PS/PC).

Résultats

Le modèle d'ajustement. La distribution de l'IC confirme que les eaux sont plus riches trophiquement dans le golfe du Lion, en relation avec les apports nutritifs du Rhône, que dans l'Est de la région PACA et la Corse. Les lagunes se situent dans une position intermédiaire . Sur l'ensemble des résultats la concentration tissulaire en contaminant est généralement soit proportionnelle (Cr, PCB, DDT, DDD, DDE, HAP) soit inversement proportionnelle (Zn, Hg, Cd, As, Cu, Ni, Pb), à l'IC. Pour chaque contaminant, quelques stations s'individualisent des modèles linéaires obtenus par des résultats systématiquement supérieurs (figure 1). Le retrait de la base de donnée de ces stations situées, à priori, dans des secteurs contaminés, permet de déterminer un modèle par contaminant qui exprime l'effet « indice de condition » et caractérise le niveau moyen de la contamination à l'échelle du réseau. Les concentrations brutes peuvent être ajustées à un individu standard et comparées entre elles indépendamment du site. Pour les radionucléides, compte tenu du faible nombre de valeurs supérieures à la limite de détection et d'une valeur moyenne des IC égale à 1, la concentration est multipliée par la valeur correspondante de l'IC pour chaque station.

Les résultats ajustés (exprimés en poids sec de chair). Trois pics de cadmium ont été identifiés dans le complexe lagunaire de Bages et d'Ayrolle (3,1 μg/g) avec un gradiant décroissant du Nord vers le Sud en relation avec la position de l'apport identifié de cadmium. Le niveau moyen en mercure est de 0,13 μg/g avec un pic dans l'étang du Prévost (0,43 μg/g). Le niveau moyen en zinc se situe au dessous de 150 mg/kg de p.s, sans pic significatif. Il existe également une forte homogénéité des concentrations en cuivre (6 μg/g), à l'exception d'un pic à la station mer de Port La Nouvelle (16,4 μg / g). Pour le plomb les niveaux les plus élevés sont localisés dans les secteurs de Marseille, Toulon et Fréjus (2,2 μg/g). En Corse, la station mer de Pino présente un pic de chrome (2 μg/g) et de nickel (4,9 μg/g) qui pourraient être liés aux anciennes activités d'extraction et de traitement de l'amiante situées sur le bassin versant (7). Seuls les CB 138 et 153 ont été identifiés dans le secteur de Marseille (28,7 ng/g), de l'émissaire de Cortiou (22,9 ng/g), de

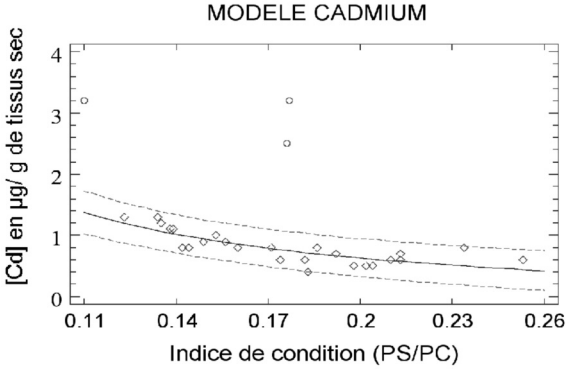

Figure 1 : Modèle de régression linéaire pour le cadmium. En rouge l'intervalle de confiance à 95 %. Les trois stations hors de cet intervalle correspondent au complexe lagunaire de Bages.

Fos (18,8 ng/g) et dans les étangs de Thau (13,9 ng/g) et du Prévost (18,7 ng/g). Pour le DDT les niveaux sont très faibles, mais les produits de dégradation (DDE et DDD) sont présents (33,3 ng/g) dans les lagunes, ce qui témoigne d'une contamination ancienne par le DDT. Pour les PAH, seul le fluoranthène donne des résultats supérieurs aux seuils analytiques avec des pics dans le secteur de Fos - Marseille et La Ciotat (9,4 ng/g). Pour les radionucléides artificiels seul le Césium-137 a été détecté dans 60% des échantillons. On note la présence d'un pic au niveau de l'embouchure du Rhône et d'un gradiant décroissant vers l'Ouest qui correspond à la direction principale du transport advectif du panache du Rhône (8).

Discussion

La méthode d'ajustement des résultats permet de discriminer les secteurs contaminés et de confronter les données à celles disponibles chez *Mytilus galloprovincialis*. Par rapport aux données fournies par le RNO entre 1986 et 1996 en Méditerranée, on constate que les résultats obtenus sur les stations artificielles sont équivalents à ceux obtenus avec des populations naturelles prélevées sur le rivage où les moyennes sont de l'ordre de 2,62 μg/g, 153,3 μg/g, 0,9 μg/g, 0,1 μg/g , 5,8 μg/g, 0,7 μg/g et 20 μg/g respectivement pour le plomb, le zinc, le cadmium, le mercure, le cuivre, le chrome et l'arsenic. Pour le nickel la bibliographie permet de faire le même constat, avec des niveaux moyens de l'ordre de 1,7 μg/g (9). Ces résultats ne témoignent pas d'un "effet de dilution" lié à la distance des stations à la côte. Pour le CB 138 et le fluoranthène et en général les molécules organiques cet effet est par contre significatif. Les pics observés au large de Fos ou de Marseille ne sont pas représentatifs d'une forte contamination, car les niveaux mesurés dans le cadre du RNO peuvent atteindre respectivement 500 ng/g et 100 ng/g dans des sites contaminés.

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PORE WATER DISTRIBUTION OF FE, MN AND DOC IN SEDIMENTS OF A SEMI-ENCLOSED BAY IN THE ISLAND OF LESVOS, GREECE

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Abstract

Sediment cores collected from two stations in the Bay of Kalloni revealed anoxic conditions near the sediment-water interface. The combination of anoxic sediments with an oxygenated water column can be attributed to episodic transport of organic material to the Bay, through river discharges, which is also reflected in the profiles of dissolved organic carbon concentrations.

Keywords : Iron, Manganese, anoxic sediments, Greece

The Bay of Kalloni (island of Lesvos, Aegean Sea) is a semi-enclosed shallow water body (Figure 1) with signs of environmental degradation (water coloring, planktonic proliferation, benthic community disturbance) because of the increased input of organic matter and nutrients from the land (1). Nutrient concentrations are not seriously enhanced and therefore the Bay cannot be considered as eutrophic since it shows a good rehabilitation capacity.

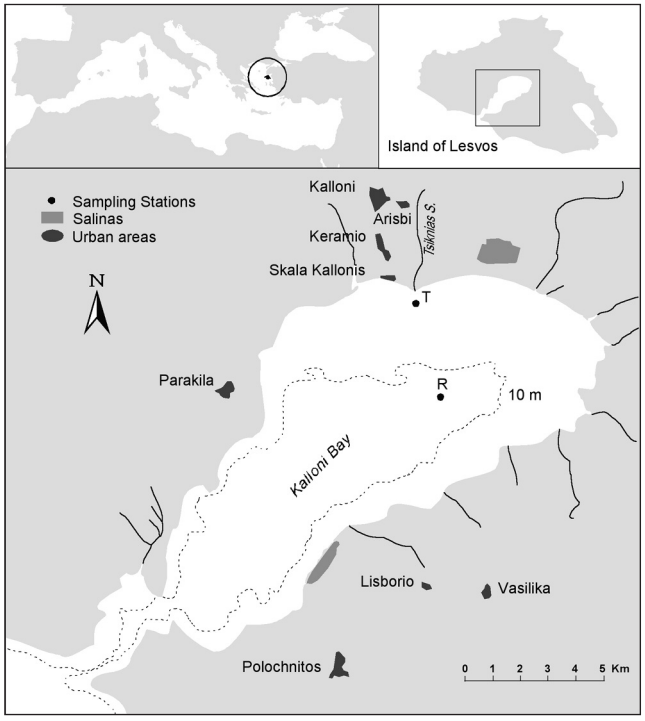

Figure 1 The study area and sampling sites

In the present study sediment cores were collected from the stations R and T in the Bay (Figure 1). At Station R (depth 13 m) the core was homogenous and fine-grained (97.6% ± 1.7% in the silt+clay fraction [< 63 _m]) containing relatively low concentrations of organic carbon (1.03% ± 0.12%). At station T, in front of the mouth of the stream Tsiknias (depth 3 m), the core was coarser (21.2% ± 11.2% in the silt+clay fraction). Organic carbon content was 1.4% ± 0.29%. The cores were sectioned and analyzed for Fe, Mn and organic carbon in the pore water.

At station R, dissolved Mn concentration in pore waters had a maximum at 2 cm below the surface, an observation which is attributed to a redox minimum in that depth, while dissolved Fe showed a maximum at 14 cm below the surface. The dissolved organic carbon content fluctuated greatly in the first 10 cm of the core, with a maximum at 8 cm (Figure 2a). In core T the reduction zones were more compressed, since the Mn maximum was located at the very surface of the sediment (Figure 2b). Dissolved organic carbon distribution present two maxima, at 8cm and 20 cm below the sediment surface.

Considering that, (a) the sediments in both the coastal and the deep stations are anoxic near or at the surface, (b) the organic carbon content of the sediments is not high, (c) the water column is well oxygenated although the Bay presents signs of ecological disturbance, we can assume that organic matter reaches the sediments in fluxes due to the intermittent flow of the local streams and the seasonal productivity of the Bay. Following its deposition organic matter degradation may lead to dissolved oxygen and dissolved organic matter depletion (2) in the pore water until the next episodic deposition, which will be superimposed on the previous layer of partially oxidized material, initiates a new cycle. The sequence of different episodic events could lead to a sequence of higher and lower DOC concentrations, similar to that presented in Fig. 2a.

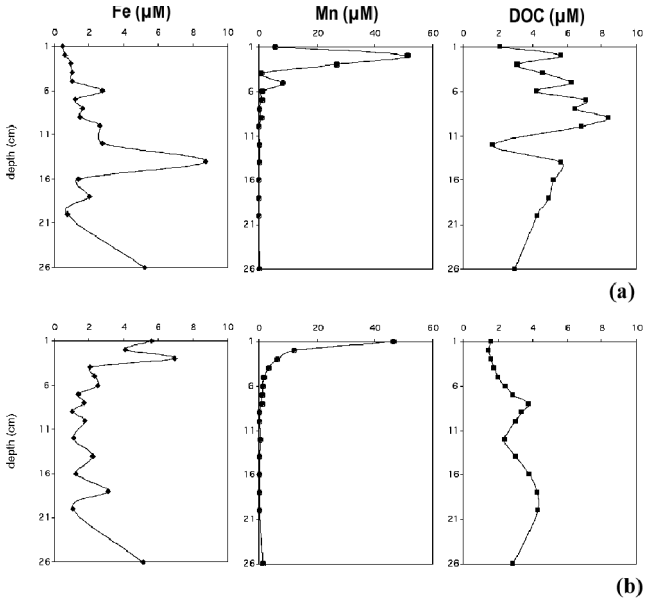

Figure 2. Fe, Mn and DOC profiles in cores R (a) and T (b).

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BENTHIC FLUX OF SILICATE IN THE COASTAL AREA OF THE MIDDLE AND SOUTHERN ADRIATIC SEA

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Abstract
The benthic flux of silicate was determined during the period June 1997-October 2000 at 8 stations in the coastal area of the Eastern Adriatic Sea. Temporal distribution of fluxes showed enhanced fluxes during the warm period of the year. During this time significant correlation of Si-fluxes with PO4-fluxes and the bottom layer Si concentrations were found. An estimation of silicate contribution to the coastal zone by benthic flux (BF-Si) versus riverine Si input (R-Si) showed a ratio of BF-Si : R-Si of 3.8 : 1 in the warm period and 1.1: 1 in the cold period of year.

Keywords: Adriatic Sea, Benthic-Pelagic coupling, Geochemical cycles

Introduction

Dissolved silicate is an essential nutrient for diatom and radiolarian skeleton development. After the life cycle of this species, biogenic silica (opal) dissolves to a great degree in the water column (1) while the remainder reaches the sediment and continues to dissolve at the sediment/water interface and in the sediment (2). Besides dissolution of biogenic silica, another important process in seawater silica enrichment can be river inflow, especially in estuarine regions and nearshore waters (3).

Material and Methods

Sediment sampling was performed by a gravity corer (plastic tube, i.d. = 6.5 cm, l = 100 cm) in triplicate at 8 stations (depth between 38 and 82 m) in the coastal area of the eastern Adriatic Sea during 1997 – 2000 period. The sediment samples were incubated onboard the R.V. *Bios* for 9 – 12 h at bottom temperature after exchange of the sediment overlying seawater with collected bottom water. The benthic flux of silicate has been calculated on the basis of concentration changes in the overlying water during the incubation and the surface area of the sediment samples. Silicate concentrations were determined by a standard photometric method using an AutoAnalyzer II (4).

Results and Discussion

Analysis of established silicate flux values during 1997 –2000 in the coastal waters of Croatia (from Dubrovnik to Zadar) showed different situations in the warm (WPY: May to October) and cold period of year (CPY: November to April). The flux (mmol m^{-2} day^{-1}) in the WPY was in the range between 0.78 – 2.67, and 0.16 to 1.87 in the CPY. The difference in Si-flux behaviour in the cold and warm period of the year is probably related to different hydrodynamic conditions throughout the year in the studied area. In addition, the increased bottom layer temperature in the WPY (up to 7.3 °C) may enhance Si-flux during this period by increasing the Si-sediment diffusion coefficient as well as the solution rate constant of opal (2). In comparison with other coastal areas (5), the flux in the eastern Adriatic sector is lower.

Correlation analysis between benthic Si-flux and N-, P-fluxes as well as between benthic Si-flux and Si bottom water layer concentrations showed significant correlation only in the WPY for the Si – PO4 flux pair ($r = 0.620$, $p < 0.05$, $n = 12$), and the Si concentration-Si flux concentration ($r = 0.646$, $p < 0.01$, $n = 18$). The possible relation between Si-PO4 fluxes has already be stated by Redfield et al. (6), while flux-bottom concentrations relations hips have been found by Henriksen et al. (7) for nitrate.

As the coastal waters of the eastern Adriatic receive freshwater from four main rivers (Neretva, Cetina, Jadro and Krka, Fig. 1), an estimation of silica enrichment of the water column by rivers versus benthic silicate flux has been made.

The coastal area of the eastern Middle Adriatic region was estimated to be 1.941×10^9 m^2. Using average Si-fluxes for this area, a benthic flux contribution of 5.45×10^8 mole Si (WPY) and 3.27×10^8 mole Si in the CPY was estimated. Based on hydrological data for average monthly River flow (Fig. 1) and corresponding Si concentrations in 1998, the calculated average riverine Si-input was 1.45×10^8 mole in the WPY and 3.09×10^8 mole Si in the CPY. This indicates

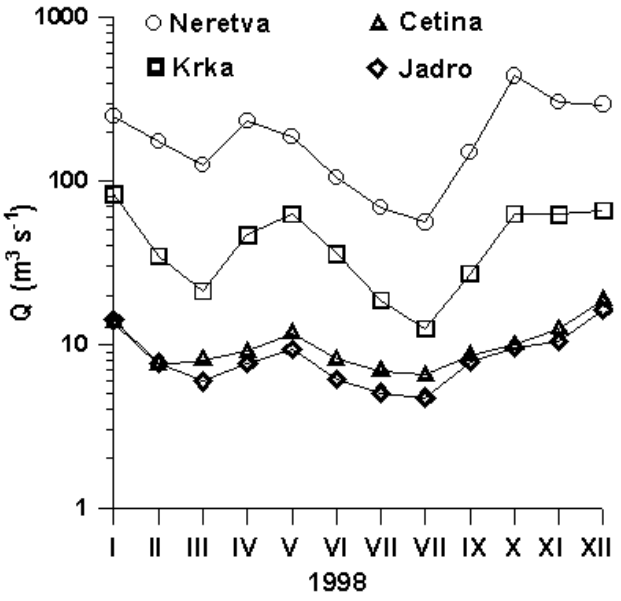

Figure 1. Average monthly flow of the main rivers on the eastern Adriatic coast.

that benthic Si-flux contribution in the coastal area of middle and southern Adriatic is especially important in the WPY, while in the cold period riverine inputs and flux contributions are of the same order of importance.

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LEVELS OF ANIONIC SURFACTANTS IN COASTAL WATERS OF THE EASTERN ADRIATIC

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Abstract
The concentrations of anionic surfactants were determined in the vicinity of urban centers along the Croatian coast, areas which may be affected by untreated municipal and industrial waste waters. The concentrations obtained, determined as methylene blue active substance (MBAS index), were mostly lower than 10 mg/L. Significantly higher concentrations of anionic surfactants (195-620 mg/L MBAS) which could represent a risk for marine organisms have been found in the proximity of untreated waste water outlets.

Keywords: anionic surfactants, MBAS index, Adriatic Sea

Introduction

Anionic surfactants, the main constituents of modern laundry and industrial detergents, have been widely used throughout the world since early 1960s. World consumption of these synthetic surfactants significantly increases every year [1]. The most important sources of anionic detergents in the marine environment are land-based sources. The detergents are introduced into the sea directly from outfalls or through coastal dispersion, and indirectly through rivers, canals or other watercourses. Coastal water and estuaries are acknowledged not only as the most productive but also very sensitive areas of biological activity which could be seriously endangered if the self-depuration capacity of the environment is not high enough to remove anthropogenic pollutants [2]. Therefore, it is important to monitor the level of these widespread contaminants in seawater especially considering that urban coastal areas in Croatia are direct recipients of untreated municipal and industrial waste waters.

Materials and Methods

Study areas and sampling. The Adriatic Sea represents a region in the Mediterranean with significant gradients of physical, biological and chemical oceanographic parameters [3]. Seawater samples used for anionic surfactants analyses were collected at the stations located at 500-1800 m distance from main urban and industrial centers along the Croatian coast, i.e. from Pula (Northern Adriatic) down to Dubrovnik (Southern Adriatic). Sampling was performed seasonally during a one year period from November 1998 until August 1999. All samples were collected using 5 l Niskin bottles at the depths of 0 m and 5 m.

Analytical method. International Standard Method ISO 7875-1:1996 for determination of anionic surfactants by measurement of the methylene blue index (MBAS) was used. Prior to MBAS determination, the concentration and separation of surfactants by a stripping (solvent sublation) procedure was performed.

Results and Discussion

The presence of anionic surfactants in marine environment indicates mostly contamination with modern household detergents. Owing to the relatively scarce data on the level of anionic surfactants in the Adriatic Sea and the increased concentrations of these pollutants noted in municipal waste water of coastal towns, there was an urgent need to perform systematic monitoring of anionic surfactants levels in all urban coastal areas that may be affected by untreated waste waters.

The concentrations of anionic surfactants in the surface layer (0 m) of coastal seawater in the vicinity of main urban and industrial centers are presented in Table 1. It is evident that surfactant concentrations determined as MBAS index in most cases were below 10 μg/L and on some occasions values were slightly higher (10,4-17,3 μg/L). The concentrations of anionic surfactants at 5 m depth were in general lower or similar as those in the surface layer (0 m). Although these relatively low concentrations of anionic surfactants in seawater do not indicate significant pollution of coastal areas by detergents, it is important to note that chronic and sublethal effects of linear alkylbenzensulfonates (widely used anionic surfactants) in some marine organisms have been reported even at concentrations as low as 5-10 μg/L [4]. Significantly higher concentration levels were observed in seawater near the points of discharge of untreated waste water. This was especially evident in semi-enclosed Sibenik Harbour (240-620 μg/L MBAS) near the main outlet, and in Kastela Bay (195-250 μg/L MBAS) which receives untreated municipal and industrial waste waters from Split, the largest town in the Middle Adriatic. The concentrations observed in the proximity of untreated waste water outlets represent a risk for marine biota. It was also found that anionic surfactants accumulate in sediments close to waste water outlets, a finding which represent a potential danger to benthic communities [4].

Table 1. Concentrations of anionic surfactants in surface seawater along the Eastern Adriatic coast expressed as the methylene blue substance (MBAS index).

Station	Nov 98	Feb 99	May 99	Aug 99
	µg/L MBAS			
PUE 02	8.5	ND	8.7	9.1
PUE 03	8.4	ND	6.8	8.1
PUE 05	9.0	ND	8.3	11.9
RI 20a	4.7	ND	10.6	8.5
RI 10a	ND	ND	13.8	10.4
RI 007	4.3	ND	5.8	8.1
CR 001	4.7	ND	6.0	12.8
ZD 102	ND	4.9	12.5	8.6
ZD 103	8.9	ND	10.5	9.0
ZD 104	5.9	ND	8.8	7.3
SI 103	15.2	15.8	ND	13.3
SI 201	ND	3.7	ND	9.4
SI 203	7.5	5.8	ND	6.6
SI 204	6.8	4.3	ND	ND
ST 101	8.6	11.2	ND	6.6
ST 102	7.3	10.5	ND	8.4
ST 103	7.0	12.8	ND	ND
ST 201	8.2	7.6	ND	11.0
ST 202	7.0	8.7	ND	12.8
ST 203	6.6	5.1	ND	11.9
ST 204	8.3	6.8	ND	8.5
PL 101	3.7	8.2	6.0	8.1
PL 102	3.8	8.1	11.3	8.4
DU 002	3.6	11.8	17.3	8.5
DU 001	8.5	ND	17.1	8.0

Areas of urban centers: Pula (PUE); Rijeka (RI); Crikvenica (CR); Zadar (ZD); Sibenik (SI); Split (ST); Ploce (PL) and Dubrovnik (DU).
ND - not determined.

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CONCENTRATION DES MÉTAUX LOURDS CHEZ LA PALOURDE *VENERUPIS DECUSSATA* (L.) DANS UN ESTUAIRE MAROCAIN : L'OUED BOU -REGREG, RABAT

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Résumé

Les teneurs en Fe, Zn, Pb et Cu ont été mesurées chez la palourde dans les sédiments provenant d'un milieu estuarien marocain. L'étude a porté sur 120 individus au cours d'un cycle annuel (septembre 1998 -septembre 1999). Les concentrations métalliques relatives au Fe (6362,22 mg/Kg de poids sec), au Zn (107,95 mg/Kg), au Pb (16,65 mg/Kg) et au Cu (6,18 mg/Kg) et dans le sédiment, (Fe: 21240 mg/Kg, Zn: 109,62 mg/Kg, Pb: 92,67 mg/Kg et Cu: 18,55 mg/Kg), s'avèrent très importantes .

Mots clés : Venerupis decussata, sédiments, métaux lourds, estuaire, Maroc

L'estuaire considéré (34°N, 6°50'W) est soumis à l'influence d'intenses sources de polluants (1) et les apports d'eau douce diluant ces polluants sont, depuis 1974, considérablement réduits par la mise en place du barrage de Sidi Mohammed ben Abdallah. Pourtant, cet estuaire est d'un grand intérêt socio-économique. Les principaux objectifs sont de diagnostiquer l' état de contamination métallique de ce milieu et de comparer la contamination des bivalves entre l'Atlantique et la Méditerranée.

Matériel et méthodes

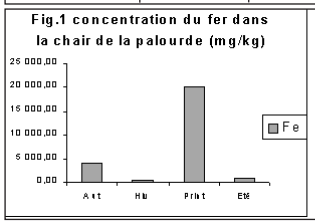
L'étude est saisonnière s'étalant entre septembre 1998 et septembre 1999. Le matériel biologique, est prélevé dans la station St 1 située à 1,5 Km. de l'embouchure dans un secteur à influence marine prépondérante (2). Les sédiments ont été prélevés dans la station (St_1) et aussi dans une station (St_2) *située* à 3,7 Km. de l'embouchure. Dans chaque prélèvement, une trentaine d'individus a été récoltée et une classe de taille (2,5 à 3,5 cm) a été retenue (3). Les échantillons sont débarrassés de leurs coquilles puis lavés~ séchés à 80°C jusqu'à atteindre un poids constant, puis broyés à l'aide d'un mortier en azote, avant d'être minéralisés. Le dosage des métaux a été fait aussi bien pour la chair que pour le sédiment par spectrophotométrie d'absorption atomique (SPectrophotomètre d'Zeeman équipé d'un four graphite HGA600 et d'un passeur d'échantillon AS.60.)

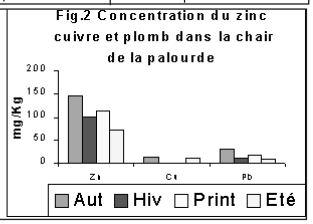
Résultats

A l'exception du zinc (107,95 mg/Kg, tab. 1), tous les éléments analysés dans la chair: fer (6362,22 mg/kg), plomb (16,65 mg/kg) et le cuivre (6,18 mg/kg) montrent une moyenne annuelle inférieure à celle trouvée dans le sédiment, ce qui montre le rôle primordial du sédiment dans la contamination métallique de l'espèce. Les fluctuations saisonnières des concentrations du Fe, Zn et Pb, comparables (tab. 1), montrent, toutes, deux pics bien individualisés: le premier, automnal (4123,9 mg/kg pour le fer; 144,70 mg/kg pour le zinc et 30,70 mg/kg pour le plomb); le second, printanier, marqué par les fortes concentrations de fer (20130 mg/kg), de zinc (115 mg/kg) et de plomb (17,30 mg/kg) (Fig 1 et 2).

Tableau 1 : Les concentrations saisonnières des métaux lourds chez *Venerupis decussata* de l'estuaire de l'oued BouRegreg

Saisons / Métaux lourds mg/kg du poids sec	Automne	Hiver	Printemps	Eté	Moyenne/an
Fer	4123,9	415	20130	780	6362,22
Zinc	144,70	100,3	115	71,90	107,95
Cuivre	13,75	0,25	0,75	9,97	6,18
Plomb	30,70	10,30	17,30	8,30	16,65





Les valeurs minimales enregistrées sont: pour le fer (415 mg/Kg en hiver et 780 mg/Kg en été), pour le zinc (100.3 mg/Kg en hiver et 71.90 mg/Kg en été) et pour le plomb (10.3 mg/Kg en hiver et 8.3 mg/Kg en été). Les variations sont légèrement différentes pour le cuivre: faibles en hiver et au printemps (0,25 mg/kg, 0,75 mg/kg) élevées en automne et en été (13,75 mg/kg, 9,97 mg/kg). Dans les stations St1 et St2, les concentrations de ces métaux dans les sédiments sont respectivement: pour le fer (21 240 mg/Kg et 19 205 mg/Kg), pour le zinc (109,25 mg/Kg et 121,62 mg/Kg); pour le plomb (92,67 mg/Kg et 92,92 mg/Kg; -pour le cuivre (18,55 mg/Kg .et 15,03 mg/Kg).

Discussion

Certains travaux (4,5,6 et 7) ont montré que *Scrobucularia plana* qui vit avec *Venerupis decussata* supporte, au laboratoire, de fortes pollutions métalliques. La moyenne annuelle des teneurs des éléments métalliques dans la chair (tab. 1) montre que la bioaccumulation est plus importante pour le Fe, le Zn le Pb ou le Cu. Certains paramètres physico-chimiques (température, pH, salinité) ainsi que les processus physiologiques liés au métabolisme et surtout à la reproduction, sont les facteurs essentiels qui déterminent les fluctuations en métaux dans la chair. Nos résultats relatifs aux concentrations métalliques saisonnières semblent suivre, le cycle de reproduction de la palourde, exception faite du cuivre, qui pourrait être régulé par l'espèce (8). Pendant la période de reproduction de cette espèce, située vers la fin hiver-début printemps et été-automne (6), les gonades, développées, constituent un lieu d'accumulation des métaux, alors qu'après la période de ponte, à la fin de l'hiver, on assiste à une nette chute des teneurs métalliques chez l'espèce. Ce phénomène a été également observé dans l'étang de Prévost (9) et dans la lagune méditerranéenne de Nador (10). La teneur des métaux lourds chez la palourde de l'oued Bou-Regreg est plus forte que celle relevée dans d'autres sites méditerranéens (tab.2) tel qu'en Algérie (3) ou en Turquie (11). De plus, la palourde du site étudié s'y révèle plus contaminée qu'en 1988 (8).

Tableau 2 : Comparaison des concentrations moyennes des métaux lourds chez *Venerupis decussata* dans différentes régions (Maroc, Algérie. Turquie).

Métaux lourds mg/kg du poids sec				
Fer	**Zinc**	**Plomb**	**Cuivre**	**Référence**
6362,22	107,95	16,65	6,18	Présente étude
-	38,4		6,32	Cheggour 1988
-	11,4	0,82	2,9	Boudjellal 1998
-	13,64	1,44	1,61	Ozdfemir 1998

Conclusion

Les concentrations des métaux lourds dans le sédiment de l'oued Bou-Regreg sont plus élevées que dans d'autres sites méditerranéens (11) tels que la baie d'Alger (12), la baie d'Izmir (13) ou la Méditerranée (14). Le sédiment très pollué et le régime déposivore de cette espèce seraient le vecteur essentiel de la contamination chez la palourde (8 et 15), ce qui est également le cas d'autres espèces telles que *Scrobicularia plana* (8). On peut parler ainsi, pour l'estuaire du Bou-Regreg, d'une pollution alarmante qui mérite une surveillance continue.

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LEAD CONTENT IN A SEDIMENT CORE OFF RAB ISLAND (CROATIA)

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Abstract

Changes during sedimentation and recent anthropogenic pollution are recorded in marine sediment. Granulometric composition, carbonate, organic matter and lead content in the sediment sample collected near Rab Island were determinated. The sediment core recovered indicates that there were no dramatic changes during sedimentation, however, anthropogenic influences in the form of lead pollution have increased with time.

Key words: lead, organic matter, sediments, Adriatic Sea

Introduction

Numerous studies show that lead is a ubiquitous metal contaminant emitted into the atmosphere of the Northern Hemisphere. Lead, mainly transported and deposited via the atmosphere, has become a global issue. The strong increase in the environmental lead concentration in Europe coincides with the introduction of tetraethyl lead gasoline after World War II.

In surface sediments of the open Adriatic, lead content varies from 5 to 51 mg kg^{-1} dry weight (1), while in sediments in coastal regions of the Adriatic it varies from 10 (Stoncica, Island Vis – unpolluted area) to 300 mg kg^{-1} (Gruz harbor, Dubrovnik – heavily polluted area) (2, 3).

Transport, burial, and diagenesis play a key role in the preservation of historical records for metal contamination in sediments. These historical records may be disrupted by bioturbation, erosion, trawling and other sediment mixing processes.

Material and methods

A sediment core 88 cm long was collected at 89.5 m depth using a plastic gravity corer (6 cm diameter) in July 1996 at a station located off Rab Island (Lat. 44° 51' 23'' N; Long.14° 35' 02''E). The sediment core was sliced into 1 (0-10 cm), 2 (10-50 cm) and 4 cm (50-88 cm) thick sub-samples. The granulometric composition of sediment was determined by sieving (>63 mm) and hydrometring according to Casagrande (<63 μm) of 4 cm thick sub-samples. Carbonate content was determined as weight loss after treatment with 4M HCl (4). The organic matter content was determined as a weight loss after H_2O_2 treatment and ignition at 450° C for 6 h.

Samples were digested with a mixture of HF, HNO_3 and $HClO_4$ (5). Lead concentrations were measured by GFAAS method using a Perkin-Elmer 1100 B instrument. The accuracy of the analytical procedure used was repeatedly checked by analyzing samples of reference sediment standards (IAEA marine sediments SD-M-2/TM and SRM 1646 estuarine sediments).

Results

The results of granulometric analysis are listed in Table 1, while the level and distribution of carbonates, organic matter and lead content along the sediment core are presented graphically in Figure 1. The organic matter varied from 3.7 to 8.1 %, carbonate from 26 to 51 % and the lead concentrations were in the range 6.52 – 26.35 mg kg-1 (Figure 1).

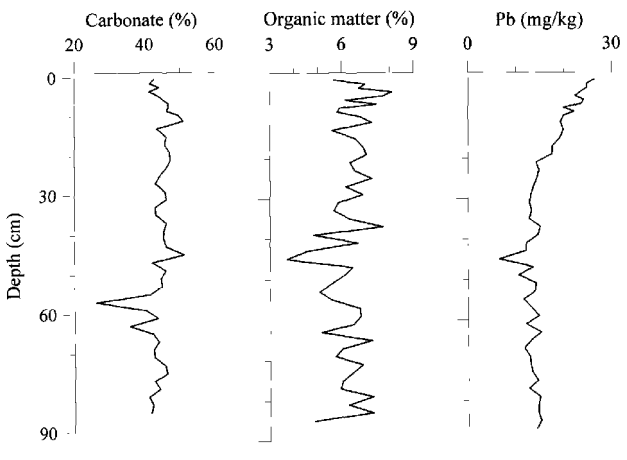

Figure 1. Carbonate, organic matter and lead content in the sediment core.

Discussion

The sediment in the core is clayey silt, except the first 4 cm in which it is silt. In the surface layer biogenous remnants (foraminifera) predominate. In all sub-samples (>63mm) observed under binocular microscope, biogenous material made up the predominant fraction (foraminifera and other remnants of benthic organisms). The sediment record indicates equal environment sedimentation along the core. A good correlation between organic matter and carbonate content along the core was found (0.72, P<0.01). That also indicates the autochthonous orgin of the organic matter and carbonate content. The relatively low concentrations of lead found in this study indicate a rather low level of lead pollution in the investigated area (1, 2, 3). If it is assumed that the topmost 20 cm (lead concentration >17 mg kg^{-1}) were sedimented over the last 50 years, the sedimentation rate could be of the order of 0.4 cm/year. According to this assumption the whole sediment core collected could have been formed during the last 220 year. However, if there was mixing of sediment due to the bioturbation or trawling and lead penetrated deeper in the sediment, the true sedimentation rate could be lower, and hence the sediment core might represent a longer time span. Geochronological dating techniques would help resolve this question.

Table 1. Granulometric characteristics of sediment samples (Mz- mean size), and sediment type (6)

Depth (cm)	sand (%)	silt(%)	clay(%)	Mz (mm)	Sediment type (6)
0-4	3	80	17	13.14	silt
4-8	3	71	26	8.57	clayey silt
8-12	4	66	30	7.9	clayey silt
12-16	3	69	28	8.18	clayey silt
16-20	3	67	30	7.21	clayey silt
20-24	3	64	33	6.2	clayey silt
24-28	2	65	33	6.72	clayey silt
28-32	3	64	33	6.06	clayey silt
32-36	3	65	32	7.9	clayey silt
36-40	3	63	34	5.59	clayey silt
40-44	2	65	33	6.65	clayey silt
44-48	2	67	31	6.96	clayey silt
48-52	2	69	29	7.72	clayey silt
52-56	3	66	31	6.96	clayey silt
56-60	3	67	30	7.46	clayey silt
60-64	2	69	29	7.72	clayey silt
64-68	2	69	29	7.37	clayey silt
68-72	3	64	33	5.92	clayey silt
72-76	2	66	32	6.06	clayey silt
76-80	3	64	33	5.92	clayey silt
80-84	2	62	36	5.15	clayey silt
84-88	2	63	35	5.15	clayey silt

Conclusions

The sediment record indicates that the changes in the sedimentation environment were not dramatic along the core. Furthermore, the lead concentration shows a gradual increase towards the surface, as a result of the effect of global pollution.

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NUTRIENTS AND SUSPENDED MATTER IN THE PO RIVER PLUME (ADRIATIC SEA) DURING A RECENT FLOOD EVENT.

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Abstract

After the Po River flood occurred in October 2000, an oceanographic survey was carried out in the prodelta area of the northern Adriatic. The flood supplied highly turbid freshwater, rich in inorganic nutrients, which was dispersed following the main cyclonic circulation. The suspended sediment settled close to the coast. In the southern branch of the plume, the decrease in turbidity and the availability of nutrients favoured the development of phytoplankton blooms.

Key Words: Po River - Flood Dispersion - Adriatic Sea

Introduction

In October 2000, after a long period of intensive precipitation particularly over the northwestern part of Italy , a flood of the Po River took place causing great damage along most areas of the river basin. The Po River, 673 km long, is the largest Italian river and supplies over 50% of the fresh water to the northern Adriatic basin. The river input heavily influences the hydrodynamics and biogeochemistry of the Adriatic, and it represents one of the greatest freshwater contributors to the Mediterranean Sea. The annual mean river discharge is approximately 1500 $m^3\ s^{-1}$, with 2 relative peaks of 2,000-4,000 $m^3\ s^{-1}$ in spring and in autumn. The river provides about 50% of the external annual input of nutrients to the northern Adriatic, and it has been estimated that this input of nutrients is of the same order of magnitude as the regeneration rate (1).

During the flood event, the water discharge reached 12000 $m^3\ s^{-1}$, with a daily mean maximum value of 9650 $m^3\ s^{-1}$, representing the highest flood of the last decade and one of the major flood events in the past century after that which occurred in 1951.To study the effects of the flood event in the Adriatic coastal area and the dispersion of the suspended matter supplied by the river, a few days after the Po River flood water reached the Adriatic Sea (26-27 October 2000), an oceanographic survey , on board the Italian R/V *U. D'Ancona* (IBM, CNR) was carried out in the prodelta area.

A pool of 27 stations, along 5 transects offshore the river mouths was sampled (Fig.1). Continuos vertical CTD profiles of temperature, salinity, pH, dissolved oxygen, fluorescence and turbidity were performed at each station, and at selected stations discrete water samples were collected for determination of dissolved oxygen, pH, total suspended matter (dry weight), particulate organic carbon, particulate nitrogen, organic carbon stable isotopes, dissolved nutrients, particle size spectra and concentration, and phytoplankton abundance and composition.

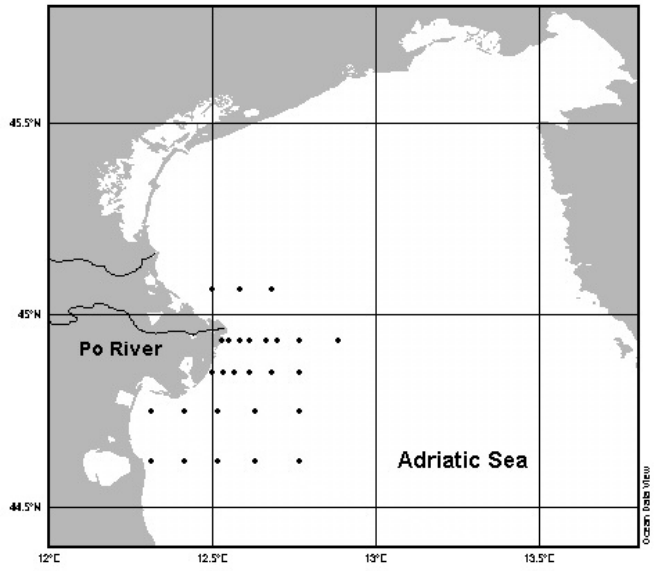

Fig. 1. Sampling stations

Results and Discussion

During the flood event, the river plume spread eastward and southward following the main cyclonic circulation. A thin surface layer (1-1.5 m thick) of very low salinity water (P.S.U. ranging from 2.23 to 10.85), extended out of the main river mouth to about 18 km from Punta Maestra. This layer displayed high turbidity and suspended matter concentration that was mainly inorganic in nature. Total suspended matter was on average 11.4 mg l^{-1}, with a peak value of 15.8 mg l^{-1} and a mean particle concentration of 185 x 10^3 particles cm^{-3}. The fine lithogenic fraction (particle diameter < 5 μm) was prevalent and the organic $\delta\ ^{13}C$ values were very negative, down to -26.81‰, confirming the terrestrial origin of the organic particulate material (2).

The surface layer showed high concentrations of dissolved inorganic nitrogen (DIN), SiO_4 and PO_4 (maximum values for DIN =112 μM, SiO_4 =122 μM and PO_4 =1.14 μM) in the eastward branch of the riverine plume.

In the low salinity water in front of the main river mouth, phytoplankton abundance and biomass were not particularly high (7.9 x 10^5 cell l^{-1}; 16.4 μgC l^{-1}, respectively), probably due to the high turbidity. The algal community was mainly represented by nanoflagellates and diatoms, together with some freshwater species belonging to chlorophyceans and cyanophyceans.

In the southward branch of the plume, surface salinity progressively increased to values higher than 10 P.S.U.; the decreased turbidity and the availability of inorganic nutrients favoured the development of phytoplankton blooms, with oxygen saturation values up to 200%, high fluorescence, and POC concentration reaching 2 mg l^{-1}. Here, the $\delta\ ^{13}C$ values were less negative (up to -21.38‰) indicating a marine origin of the POC. At the surface, nitrate, silicate and phosphate concentrations decreased probably as a consequence of the consumption by the phytoplankton bloom, whereas high NH_3 and PO_4 concentrations were found near the bottom where regeneration processes prevailed. The phytoplankton bloom at the surface was mainly composed of diatoms with an abundance of 50 x 10^6 cell l^{-1} and biomass of 1144 μgC l^{-1}, which represented more than 55% of the POC.

In the prodelta area close to the coast, high suspended matter concentration (up to 30 mg l^{-1} and particle concentration 300 x 10^3 particles cm^{-3}) with particles of larger diameters (~ 6-8 μm), and low $\delta\ ^{13}C$ values were recorded near the bottom indicating that flocculation processes and rapid vertical transfer of the suspended sediment to the seabed were effective (3).

Suspended-sediment inventory in the benthic nepheloid layer was similar to that in the surface plume. Considering the limited water energy observed at that time, the sediments rapidly transferred to the seabed during the flood are assumed to have a high potential for resuspension during more energetic conditions in the Northern Adriatic.

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SEDIMENT, ORGANIC CARBON AND CARBONATE MASS ACCUMULATION RATES ON THE WESTERN CONTINENTAL MARGIN OF THE BLACK SEA

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Abstract

Mass accumulation rates (MAR) based on ^{210}Pb dating were determined in cores BS-9 and BS-15 located on the western continental margin of the Black Sea in water depths of 600 and 1319 m. The total MAR for these sites is 171.5 and 71.3 g m^{-2} yr^{-1}, respectively. The average MARs of total organic carbon (TOC) and carbonate during the last 125 yr in Core BS-15 are 0.75 and 11.85 g m^{-2} yr^{-1}, whereas the corresponding values for the Core BS-9 are 0.39 and 6.21 g m^{-2} yr^{-1}. The average total MAR values for the last 125 yr are considerably higher than those for the last 2000 years, computed from published ^{14}C ages, suggesting that the sedimentation rate has considerably increased in recent times.

Key-words: Black Sea; Accumlation rates, Holocene sediment, Organic Carbon; Carbonate.

Introduction

The Black Sea is the largest modern anoxic basin of the world with a maximum depth of 2250 m. It has a pycnocline at a depth of about 100-150 m, separating aerated brackish waters (*18 ‰) from anaerobic, H_2S-rich more saline waters (*22.5 ‰). The Black Sea Holocene sediments consist of three units. These from top to base are a laminated coccolith marl (unit 1), a micro-laminated organic-rich sapropel (unit 2) and a lacustrine lutite unit (unit 3). Based on modern AMS ^{14}C datings of numerous core samples from various parts of the basin, the calibrated ages of 2720 and 7900 yr BP were assigned to the unit 1/unit 2 and unit2/unit 3 boundaries, respectively [1]. Later, the same boundaries were dated at 2000 and 7800 yr [2]. In this paper, we study the mass accumulation rates of total sediment (MAR_{SED}), total organic carbon (TOC) and total carbonate in the Holocene sediment section in two cores located on the western continental margin of the Black Sea (Fig. 1). The study is based on ^{210}Pb dating and TOC and total carbonate analyses of the core samples. The chronology determined by ^{210}Pb dating is compared with the published ^{14}C data for the unit 1/unit 2 boundary and both the 210Pband 14C chronologies are used to compute the MARs of TOC (MAR_{TOC}) and carbonate (MAR_{CaCO3}) for the upper parts of units 1 and 2.

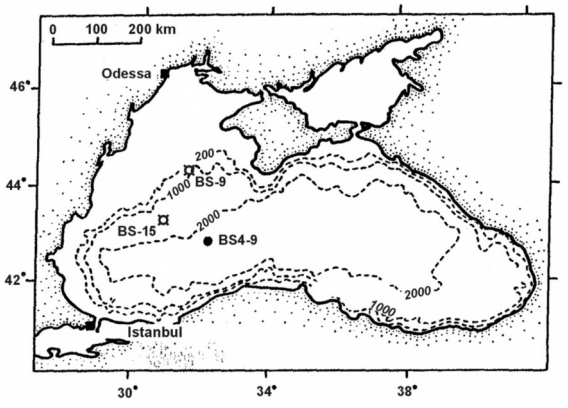

Figure 1. Location of studied cores. Isobaths are in metres. The location of Core BS4-9 studied by Calvert *et al.* [3] and Buesseler and Benitez [4] is also shown.

Methodology

The Cores BS-9 (44°28.118'N, 31°15.178'E, 600 m depth) and BS-15 (: 43°29.094'N, 30°42.367'E, 1319 m depth) were recovered during the IAEA sponsored RADEUX 1998 expedition in the western Black Sea (Fig.1). Undisturbed cores with an intact fluff layer were obtained using a MARK II 400 multicorer. The cores were sliced into 1-cm-thick sections.

Porosity was determined from the water content after correction for the presence of salt. The ^{210}Pb activity was determined by measurement of the ^{210}Po by low-level alpha counting after a total acid digestion and silver disc plating. In this method a secular equilibrium (reached in two years) between ^{210}Pb and its daughter product ^{210}Po was assumed. Sediment accumulation rates were determined from the unsupported or excess ^{210}Pb. Supported levels of ^{210}Pb were assumed to be equal to the downcore asymptote. The mean value is subtracted from the total activity of each sample to arrive at the unsupported level. The average supported activity of ^{210}Pb in Cores BS-9 and BS-15 were 38 Bq/kg and 30 Bq/kg, respectively. In the absence of bioturbation and assuming that both the flux of ^{210}Pb ($F_{Pb\text{-}210}$ in Bq cm^{-2} yr^{-1}) to the sediment/water interface and the sediment accumulation rate (MAR in g cm^{-2} yr^{-1}) have remained constant (i.e., constant flux-constant MAR model), there is the following relationship between the excess ^{210}Pb activity $A_{Pb\text{-}210}$(m) and the mass-depth (m; g.cm^{-2}):

$$A_{Pb-210}(t) = \frac{F_{Pb-210}}{MAR} . e^{-\lambda m/MAR} = A_0 e^{-}$$

where λ = radioactive decay constant for ^{210}Pb (0.693/22.26 yr). A semi-logarithmic plot of excess ^{210}Pb activity versus m gives a straight line with a slope = - λ/MAR and intercept Y= $F_{Pb\text{-}210}$/MAR.

TOC was analyzed in acidified sediment samples using a CHN elemental analyzer. Total carbonate contents were determined by a gasometric-volumetric method. The precision of these methods is better than 10% at 95% significance level. MAR (g m^{-2} yr^{-1}) is calculated for total sediment, TOC (wt %) and carbonate (wt %) using

MAR= TOC (or $CaCO_3$) / 100 x SR x (1-ρ)-(1.02 x Φ / 100) (2)

where SR = sedimentation rate (cm/kyr), Φ = porosity (%), ρ = bulk density (g/cm^3).

Results and Discussion

The excess ^{210}Pb data for Cores BS-9 and BS-15 follow smoothly decreasing exponential curves for the upper 3-9 cm. Using equation 1, we found sedimentation rates of 72 cm kyr^{-1} (MAR_{SED} = 171.5 g m^{-2} yr^{-1}) and 24 cm.ky^{-1} (MAR_{SED} = 71.25 g m^{-2} yr^{-1}) in Cores BS-9 and BS-15, respectively. The sedimentation rate at Site BS-9 is thus about 3 times higher than at Site B-15. The high sedimentation rate at the former site is in line with its location being closer to the sediment source than Site BS-15 on the Danube submarine fan. Considering that the corrected AMS ^{14}C age for the unit 1/unit 2 boundary is ≈2000 yr [2] and assuming a linear sedimentation rate between the core top and the unit 1/unit 2 boundary, sedimentation rates for unit 1 in Cores BS-9 and BS-15 would be 25 and 16.3 cm kyr^{-1}, respectively. These rates averaged over 2000 yr are therefore about 1.5 to 3 times lower than those for the last 125 yr determined from the ^{210}Pb data. This suggests that the sediment accumulation rates have not been constant in the last 2000 years and that they significantly increased probably in the last 1000 years as a result of man's impact. Previously using several AMS ^{14}C datings, Calvert et al. [3] calculated a MAR_{SED} value of 38.7 g m^{-2} yr^{-1} in a core in 2087-m water depth in central part of the western Black Sea. However, based on ^{210}Pb data in the same core Buesseler and Benitez [4] determined a MAR_{SED} value of 69±3 g m^{-2} yr^{-1}, again suggesting a major increase in sedimentation rate in recent times. This last value is comparable with the MAR_{SED} value of 71.25 g m^{-2} yr^{-1} found by us at Site BS-15. The average MAR_{TOC} and MAR_{CaCO3} in the upper 3 cm of the Core BS-15 representing the last 125 yr are 11.85 and 0.75 g m^{-2} yr^{-1}, respectively, whereas the corresponding MAR_{TOC} and MAR_{CaCO3} values in Core BS-9 are 6.21 and 0.39 g m^{-2} yr^{-1}. Subtracting the MAR_{TOC} and MAR_{CaCO3} from the MAR_{SED}, we estimate that Site BS-9 has received 2.7 times more siliciclastic material than that has Site BS-15. Assuming that at Site BS-15 the top of sapropel unit (unit 2) has the same linear sedimentation rate as unit 1 (i.e., 16.3 cm kyr^{-1}), the average MAR_{TOC} and MAR_{CaCO3} in the upper part of unit 2 are found to be 3.86 and 0.93 g m^{-2} yr^{-1}. The MAR_{TOC} in the sapropel unit is about 25% higher and the MAR_{CaCO3} is 3 times lower than those in the upper part of unit 1. The high MAR_{CaCO3} in unit 1 is essentially caused by the coccolithophore *E. Huxleyi*, which usually blooms during the summer and autumn forming the white laminae.

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TRACE ELEMENTS IN ORGANS AND TISSUES OF DIFFERENT SPECIES OF CETACEANS FROM THE LIGURIAN SEA

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Abstract:

The concentrations of Hg (total and organic), Cd, Pb, Cu, Fe, Mn, Zn and Se were determined in the muscle, liver, kidney and heart of cetaceans belonging to 5 different species from the Ligurian sea. The levels of the different elements in the various organs are discussed and the measured values are compared with data from literature.

Keywords: cetacea, Ligurian sea, trace elements.

Introduction

Marine mammals can be considered among the best biological indicators of the health of the marine environment, due to their sensitivity to environmental variations, their position at the top of the trophic chain, and to the large number of studies on the levels of trace elements in cetaceans from different locations.

The distribution of Hg (total and organic), Cd, Pb, and the essential elements Cu, Fe, Mn, Zn and Se was studied in tissues and organs of five different species of cetaceans: 1 fin whale (*Balaenoptera physalus*), 1 Cuvier's beaked whale (*Ziphius cavirostris*), 2 Risso's dolphins (*Grampus griseus*), 1 bottlenose dolphin (*Tursiops truncatus*) and 2 striped dolphins (*Stenella coeruleoalba*), all stranded along the coast of the Ligurian Sea or found dead offshore during the period 1990-1999. These species are located at different levels of the trophic chain: *Balaenoptera physalus* is a mysticeton, feeding on krill; *Ziphius cavirostris* and *Grampus griseus* mainly feed on squids; *Tursiops truncatus* and *Stenella coeruleoalba* can feed mostly on fish and, to a lesser extent, squid.

Materials and Methods

The individuals were classified and measured: they were adult, except for *Tursiops truncatus* (suckling specimen), one of the two *Stenella coeruleoalba* and one of the two *Grampus griseus* (subadults). From each individual, muscle, liver, kidney and heart were collected; only muscle was available for *Balaenoptera physalus*. Moreover, the milk contained in the stomach of *Tursiops truncatus* was sampled and analysed.

Trace element concentrations in biological tissues were determined by atomic (emission and absorption) spectrometric methods: details on analytical methods and quality assurance control are described elsewhere (1).

Results and Discussion

In all of the individuals, liver was the organ containing maximum Hg concentrations (reaching more than 2000 $\mu g\ g^{-1}$), Pb and Se concentrations (higher than 1000 $\mu g\ g^{-1}$). Kidney contained lower Hg concentrations. In liver, increasing Hg concentrations correspond to a lower organic Hg percentage. A significant correlation between Hg and Se is observed in all of the analysed organs, except for heart. The essential elements Zn, Cu and Mn generally show concentrations within a restricted range of values in the different organs, with the lowest concentrations found in muscle.

The concentrations of the different elements in milk are comparable with the values measured in muscle, except for Fe, present in much lower amount, whereas Mn and Pb levels are somewhat higher. Hg is predominantly in the organic form (87% of the total).

A comparison between the different species sampled is made difficult by the biological variability (sex, age) of the specimens; however, the finding that high concentrations of Hg are found in *Grampus griseus*, also as a consequence of their specific dietary intake (2), are confirmed here.

Table I gives a summary of the results of the comparison between our data and data from literature: only Hg concentrations are reported for individuals having comparable size and age. Since age can affect the Hg concentration in dolphins (3), no comparison is made with literature data regarding *Tursiops truncatus*, since no data pertaining to suckling individuals were found.

Our specimens show Hg values comparable with other data for cetaceans from the Mediterranean sea, while they show much higher Hg content than in Atlantic specimens, thus confirming results of previous investigations (1,6).

Table I – Ranges of Hg concentrations taken from the literature and our values.

	N	Origin	Hg-tot (μg g^{-1} d.w.)	Hg-org (μg g^{-1} d.w.)
Balaenoptera physalus				
Sanpera *et al.* (4)	36	Spain-Iceland	0.46-0.71	0.36-0.61
Our data	**1**		**2.64**	**2.57**
Ziphius cavirostris				
Storelli *et al.* (5)	1	Southern Italy	36 [(a)]	26 [(a)]
Our data	**1**		**34**	**20**
Grampus griseus				
Frodello *et al.* (2)	1	Corsica	189	-
Storelli *et al* (5)	2	Southern Italy	98-114 [(a)]	55-58 [(a)]
Our data (only adult)	**1**		**139**	**24**
Stenella coeruleoalba				
Holsbeek *et al.* (3)	1	France (Atlant.)	5	-
Andrè *et al.* (6)	7	France (Atlant.)	6-44 [(a)]	-
	8	France (Medit.)	42-300 [(a)]	-
Augier *et al.* (7)	13	France (Medit.)	7-155	-
Frodello *et al* (2)	1	Corsica	21	-
Cardellicchio *et al.* (8)	5	Southern Italy	30-53 [(a)]	-
Leonzio *et al.* (9)		N-W Italy	37-168	-
Our data [(b)]	**8**		**65-260**	**14-45**

[(a)] data converted from wet to dry weight;

[(b)] only adults, taken from the present work and from a previous work (1)

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METAL CHARACTERISATION OF GREEK COASTAL AREAS USING BIOCONCENTRATION LEVELS IN THE GASTROPOD PATELLA SP.

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Abstract

The concentrations of Cu, Cr, Ni, Zn, Fe and Mn were determined in *Patella sp*. samples collected at nine characteristic Greek coastal areas. The set of data provides global information concerning different and distant sampling sites and gives the possibility to examine *Patella sp*. as a potential sentinel organism.

Key words: metal, gastropod, bio-accumulation, sentinel organism

Metal content of marine mollusks is used wideworld in order to study and monitor metals in the marine environment (1). Among gastropods, *Patella* sp is considered as adequate pollution indicator, since the concentration of the accumulated metals in its tissues is related to the bio-available metal levels in the environment (2). The present work dealing with metal bioaccumulation in the soft tissues of *Patella* sp. collected at different coastal areas aims to provide information on metal levels in an infralittoral species, and moreover to contribute to the characterisation /identification of the Greek coastal zones according to their metallic profile.

Methods and materials

Patella sp. specimens of approximately the same size were collected during the decade 1985-1995 from 9 different coastal areas of Greece. Several pooled samples from each site were analysed for the metals Cu, Cr, Ni, Zn, Fe, Mn by AAS. The methodology was tested by the simultaneous analysis of reference materials.

Results and discussion

The results of the analysis of about 450 samples of *Patella sp*. is presented in Table 1, expressed in Ìg/g dry weight.

Table 1 : Mean metal concentrations and ranges in *Patella sp.* from Greek areas (in lg/g dry weight).

Area	Cu	Cr	Ni	Zn	Fe	Mn
Kerkyra	7.96±2.13	3.94±1.81		58.5±9.8	1732±654	
N=38	(4.24-14.7)	(1.49-9.17)		(33-75)	(949-3959)	
Lesbos	4.28±3.65	3.65±1.81	9.40±3.52	45.5±4.4	603±230	24.14±20.26
N=7	(0.29-9.26)	(0.87-5.99)	(4.02-15.44)	(42-51)	(442-867)	(12.24-47.53)
Larymna	7.91±4.24	25.22±15.97	15.61±6.97	55.7±15.7	4574±2522	
N=86	(3.3-34.3)	(2.38-77.22)	(5.89-35.25)	(37-97)	(965-11289)	
Lavrio	13.72±2.67	8.98±6.38	6.57±1.85	302.2±64	1256±190	
N=6	(9.68-16.4)	(4.83-21.85)	(3.38-9.8)	(249-412)	(967-1416)	
Milos	9.63±3.87	5.69±4.18	20.20±14.32	45.1±21	291±42	13.14±10.62
N=69	(3.2-21.9)	(1.02-19.08)	(0.33-58)	(5.7-177)	(254-352)	(2.8-57.2)
Pagassitikos	9.23±1.47	7.36±5.45	5.54±6.88	519.5±344	2788±3157	26.10±21.22
N=23	(7.31-12.1)	(1.42-17.95)	(0.72-20.17)	(58-1014)	(56.5-9699)	(2.98-62.35)
Rhodos	6.29±1.41	6.88±2.76	7.13±3.24	164.4±191.9	975±586	6.44±4.38
N=45	(4-10.4)	(1.76-13.98)	(1.59-22.33)	(47.8-631.7)	(158-2218)	(1.73-18.32)
Saronikos	10.42±3.47	6.51±6.31	17.83±10.35	56.9±15.3	710±351	8.23±4.69
N=146	(3.31-35.3)	(0.37-36.21)	(1.74-53.7)	(4.8-138)	(110-2103)	(1.69-27.03)
Sandorini	3.69±1.3	1.01±0.7	5.34±3.12	34.9±15.3	223±70	4.07±2.67
N=4	(2-4.96)	(0.1-1.6)	(2.6-9.17)	(17-50)	(143-311)	(1.4-7.3)

Generally, samples from Lavrio (ancient silver mining site) exhibited the highest Cu and Zn levels. This is obviously due to the by-products of silver extraction -which still remain in the coastal zone of this area and are rich in several metals such as Pb, Zn and Cu (3). Elevated Cu values can be also attributed to the industrial activities of the Lavrio area. The highest Cr, Ni and Fe concentrations present in samples from Larymna bay (Table 1) are in accordance with other studies (4), and are attributed to the ferronickel smelting plant operation. The limpets coming from Saronikos Gulf, as mussels from the same area do (5) contained Ni in high proportions. The data from Sandorini Island show the lowest values recorded in this study indicating a relatively clean marine environment. Finally the samples collected in Pagassitikos Gulf had high Zn and Mn concentrations that are consistent to the high levels in sediments, which in turn are due to human activities. Especially the abundance of Mn was probably related to the biogenic phase of the sediments (6). The abundance of a specific metal as well as the proportion of several metals can characterize a coastal area. The participation of metals in the structure of the sediment minerals theoretically results in their stable proportion in an area. The change of this ratio may be attributed to anthropogenic impact and thus it seems important to study it. In addition the relationship of the bio-accumulated metals could also be of major interest. We should emphasise that the concentration of metals in an organism depends not only on their abundance in the environment but also on the capability of the organism to bioaccumulate them. Thus, the use of a unique sentinel species for the characterisation of an area removes this disadvantage. In Figure 1 are presented the plots of median concentration of pairs of metals in *Patella* samples from different Greek areas. These plots reveal directly the sites of extreme metal levels (ie: Larymna. Lavrio. Pagassitikos)

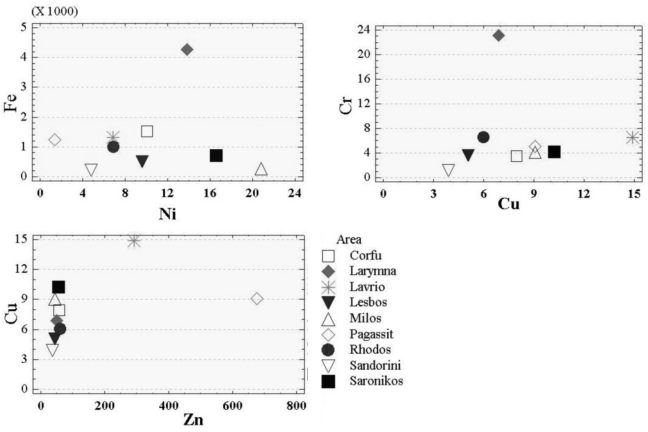

Figure 1. Plot of median concentration values of pairs of metals.

and at the same time identify the specific metal responsible for this differentiation. Finally we performed cluster analysis using the average values of metals in order to classify the studied sampling sites (Fig. 2). We observe that the areas displaying high concentrations for at least one metal distinguish and are accordingly clustered, i.e Lavrio-Pagassitikos due to Zn levels. Milos-Saronikos to its Ni levels, etc. In addition this analysis confirms the information obtained from the plots of Figure 1.

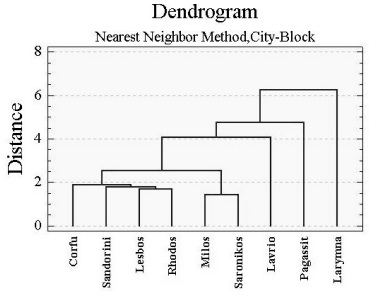

Figure 2. Classification of the Greek coastal areas by cluster analysis.

Conclusions

There is evidence that metal bioaccumulation in *Patella sp*. reflects accurately the metal profile of each coastal zone since in every specific area it provides information on the surrounding environment. Furthermore the data for this particular species agrees well with data concerning other species from the respective area. In conclusion, *Patella sp*. could be a metal pollution sentinel organism for the Greek coastal zone as in most cases has the two basic qualities (7): it reflects the spatial changes of metals in the environment, and provides similar results with other species of the same area.

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RESULTATS PRELIMINAIRES DE L'ETUDE DE LA MATIERE ORGANIQUE DANS LES SEDIMENTS RECENTS DE LA SEBKHA DE MOKNINE.

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Résumé

La superposition de niveaux pauvres (0,23%<COT<0,54%) et de niveaux riches (0,5%<COT<1,55%) en matière organique (MO) dans les sédiments récents de la sebkha de Moknine correspond à la présence de deux stocks organiques dans la colonne lithologique. Le premier, allochtone d'origine continentale est amené par les cours d'eau, le second, autochtone correspond à la destruction sur place du couvert végétal à la suite des inondations intermittentes. La pyrolyse Rock-Eval, révèle que l'essentiel de MO est d'origine continentale, ligno-cellulosique et qu'elle ne dépasse pas le stade de la diagenèse précoce. L'étude des bitumes libres montre que ce milieu est régi par une intense activité bactérienne et microbienne, confirmée par la prédominance des n-alcanes, nC18 et nC22. Cette activité est méthanogène et halophile. Elle est clairement exprimée par la présence de deux "marqueurs biochimiques fossiles" à savoir l'isoprénoide en C25 et le squalane. L'analyse des hydrocarbures atteste l'absence de pollution dans le système par ces composés. Ces derniers proviennent pour la plupart de la synthèse microbienne.

Mots clés : matière organique, sédiments lacustres récents, biodégradation, activité méthanogène, marqueurs biologiques

Introduction

La distribution de la matière organique (MO) peut être suivie par la mesure du COT contenu dans les sédiments (1). Sa préservation dans les faciès sédimentaires est sous la dépendance de plusieurs facteurs : type de la matière organique, le milieu de dépôt et les conditions au cours de la diagenèse précoce (2). Cette MO se présente sous la forme d'un mélange de substance. Les hydrocarbures ne constituent qu'une fraction faible des composés lipidiques totaux, qui a leur tour ne représentent qu'une fraction subordonnée de MO du milieu (10% du COT). L'étude de ces composés nous renseigne sur l'origine de la MO (marine ou terrestre) et la nature des différents organismes qui la composent. Ils fournissent aussi des informations sur les conditions biophysico-chimiques ayant régnées dans le milieu et le degré de dégradation de la MO (3). Dans ce travail, l'étude de la MO avait plusieurs buts :

- la détermination des facteurs contrôlant la distribution de la MO dans les sédiments récents de la sebkha,
- les variations quantitatives latérale et verticale de cette MO sédimentée,
- la détermination de l'origine contientale (allochtone) ou lacustre (autochtone) de la MO, et
- l'étude de la composition de la MO et les conditions d'évolution qui permettent d'avoir une idée sur les différentes transformations, ayant lieu dans les premiers centimètres du sédiment.

Matériels et méthodes

Site d'échantillonnage : sept carottes sont prélevées dans la sebkha de Moknine (novembre 1996). Cette dernière est située au Sud-Est de Moknine et au Nord-Ouest de Mahdia (Tunisie). Toutes les carottes sont implantées dans la zone orientale pour éviter toute interférance avec des MO d'origine anthropique.

Mode d'échantillonnage : Le carottage a été réalisé à l'aide de tube en PVC (∅=75mm) sur une profodeur moyenne de 1m.

Etude de la MO:

- Analyse du COT par coulométrie à l'aide de l'appareil coulomat 702.
-Analyses des composés hydrocarbonés par la méthode de pyrolyse Rock Eval (O.S.A.).
-Extraction des bitumes libres et détermination de leur composition par fractionnement à l'aide de la C.P.L. et analyse de la fraction saturée par C.P.G. (Carlo Erba HRGC 5300 MEGA SERIES).

Résultats et discussion

COT : L'hétérogénéité des lithofaciès s'accompagne d'une hétérogénéité dans la distribution de la MO. Seule les carottes internes montrent une nette corrélation négative avec la profondeur.

Pyrolyse Rock Eval : les valeurs relatives aux hydrocarbures libres (S1) sont en général faibles (< 0,3 mg/g de roche) et ne dénotent pas d'une origine provenant d'une source de pollution .Les valeurs des hydrocarbures potentiels (S2) sont (S1) sont hérités de la biomasse originelle. A la périphérie, ces composés ne montrent aucune variation ni avec la profondeur, ni avec la nature lithologique. Cependant vers l'interieur (SM3 et SM6), ces derniers enregistrent une nette diminution avec la profondeur. Ce résultat atteste encore de l'homogénéité de la MO de point de vue origine et degré d'évolution vers le centre de la sebkha. Les valeurs des composés hydrocarbonés (S1+S2) sont faibles à moyennes et typique d'une MO type III (ligno-cellulosique). Enfin les valeurs de l'index IH sont généralement faibles provenant encore l'origine continentale de cette MO.

Bitumes libres : Les teneurs en extrait chloroformique sont faibles. Elles varient entre 65 ppm et 465 ppm à la périphérie et de 95 ppm à 500ppm vers l'intérieur. L'essentiel de cet extrait est sous forme de composés polaires (40 à 90% en poids) attestant l'absence de pollution par les hydrocarbures. Les chromatogrammes montrent un mode centré sur les légers (C17 et C23), avec un maximum en nC18 et nC22 donc l'origine est algaire et/ou planctonique (3). Un deuxième mode est centrée sur C25-C31 avec une forte prédominance des composés à nombre d'atomes de carbone impair, typique de cires cuticulaires des végétaux supérieurs (4). La prédominance du nC22 est conforme à l'hypothèse d'une importante activité bactérienne. La présence des isoprénoides acycliques concidérables est un signe d'une biodégradation partielle (5). Le rapport Pr/Ph<1 montre que la chaîne de phytol a évolué dans un milieu réducteur (6) et indique encore une activité bactérienne très importante. Enfin la présence du squalane et l'isoprénoide irrégulier en C25 reflète une activité méthanogène (7) dans les sédiments de surface de la sebkha.

Conclusion

La matière organique sédimentée dans la sebkha de Moknine est peu abondante. Elle présente deux origines : une allochtone apportée par les cours d'eau à partir du continent et une autre autochtone correspondant à la destruction sur place du couvert végétal suite à des inondations intermittentes. Cette matière organique hétérogène a évolué dans un milieu anoxique régie par une activité bactérienne et microbienne méthanogène.

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ELECTROCHEMISTRY OF COMPLEXED COPPER(II) AT SEAWATER CONCENTRATION LEVELS

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Abstract

The electrochemical reactions of the copper(II)-salicylaldoxime complex (Cu(II)-SA) adsorbed onto mercury drop are influenced by the "neutral" buffer 4-(2-hydroxyethyl)-1-piperazineethanesulfonic acid (HEPES). The reduction currents of the Cu(II)-SA complex in 0.55 M NaCl and 0.7 M $NaClO_4$ solutions increased by a factor of two in the presence of the HEPES (pH = 8.0), whereas the reduction potential shifted to more positive values. The weak adsorption of the HEPES onto mercury drop facilitates the electron transfer between the mercury electrode and the adsorbed Cu(II)-SA complex.

Keywords: electrochemistry, trace elements, metals, copper(II)

Introduction

Chemical speciation and determination of trace metals in natural waters have been extensively studied using various electrochemical methods and techniques· (1,2) The determination of the concentrations of copper ion in natural waters by a cathodic stripping voltammetry (CSV) using ligands such as: catechol, 8-hydroxyquinoline (oxine), tropolone, 1,10-phenanthroline, and salicylaldoxime (SA) is described (3).Various buffers, such as *N*-2-hydroxyethylpiperazine-*N´*-2-ethanesulfonic acid (HEPES) and piperazine-*N,N´*-bis(2-ethanesulfonic acid) (PIPES), generally accepted as chemically inactive compounds, are commonly applied (4). Since all of these buffers are zwitterionic acids with pK_a values between 6.8 (PIPES) and 8.1 (HEPPS), they are suitable for the experiments in the pH range of natural waters. It has been observed that the HEPES enhances by factors two and four the electrochemical signal of Co(II) and Ni(II)-cyclohexane-1,2-dione dioxime (nioxime) complexes, as well as Fe(III)-salicylaldoxime (SA) complex (5,6) . The role of the HEPES buffer can only be clarified by detailed investigations.

Methods and materials

The experiments were performed using an AUTOLAB potentiostat PSTAT 10 (ECO Chemie, Utrecht, The Netherlands) in an electroanalytical quartz cell (50 ml). The working electrode was a hanging mercury drop electrode (HMDE) (Metrohm, Herisau, Switzerland), Ag/AgCl as reference electrode and counter electrode was platinum wire. The stock solutions of 10^{-5} M of copper(II) (p.a., Kemika, Zagreb, Croatia), and a 10^{-2} M of salicylaldoxime (SA) (p.a., Acros Organics, New Jersey, USA) and 1.3 M of HEPES (p.a., Chempur, Karlsruhe, Germany) were prepared.

Results and discussion

The electrochemical measurements of the redox system Cu(II)-SA were performed either in a 0.55 M NaCl or a 0.7 M $NaClO_4$ solution (Fig. 1), both in the absence and in the presence of the HEPES buffer (pH=8.0). The HEPES buffer surely affects the electrode process of the Cu(II)-SA complex, since the reduction peak current doubles in a 0.7 M NaClO4 solution, and the reduction potential shifts towards more positive values (for about 50 mV) (Fig. 2). These results suggest a mechanism which facilitates an electron transfer between the electrode and the adsorbed Cu(II)-SA complex in the presence of the HEPES molecules. Also, the surface coverage of the Cu(II)-SA complex remained unchanged regardless of the presence of the HEPES buffer. The facilitated electron transfer possibly includes the reorientation of the Cu(II)-SA molecules in the presence of the HEPES buffer which acts as a surfactant. Thus, the electron transfer rate to the mercury drop electrode surface is accelerated by a more favourable orientation of the adsorbed Cu(II)-SA molecules (5).

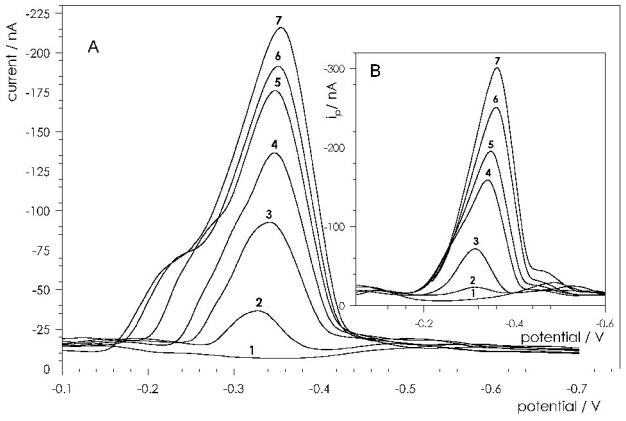

Fig. 1 Dependence of the DPCSV reduction current of the complex Cu(II)-SA on added Cu(II) concentration.
1) 0.55 M NaCl, 2) 0.7 M NaClO4. (a) without, (b) with HEPES. 25 mM SA, 6.5 mM HEPES. pH=8.0, Eacc = -0.05 V, tacc = 300 s, a = 25 mV, scan rate = 20 mV/s.

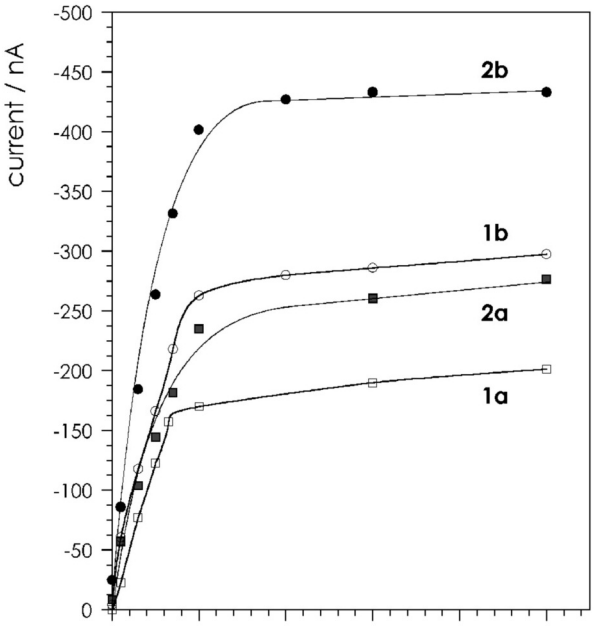

Fig. 2 DPCS reduction voltammograms of the Cu(II)-SA in (A) 0.55 M NaCl and (B) 0.7 M NaClO4; 25 mM SA; [Cu(II)]/M = (1) 0; (2) 1x10-8, (3) 3x10-8, (4) 5x10-8, (5) 7x10-8, (6) 1x10-7, (7) 5x10-7; pH=8.0;
Eacc = -0.05 V; tacc = 300 s; a = 25 mV; scan rate = 20 mV/s.

Conclusion

Generally, we suggest that prior to measurements, the electrolytes containing the so-called "inert" buffers, should be thoroughly tested in order to prevent potential effects they might exert upon the electrochemical and chemical reactions of the systems investigated, as well as to avoid ambiguous results.

It can be concluded that applied analytical procedure enables determination of dissolved copper ion in natural waters at the concentration level below 10^{-9} M Cu.

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METAL POLLUTION IN SPERCHIOS ESTUARY, GREECE

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Abstract

Sperchios is a small river in eastern central Greece having a catchment area of 1,640Km^2, length of about 80km and water flow 5-50m^3/sec. It is polluted from agricultural, domestic and industrial effluents, both from point and non point sources. Sperchios River carries a significant load of pollutants to the sea, which has to be minimised by the proper environmental management in order to avoid ecological damages. The chemical study of trace metals in the estuary indicates an intermediate level of metal pollution and the significant role of suspended particulate matter of small size in the transport of metals to the sea.

Keywords : estuaries, pollution, trace elements, zinc

Introduction

The understanding of the chemical processes taking place in estuaries polluted by a variety of sources is of great importance because these processes are strongly responsive to changes in major physico-chemical variables and to hydrodynamic processes that affect particle/solution interactions. Changes in these parameters can be significant in small rivers that are systems in danger of environmental deterioration [1].

The studied area

Sperchios is a small river in eastern central Greece. Its catchment area is 1,640Km^2, its length about 80Km , and its flow ranges between 5 and 50 m^3/sec. The wetlands at the estuary form a unique and extensive ecosystem which is a wintering place for large bird populations and a nesting area in summer for rare species. The area is included in the European network "NATURA 2000" according to 92/43 E.U. directive .

The population of the region reaches 90,000 inhabitants. The main city is Lamia having about 45,000 inhabitants. The wastewater treatment plant of Lamia is located by the estuary and its load is about 700kg BOD_5/day. The treated effluents are disposed into the river. The main cultures in the catchment basin are cotton, cereals, olives, and pistachio trees, since large areas near the delta are planted with rice. The area is drained through an extensive network of channels. Some industrial and small manufacturing enterprises like olive oil refineries, wheat mills, abattoirs, dying works etc, discharge their waste directly or indirectly into the river. Our team has carried out environmental research studies in this area since 1984 [2].

Methodology

The studied area is shown in Figure 1.An extensive sampling was carried out during April 2000 (high flow period) when riverine, estuarine and marine samples were collected by Hydro-Bios sampling bottles. Dissolved O_2, temperature, conductivity, salinity and pH were measured in situ. The water samples were filtered in succession through 8 and 0.45 μm Millipore filters [3]. The filters were treated with concentrated HNO_3 in PTFE beakers. The water samples were preconcentrated by using Chelex-100 resin [4]. Trace metals were measured by Flameless Atomic Absorption Spectrophotometry (VARIAN SpectrAA 640Z).

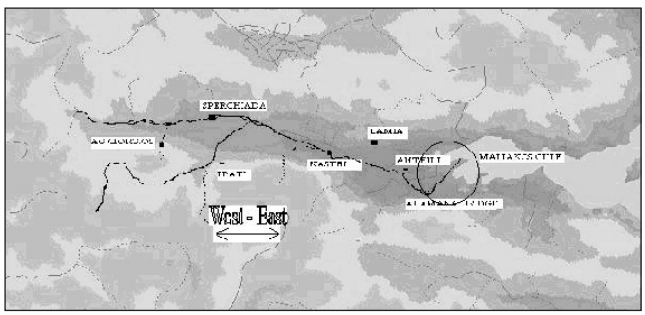

Figure 1 : The Sperchios river and the studied area.

Results and discussion

The water temperature was 15-16°C, the concentrations of dissolved O_2 were very close to the saturation values and the pH was 7.2-7.8 in river and estuary and about 8.1 in seawater. The conductivity in the upper part of the river was lower than the one in the estuary due to partial mixing of fresh and marine water there. The general picture of the river was rather normal for a small Mediterranean river. The whole system is divided to three parts. Upper river includes the area up to Alamana Bridge, whereas the estuary includes six stations in the mixing zone. The salinity in the neighboring marine area and in seawater samples was higher than 33‰

Table 1.

	Cu					Ni				
	D	P1	P2	Kds	Kdt	D	P1	P2	Kds	Kdt
Riverine	0.42	0.18	0.16	12.8	1.7	0.41	2.22	0.16	11.8	18.5
Estuarine	0.23	0.40	0.07	23.9	1.4	0.65	5.49	0.11	14.8	7.0
Marine	0.25	0.46	0.06	1.2	1.0	0.25	1.98	0.66	0.1	2.4
	Pb					**Zn**				
	D	P1	P2	Kds	Kdt	D	P1	P2	Kds	Kdt
Riverine	0.37	0.54	0.35	21.0	1.5	2.46	2.85	2.21	22.2	3.5
Estuarine	0.33	1.75	0.25	92.2	3.8	2.63	3.64	2.04	61.1	1.6
Marine	0.62	0.54	0.16	0.5	1.1	2.77	1.54	1.8	1.5	1.2

In Table 1 are presented the results of our study. It contains the mean metal concentrations (w/v) in ppb-μg/l (D: dissolved, P1: particulate retained on the filter of 8μm, P2: particulate retained on the filter of 0.45μm). It contains also the mean values of partition coefficient Kd : Cp/Cd where Cp the metal content of the particles and Cd the concentration of dissolved metals [5]. Kds are referred to the particles that are smaller than 8μm, and Kdt to the total particulate matter. (The values of Kd are *10^5). The main conclusions are the following :

❮ Trace metals concentrations lie in an intermediate range in comparison to rivers slightly and heavily affected by polluting activities [3].

❮ The P1 values are higher than the P2 values, due to the higher quantity of particles having diameters >8μm, although the elevated metal content of small particles .

❮ The high Kd values reveal the significance of small (<0.45μm) particles in the transport of metals, coming from polluting activities, from the river to the sea. The difference is lower in the case of Ni due to the geological origin of this element. The elevated estuarine values indicate the existence of increased adsorption in the intermixing zone whereas the significant decrease in marine zone indicates both desorption, dilution and influence by marine particles.

❮ In the case of dissolved Cu and Ni the dilution phenomenon prevails and the concentrations are lower in the marine zone. In the cases of Pb and Zn the influence of desorption of metal from the particles lead to increased values in marine waters.

❮ Similar phenomena were observed in our previous studies although there were variances in the ratios between dissolved and particulate metals due to various hydrological conditions [2].

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THE NEW DISTRIBUTION OF THE TRACER ^{137}CS IN THE EASTERN MEDITERRANEAN: RELATIONSHIP TO THE DEEP WATER TRANSIENT.

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Abstract
In the late seventies, the vertical profiles of the conservative tracer ^{137}Cs in the Eastern Mediterranean showed a relative maximum in the Levantine Intermediate Water (LIW) and an exponential decrease towards the bottom. In the late nineties, the distribution of ^{137}Cs was characterised by lower surface concentrations and higher levels at depth, related to efficient transfer of the tracer by convection processes. Moreover, the input of the new Cretan Sea Overflow Water (CSOW) from the Aegean Sea produced a marked homogenisation of ^{137}Cs concentrations all over the Ionian Sea below 1500 m.

Keywords: Eastern Mediterranean, radionuclides, deep water.

Introduction

^{137}Cs is an anthropogenic radionuclide, conservative in the open sea. Its main sources to the Mediterranean area are fallout from past nuclear weapon testing and the Chernobyl accident in 1986. From 1963 to 1986, the radionuclide concentration in surface water has regularly decreased, reflecting the decrease of the atmospheric input and vertical transport processes. The ^{137}Cs vertical profiles were characterised by decreasing concentrations from surface to bottom. In the Eastern Mediterranean, the only vertical profiles before the Deep Water Transient were obtained by Fukai *et al*. (1) and Livingston, (unpublished) in the period 1975-77. ^{137}Cs surface concentrations ranged between 4.2 and 5.5 Bq m^{-3} over the entire basin. The profiles demonstrated subsurface maxima in the upper 400 m and an exponential decrease towards the bottom. The concentrations in deep Ionian Sea (0.3-0.5 Bq m^{-3}) were about double those of the Levantine Sea. It is reasonable to assume that the spatial distribution of ^{137}Cs was similar to that of tritium in 1978 (2), which showed concentrations below 1500 m decreasing from the Western Ionian Sea towards the Levantine basin. These distributions reflected the circulation in the Eastern Mediterranean, with tracer-rich dense waters of Adriatic origin (Eastern Mediterranean Deep Water, EMDW) flowing first into the bottom of the Western Ionian Sea and then spreading eastward. In 1986 the fallout from the Chernobyl accident produced a sharp increase in ^{137}Cs concentration at the surface of the Eastern and Northern basins. Pre-Chernobyl levels were reached again in 1990. In 1995 and 1999 two sampling campaigns have been carried out in the Eastern Mediterranean to determine the recent distribution of ^{137}Cs and its relation to the Chernobyl input and to the water circulation in the area.

Materials and methods

The location of the sampling stations is shown in Fig. 1. After CTD casts, water samples (60-100 l) were collected in different water masses, to determine ^{137}Cs concentration. ^{137}Cs was pre-concentrated onboard by co-precipitation on ammonium molibdo-phosphate (AMP) at pH 1.5. 134Cs was used as yield determinant. ^{137}Cs was determined by gamma spectrometry with high purity germanium detectors (relative efficiency 60%, resolution 2.1 keV at 1332 keV). The accuracy of the results is regularly checked by participation in IAEA intercomparison exercises.

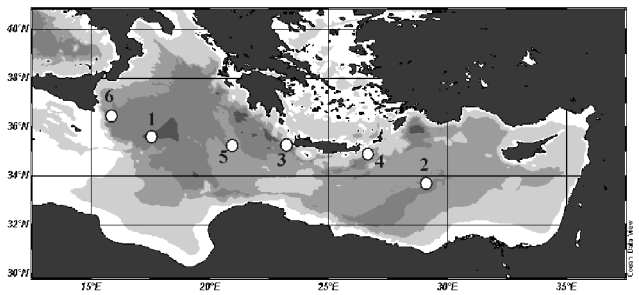

Fig.1 – Sampling points

Results and discussion

The 1995 campaign (UNESCO-POEM) found a dramatic change in the thermohaline circulation of the E-Mediterranean: a new type of water originating in the Aegean Sea, the CSOW, was flowing through the Cretan Arc straits and spreading throughout the bottom layer of the entire Levantine basin, flowing to the West and forcing upward the old deep water of Adriatic origin (3). The vertical profiles of ^{137}Cs at the two sides of Crete (St. 3 and 4) showed that the CSOW was marked by relatively high concentrations of ^{137}Cs (2-2.5 Bq m^{-3}). The most recent vertical profiles in the Ionian and Levantine Seas (St. 1 and 2) showed surface concentrations around 3 Bq m^{-3} and, as in 1977, a subsurface maximum in the LIW. However, in the bottom layer, they significantly differed from the old profiles. In the Ionian Sea, minimum concentrations (1-1.5 Bq m^{-3}) were found in the depth interval 750-1500 m, followed by an increase up to 2.5 Bq m^{-3} from 2000 m to the bottom. The deep layer was still characterised by the presence of EMDW, and the increase in ^{137}Cs concentration was due to its continuous transport from surface to bottom through convection processes in the Adriatic Sea. In the Levantine Sea (St. 2) minimum concentrations (1-1.5 Bq m^{-3}) characterised a larger depth interval, from 750 to 2000 m, but below this depth, where salinity and temperature data indicated the intrusion of CSOW, the levels increased reaching 2.5 Bq m^{-3} near the bottom. The inventory of ^{137}Cs at these two locations has more than doubled with respect to 1977, indicating an efficient transport from surface water and from the shelf areas to the deep sea.

In 1999, a new sampling campaign (SINAPSI) covered 4 stations along a transect from the Malta sill to the western side of Crete. The vertical profiles of ^{137}Cs were very similar at all stations (Fig. 2): almost constant concentrations (3-3.5 Bq m^{-3}) from surface to 300 m, decrease to a minimum value of 1-1.5 Bq m^{-3} around 1000 m and a new increase to an average value of 2.5 Bq m^{-3} from 1500 m to the bottom. Salinity and temperature profiles showed that the deep layers at the two Western Ionian stations (St.6 and 1) were characterised by EMDW, while at the other two stations CSOW dominated. As ^{137}Cs concentration was very similar in the two types of deep water, a marked homogenisation of the tracer concentration in the whole Ionian Sea is presently observed. Most of the ^{137}Cs inventory is now confined in the deeper part of the Eastern Mediterranean.

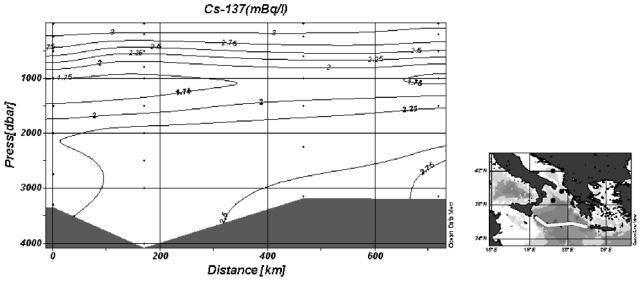

Fig. 2 – ^{137}Cs distribution along a West-East section in the Ionian Sea (1999).

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ASSESSMENT OF THE BLACK SEA RESPONSE TIME-SCALE TO POLLUTION WITH ^{90}SR AND ^{137}CS FOLLOWING THE CHERNOBYL NPP ACCIDENT

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Abstract

This assessment summarises studies of ^{90}Sr and ^{137}Cs pollution of the Black Sea Basin carried out during the period 1986-1998 following the accident at the Chernobyl NPP. Its goal is to assess the temporal evolution of ^{90}Sr and ^{137}Cs mass balance and inventories in some typical Black Sea ecosystems. It was found that the time scale of the Black Sea ecosystem response to the Chernobyl-derived pollution ranged between 21-73 years for ^{90}Sr and 11-77 years for ^{137}Cs.

Keywords: Black Sea, pollution, ^{90}Sr, ^{137}Cs, hydrobionts.

During the first weeks after the Chernobyl NPP accident, the ^{90}Sr concentration in Black Sea waters increased by 7-20%, and ^{137}Cs activity doubled due to atmospheric fallout [1]. Afterwards, the Black Sea was subjected to radioactive contamination mainly through river discharge. The present paper deals with an assessment and large-scale prognosis of pollution of Black Sea waters, biota and sediments with ^{90}Sr and ^{137}Cs, using results of measurements and subsequent modelling [1-5]. The purpose was to estimate inventories and the time scale of Black Sea ecosystem response to radioactive contamination, and to assess time periods during of which the concentrations of ^{90}Sr and ^{137}Cs in water, marine biota and the upper sediments may decrease to the pre-accidental levels.

Methods and materials

The study was carried out in 1986-2000 on oceanographic vessels and in the framework of radioecological monitoring of Sevastopol Bay with support of the EU programs EROS-2000 and EROS-21, IAEA projects NR 7400 RB and RER/2/003, and in collaboration with WHOI and EPA (USA). Intercomparison of the measurements was fulfilled jointly with WHOI, EPA (USA), Riso National Laboratory (Denmark) and IAEA.

Results and discussion

The study has shown that shortly after radioactive contamination of sea surface with atmospheric fallout, a relatively rapid decrease in ^{90}Sr and ^{137}Cs concentrations in the ecosystem compartments was observed during the first year (Fig. 1). In sediments adjacent to the Danube Delta, the ^{137}Cs concentration increased up to 1991. During the following years a decrease in radioactive contamination of waters, biota and sediments was found, and the trends may be successfully approximated by exponential equations. This allows calculating parameters A and p of the exponents:

$q = A \exp(-p\,t)$ (1) where q is inflow or outflow fluxes of radionuclide (TBq), or radionuclide concentration in the ecosystem compartment (Bq m^{-3} or Bq kg^{-1}) at time t (year); A and p are parameters. The time periods of decrease to half of the original levels (half-lives) were calculated as $T_{05} = 0.693/p$, and the time for decrease of ^{90}Sr and ^{137}Cs concentration in water, biota and sediments to the pre-accidental levels were determined with 95% probability as $T = 5\,T_{05}$. The predicted integral components of the Black Sea radioactive balance were calculated from equation:

$$Q = A \int_0^T \exp(-p\,t)\,dt \quad (2)$$

where Q is the predicted flux (TBq). The results of calculations using equations (1) and (2) are shown in Tables 1 and 2. They suggest that the time scale of the Black Sea ecosystem response to the Chernobyl-derived pollution ranges between 21-73 years for ^{90}Sr and 11-77 years for ^{137}Cs.

Fig. 1.Temporal variations in radionuclide concentrations in the Black Sea
a and b – annual average ^{90}Sr and ^{137}Cs fluxes with the Dnieper and Danube river run-off; c – ^{90}Sr (_) and ^{137}Cs (+) outflow through the Bosporus Strait; d – change of ^{90}Sr concentration in front of the Dnieper-Bug estuary; e – dynamics of ^{90}Sr (_) and ^{137}Cs (+) concentrations in the western mid-gyre; f and g – change of 90Sr and 137Cs concentrations in Sevastopol Bays; h – ^{90}Sr concentration in algae Cystoseira crinita; i – ^{90}Sr concentration in mussel Mytilis galloprovincialis (_) and fish Odontogatus merlangus (_); j – ^{137}Cs concentration (W.W.) in mussel Mytilis galloprovincialis (+) and in the upper sediments (D.W.) adjacent to the Danube Delta (_).

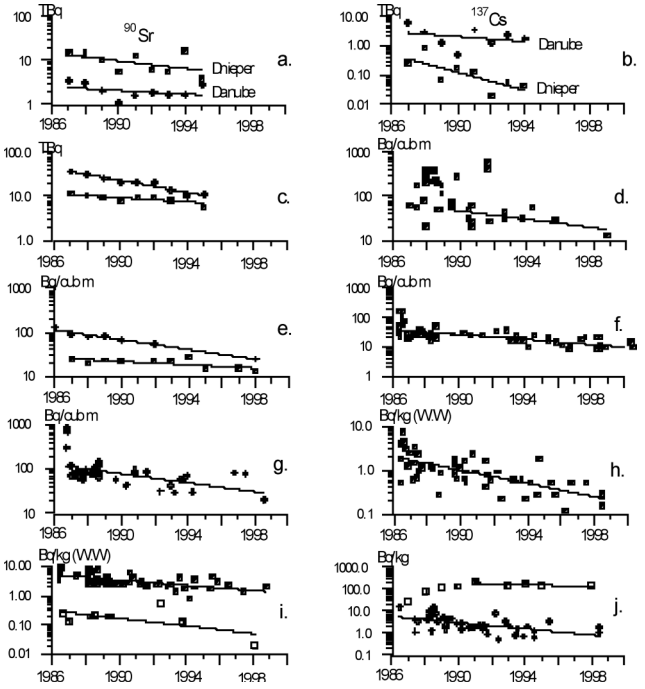

Table 1. Mass balance components and prognostic estimations for 90Sr and 137Cs in the Black Sea Basin. *Note: * - Estimations for the period 1986-1995*

Components of balance	90Sr (TBq)			137Cs (TBq)		
	Input/Outpu Assessments	Prognosis of consequent input/Output	Total	Input/output Assessments	Prognosis of consequent input/output	Total
Inventory in the whole volume before 26.04.86	---	---	≈ 1500	---	---	1400 ± 300
Atmospheric fallout in 05.86	100-300	---		1700-2400	---	
Inflow from the Dnieper River	90.2*	57.8	148.0	2.0*	0.1	2.1
Inflow from the Danube River	24.5*	32.8	57.3	24.0*	13.6	37.6
Outflow through Bosporus Strait	94.0*	130.2	224.2	225.0*	64.7	289.7

Table 2. Half – lives (T0.5) and complete response times (T) for mass balance components in some ecosystems of the Black Sea Basin to the pollution with 90Sr and 137Cs after the Chernobyl NPP accident (years) *Including period before an exponential decreasing.*

Components	^{90}Sr		^{137}Cs	
	T0.5	T	T0.5	T
Inflow from the Dnieper River (since 1987)	7.0	36.0	2.0	11.0
Inflow from the Danube River (since 1987)	14.4	73.0	6.9	35.5
Outflow through the Bosporus Strait (since 1987)	13.1	66.5	4.4	23.0
Surface waters near the Dnieper estuary (since 1989)	9.6	52.0	---	---
Surface waters of the Central Western Black Sea (since 1986)	15.6	78	5.4	27.0
Danube Delta marine bottom sediments (since 1991)	---	---	14.4	77.0
Region of the Sevastopol Bay:				
Surface waters (since 1987)	6.9	35.5	5.9	30.5
Brown seaweed Cystoseira crinita (since 1987)	4.0	21.0	4.4	23.0
Mollusc Mytilis galloprovincialis (since 1986)	6.7	33.5	4.3	21.5
Fish Odontogatus merlangus (since 1986)	4.7	23.5	---	---

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PHYSICO-CHEMICAL STUDY OF CADMIUM-METALLOTHIONEIN COMPLEXES ISOLATED FROM CADMIUM EXPOSED MUSSELS (*MYTILUS GALLOPROVINCIALIS*)

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Abstract

The amperometric titrations of the purified metallothionein (MT) chromatographic fractions with cadmium ions were performed in the buffered 0.59 M NaCl solution, pH 7.9 at 25°C. MTs were isolated from digestive glands of the mussels (*Mytilus galloprovincialis*) exposed to cadmium. Different purification procedures of the chromatographic fractions could be the reason for the differences in their metal and MT content. It is perhaps the reason for their different complexing properties for cadmium. The applied differential pulse anodic stripping voltammetry (DPASV) is suitable for physico-chemical characterization of MTs due to its species-selectivity and sensitivity.

Key words: cadmium, complexation, metallothionein, Mytilus galloprovincialis

Metallothioneins are rather small, metal-inducible and metal-binding proteins that are rich in cysteine residues, and are responsible for the metal detoxification and metal homeostasis in living organisms [1,2]. Since the knowledge of the biological functions of MTs, which is based on understanding their molecular and physico-chemical properties, is still not complete, our aim was to contribute to this knowledge by characterizing the metal-binding properties of MT isoforms, induced and isolated from the digestive gland of *M. galloprovincialis* exposed to cadmium, at a concentration level close to the cellular one at which metal interacts with the protein.

Experimental

Adult specimens of *M. galloprovincialis* (5-7 cm, from Lim channel, Northern Adriatic) were exposed for 14 days to 200 μg Cd dm^{-3} (1.8x10^{-6} M Cd^{2+} added as $CdCl_2$) in a continuous flow-through seawater system (S=38‰, 20°C). The biochemical procedure of the isolation and purification of MTs from the composite sample of the digestive glands of cadmium-exposed *M. galloprovincialis* is described elsewhere [3,4].

For further complexation studies the chromatographic fractions which contained MT were finally selected based on their highest cadmium content [4,5]. MT content was determined according to the Brdicka reaction [6,7]. Amperometric titrations of MTs with cadmium were performed at constant temperature (25.0±0.5 °C), ionic strength (0.59 M) and pH (7.9)[8]. Voltammetric measurements in a differential pulse anodic stripping mode (DPASV) were carried out with a μAutolab instrument (Eco Chemie, The Netherlands); the measurement parameters are defined elsewhere[8].

Results and Discussion

Before commencing the amperometric titration, the cadmium [4]. and metallothionein [7]. content was analysed in the selected chromatographic fractions (Table 1). It was found that dithiotreitol (DTT), added as a reducing agent during the MT isolation, competes with MT for Cd^{2+} ions and masks CdMT complex formation [6]. Therefore, DTT must be removed from the MT samples. Preferably, in the MT isolation procedure ß-mercaptoethanol should be used instead.

Table 1.Cadmium and MT content in the selected chromatographic fractions

Purified chromatographic fractions	*c*(Cd) / M	*c*(MT) / M
MT10(IV)	7.54·10^{-8}	1.5·10^{-6}
MT10(V)	5.05·10^{-8}	3.3·10^{-6}
MT10(27)	4.34·10^{-7}	2.1·10^{-7}
MT20(18)	5.34·10^{-7}	1.1·10^{-7}
MT10(12)(13)E.P.	1.08·10^{-6}	not determined
MT20(17)(18)E.P.	5.72·10^{-7}	not determined

CdMT complexes [9,10]. give the anodic signal (Fig. 1) with the peak potential at $E_p \approx$ -0.66 V. The most positive peak at -0.45 V is assigned to the oxidation of the mercury electrode in the presence of thiol groups complexed with cadmium [11]. (Fig. 1). The fact that during the amperometric titration of MT with $CdCl_2$ solution two distinct anodic signals, one of the CdMT complex and the other of Cd_{ionic} (E_p = -0.60 V; Fig. 1), are observed indicates that under the selected measuring conditions the CdMT complex is electrochemically inert and a reversible type of complex. From the peak heights of CdMT and Cd_{ionic} signals using the modified van den Berg-Ruzic-Lee method[6-8], the complexing capacity (C_L) (Table 2), and the apparent stability constants of CdMT were determined. Normalizing the available MT concentration for complexing cadmium (C_L) with the total (analytical) concentration of metallothionein (*c*(MT)) the number of cadmium ions additionally bound by the MT molecule could be determined. The variations of the Cd[4] and MT[7] concentrations (Table 1) and the stoichiometric ratio (Table 2) in the selected chromatographic fractions, suggest that different purification procedures caused differences in the metal and MT content of the chromatographic fractions and therefore resulted in different complexing properties for cadmium.

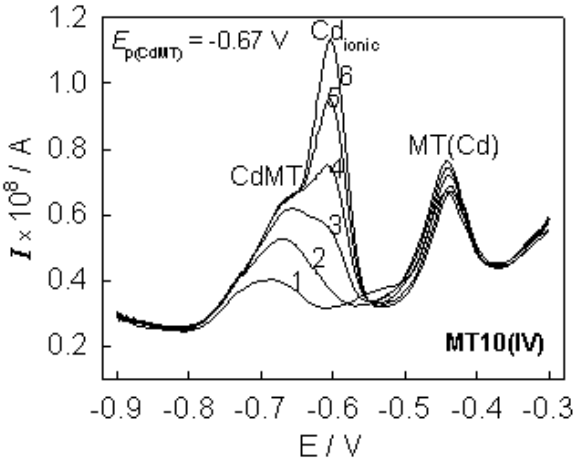

Figure 1 Amperometric titration of MT in 0.59 M NaCl, pH 7.9 with cadmium: to 50 µl MT10(IV)(or 4·10^{-9} M) Cd^{2+} solution is added in the concentration range from 1.42·10^{-9} M to 8.52·10^{-9} M[10].

Table 2.Cadmium complexing capacity (CL) of MT from differently purified chromatographic fractions. The results refer to 0.59 M NaCl, pH 7.9 at (25.0±0.5) °C

Purified chromatographic fractions	*c*(MT)* / M	C_L / M	C_L / *c*(MT)
MT10(IV)	4.0·10^{-9}	4.0·10^{-9}	1.0
MT10(V)	8.0·10^{-9}	1.0·10^{-8}	1.3
MT10(27)	5.8·10^{-10}	1.0·10^{-9}	1.7
MT20(18)	4.3·10^{-10}	5.7·10^{-10}	1.3
MT10(12)(13)E.P.	1.3·10^{-8}	7.0·10^{-9}	0.5
MT20(17)(18)E.P.	4.2·10^{-9}	1.4·10^{-8}	3.3

** aliquot of c(MT) from Table 1 diluted in 20 ml supporting electrolyte*

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BIOCHEMICAL ANSWER OF POSIDONIA OCEANICA TO A METALLIC STRESS

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Abstract
In order to demonstrate a biochemical answer to a metallic stress in *Posidonia oceanica* (L.) Delile, GST activity variations and isoenzyme A1/A1 induction have been studied for a mercuric contamination. Sampling is realized over an annual cycle in (i) an anthropized site, with highly mercuric contamination, and (ii) a reference site. Sites contaminated by mercury were those for which the highest enzyme activities were recorded, and mercury seems to increase GST activity, particularly in the bases of *P. oceanica* leaves. Moreover, A1/A1 isozyme is revealed only in bases and seems to be induced by mercury.

Key words: Phanerogams , mercury, enzymes, bio-inidicators

Introduction

Glutathione S-transferases (GSTs) are a group of dimeric enzymes catalyzing the conjugation of electrophilic xenobiotics with the endogenous glutathione (GSH) (1, 2).The effect of this reaction is generally to convert a reactive lipophilic molecule into a water soluble, non-reactive conjugate which may easily be excreted or stored (2). Plant GSTs can be induced by biotic stimuli such as pathogen invasion and abiotic stimuli, such as herbicides and heavy metals (3). Authors indicate that the level of expression of GST is a crucial factor in determining the sensitivity of cells to a broad spectrum of toxic chemicals and that GST induction is part of an adaptive response mechanism to chemical stress (4).

Material and methods

Shoots of *P. oceanica* were collected (i) in an anthropized (A) site subjected to mercury industrial wastes, in Rosignano (Italy), and (ii) in a reference (R) site in Lérins Islands (France). Only bases and blades from adult leaves were analyzed. Mercury concentrations were measured, after digestion of the tissues, by CVAA (Perkin Elmer FIMS 100). GST activities were determined in the post-mitochondrial fraction, by UV-visible spectrophotometry (Uvikon 930, Kontron) with reduced Glutathione (GSH) and Chlorodinitrobenzene (CDNB) as substrates (5) and expressed according to protein levels (determined following 6). Proteins from Rosignano and Lérins shoots were separated on SDS PAGE 12% and transferred to Hybond membrans. Blots were blocked in skimmed milk 5%, incubated overnight with 6 μg.mL^{-1} purified GST A1/A1polyclonal antibody (provided by 3) and

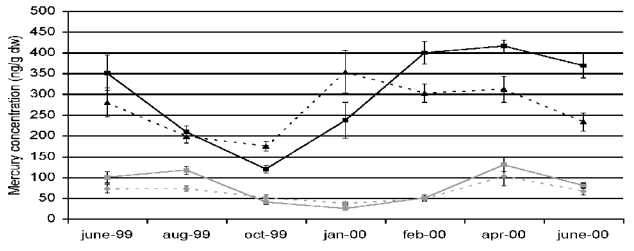

Figure 1: Mercury concentration in *P. oceanica* bases and blades from stations R and A.

then with a 1:15000 dilution of antichicken IgG-HRPeroxidase and finally revealed by ECL method.

Results

Mercury concentrations (fig.1) are significantly higher at station A (264 and 299 ng.g^{-1} y^{-1}dw on average, for blades and bases, respectively) as compared to R (63 and 77 ng.g^{-1} y^{-1} dw), regardless of the period. GST activity (fig.2) is higher at station A, regardless of the period (120 and 178 nmol.min^{-1}.mg^{-1} prot., for R and A, respectively).

Enzyme activity in adult leaves was always higher in the bases, regardless of station or period (110 and 190 nmol.min^{-1}.mg^{-1} prot. for blades and bases, respectively). ECL revelation (fig.3) demonstrates the presence of a 31kD band (A1/A1 isoenzyme) which is only present in the bases of *P. oceanica* and more accentuated from the anthropized site

Discussion and conclusion

GST activity was observed to be higher in anthropised site, it would appear that an elevated metal content is responsible for higher GST activity as yet demonstrated (5). GSTs are known to play a role in the protection of the cell against oxidative stress through the metabolism of glutathione (7). According to these authors, metals may evoke a decrease in glutathione content which could be mainly related to a

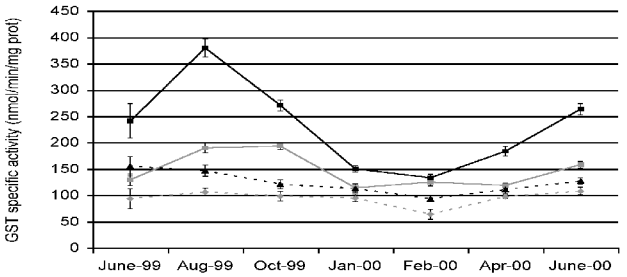

Figure 2: GST activity in *P. oceanica* bases (full line) and blades (dotted line) from stations R (grey) and A.

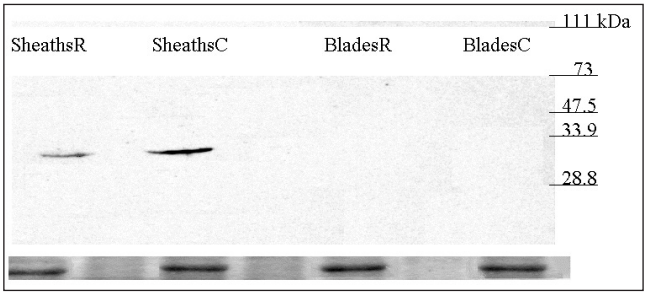

Figure 3: Western blot of GST A1/A1 from bases and blades of reference (R) and anthropized (A) stations. The amount of protein per lane was 8.6 µg.

stimulation of GST activity. The increase in GST activity, observed in *P. oceanica*, may thus be considered as an indirect or secondary effect of mercury.

Contrary to the bases, blades exhibited very low activity levels and thus provide very little information concerning variations in GST activities between seasons and between stations. These observations can be explained with the presence of A1/A1 isozyme only in the bases of *P. oceanica*, this isozyme being characterized by an high CDNB activity (3). The results, provided here, reveal that GST activity may represent a valuable marker for mercury contamination. Interpretation of GST activities along with mercury concentration data associated with isoenzymes induction can allow us to conclude that this metal induces GST activity, at least for A1/A1 isoform. It is therefore possible that another isoform, exhibiting a low CDNB activity, but high activity for an other substrate (ethacrynic acid, metolachlor…) is present, for instance in the blades. In fact, in a given organism, specific GST activities may be used as a criterion for distinguishing GST iosenzymes (3, 8). Only separation and characterization of all the isoenzymes will be necessary to determine whether or not the induction of one or several of these isoenzymes can be attributed to mercury contamination in *P. oceanica*.

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Introduction

Concern over the potential toxicity of metals to marine organisms, and to humans consuming seafood, has led to an extensive series of studies in recent years addressing the bioaccumulation of metals in marine organisms. Because plankton lie at the base of marine food webs it is critical that we understand the extent to which they can concentrate metals out of seawater and introduce them to organisms higher in the food web. The bioconcentration of metals in marine phytoplankton has already been reviewed (1, 2). This study addresses the potential impact of metals accumulated in marine copepods, an important component of the zooplankton biomass in the Mediterranean and other seas. Earlier studies have addressed metal bioaccumulation and the biogeochemical consequences of this accumulation in these organisms (3-6). This study addresses the toxicological implications of this accumulation.

Metals can be taken up by marine copepods through ingestion of contaminated food or from the direct uptake of dissolved metal from ambient seawater. In the coastal Ligurian Sea, copepods have recently been shown to concentrate silver 1.3 x 10^5 times above ambient seawater, cadmium 3.1 x 10^5 times, cobalt 3.7 x 10^4 times, and zinc 6.0 x 10^5 times (7). Application of a biokinetic metal accumulation model that was field-tested in the Ligurian Sea (7) has shown that Ag, Co, and Cd are taken up appreciably from the dissolved phase and from food, whereas Zn is accumulated primarily from dietary (phytoplankton) sources (8). Metals accumulated from water, particularly following adsorption to surfaces, are commonly associated with the exoskeleton of crustacean zooplankton, including copepods (8-11), and indeed many metals can be found to be greatly enriched in cast zooplankton molts following ecdysis (12). Metals accumulated through diet must be assimilated out of the ingested food and often accumulate in the internal tissues of the zooplankton (8-11). The efficiency with which ingested metals get assimilated varies enormously among metals, from <5% for Am and Pu (5, 10) to >90% for Se (13, 14). The assimilation efficiency can also vary with the algal diet (15) and sometimes with the physiological state of the ingested algal cells (14). A strong correlation has been found between the assimilation efficiency of ingested metals and the site of deposition of the metals in the algal food, where cytoplasmic metals are assimilated and membrane-bound metals are not, regardless of the nutritional value of the metal (14, 16, 17).

Materials and methods

To investigate the impact of metals accumulated in marine copepods, we conducted experiments to assess the sublethal and lethal toxicity of dissolved and ingested metals to the calanoid copepods *Temora longicornis, Acartia tonsa* and *A. hudsonica*. These experiments evaluated the bioaccumulation of Cd, Ag, and Hg following different uptake pathways with gamma-emitting radioisotopes (^{109}Cd, ^{110m}Ag, and ^{203}Hg), described elsewhere (11, 18). A range of different concentrations for each metal was examined, from low environmentally realistic concentrations that exist in natural surface seawater to orders of magnitude higher levels. The bioconcentration factors of the metals in the copepods was determined following uptake from the dissolved phase and from food (the diatom *Thalassiosira pseudonana*). The metal body burdens in the copepods were evaluated by analyzing the radioactivity of the copepods after pulse feedings and was related to the subsequent toxic response over a 1-wk period. The effects of the accumulated metals were determined by examining the lethal toxicity to adults and sublethal effects, primarily the impact of accumulated metals on egg production and hatching success (11, 18).

RELATING BIOACCUMULATION OF METALS TO THEIR TOXICITY IN LIGURIAN SEA COPEPODS

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Abstract

Metals (Cd, Ag, and Hg) accumulated from phytoplankton food in marine copepods can significantly depress reproductive success at body concentrations that are only 2-fold (Cd), 3-fold (Ag), or 9-fold (Hg) higher than current metal concentrations in Ligurian Sea copepods. Sublethal toxicity is manifested in depressed egg production and hatching following dietary metal exposure. Metals accumulated from the dissolved phase have no effect at environmentally realistic concentrations.

key words: zooplankton; metals; toxicity

Results and discussion

Metals were taken up by the copepods from both dissolved and dietary pathways, but only the ingested metals consistently elicited a toxic response at body burden concentrations of metals close to environmentally realistic levels. For example, lethal concentrations (LC_{50} values) of Cd, Ag, and Hg were 300, 400, and 1000 nM, respectively following uptake from the dissolved phase. These concentrations are at least 2 orders of magnitude above surface seawater concentrations in the Ligurian Sea (7), suggesting that dissolved metals are unlikely to ever approach levels that are directly and acutely toxic to copepods. Concentration factors of these metals from the dissolved phase in the copepods following 12-h exposures were 1.0×10^3 for Cd, 3.0×10^3 for Ag, and 1.3×10^4 for Hg. These metals were bound principally to the exoskeleton (from 60% for Cd to 93% for Hg).

Metals accumulated in copepods from ingested diatoms were principally bound to internal tissues (ranging from 77% for Cd to 99% for Hg) and produced a sublethal toxic effect but had no acutely toxic effects at environmentally realistic concentrations. We found assimilation efficiencies of 62% for Cd, 15% for Ag, and 14% for Hg, comparable to previous studies (3). When the algal food was exposed to concentrations as low as 1 nM for Ag or Hg and as low as 5 nM for Cd, copepods feeding on this food produced significantly fewer eggs ($p < 0.05$) and many of these eggs did not hatch, leading to a pronounced decline in reproductive success. Toxic metal concentrations in phytoplankton (nmol g^{-1} dry wt, determined by measuring metal radioisotope uptake), which affected egg production were 64 for Cd, 39 for Ag, and 34 for Hg, or 1-2 orders of magnitude above background levels in phytoplankton in the Ligurian Sea (7). Table 1 presents the sublethal effects of the ingested metals as a function of the body burdens of these metals. The results suggest that concentrations of metals in Ligurian Sea copepods are within an order of magnitude, and generally within a factor of 2-3, of levels which can interfere with egg production and hatching. Toxicological studies clearly must consider sublethal effects and dietary pathways as well as solute uptake in assessing contaminant impacts on marine animal populations.

Table 1. Effects of metal accumulated from ingested diatoms on reproductive success in marine copepods. Dissolved Cd and Ag had no effect on egg production, whereas dissolved Hg significantly depressed egg production at body concentrations 11 times higher than those produced by ingestion of diatoms.

Metal	Lowest concentration in copepods (nmom g^{-1} dry wt whole body) that significantly affected egg production. Values in parentheses are concentrations in Ligurian Sea copepods (7,12).	Reproductive success relative to controls (considering egg production and hatching success rate).	Ratio of lethal to sublethal ambient metal concentrations (LC_{50} : EC_{50} values)
Cd	42.0 (22.1)	28%	1000 nM:5 nM = 200
Ag	4.3 (1.3)	57%	400 nM:1 nM = 400
HG	2.7 (0.3)	37%	300 nM:1 nM = 300

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BIOACCUMULATION OF HEAVY METALS AND RADIONUCLIDES IN THE JELLYFISH *CASSIOPEA ANDROMEDA* AND *AURELIA AURITA* (CNIDARIA, SCYPHOZOA)

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Abstract

Experimental radiotracer studies show that both benthic (*Cassiopea andromeda*) and pelagic (*Aurelia aurita*) jellyfish readily accumulate heavy metals (Co, Zn, Ag and Cd) and radionuclides (^{137}Cs, ^{241}Am) from water and food and retain them for long periods of time with biological half-lives (Tb1/2) ranging from a few days to several weeks. Zinc and Ag were accumulated to the greatest degree (CF ~ $4x10^2$) with the benthic species showing a greater affinity for the metals than the pelagic form. Light-dark uptake experiments suggest that endosymbiotic zooxanthellae in *C. andromeda* may account for the enhanced uptake and retention capability noted in this species.

Keywords : radionuclides, bioaccumulation, Cnidaria, metals, medusae

Introduction

Jellyfish are prey for numerous invertebrate and vertebrate species and as such play a central role in the trophic organization of many marine foodchains. Furthermore, they are known to prey abundantly and selectively upon certain zooplankton species including fish larvae (1), and thereby may exert a major impact on the structure and dynamics of mesozooplankton communities as well as fish stocks (1, 2). Their impact on the environment is particularly important during summer blooms, when jellyfish may occur in very dense aggregations containing millions of individuals (3). Despite the well-known ecological importance of jellyfish, data are extremely sparse on the accumulation of metals in coelenterates (4) although their abundance, trophic position, and planktonic behaviour suggest they can affect the fluxes and fate of these contaminants in marine waters. Therefore, our objective in this study was to investigate the biokinetics of heavy metal and radionuclide transfer in jellyfish in order to assess their role in the marine fluxes of these contaminants.

Material and methods

Two jellyfish species, the benthic *Cassiopea andromeda* and the pelagic *Aurelia aurita*, were acclimated to laboratory conditions (open circuit aquaria; water renewal 10% per hour; salinity 38‰, T=18±1°C ; fed daily with *Artemia salina* nauplii) for approximately 8 weeks prior to experimentation. Both species were then experimentally exposed to radiotracers of four heavy metals (^{57}Co, ^{65}Zn, ^{110m}Ag, ^{109}Cd) and two long-lived artificial radionuclides (^{134}Cs, ^{241}Am) directly from water or through their food (viz. *Artemia* nauplii previously exposed to the tracers for 48h). Using gamma spectrometric techniques (5), uptake and excretion of the radioisotopes were followed in whole animals for 1-3 months to determine concentration factors (CF), assimilation efficiencies (AE), and retention (Tb_) of the contaminants. Tissue distribution of the isotopes was also determined by dissection. In addition, the possible influence of the symbiotic zooxanthellae on contaminant bioaccumulation in *C. andromeda* was examined by performing uptake experiments under light and dark conditions.

Results & discussion

With either exposure mode (sea water or food), ^{110m}Ag and ^{65}Zn were the metals accumulated to the greatest degree by both jellyfish species (Table 1). Furthermore, in all cases both radionuclides, ^{134}Cs and ^{241}Am, were always taken up much less efficiently and lost more rapidly than the heavy metals. Except in case of zinc which was taken up with similar efficiency by the two species, *C. andromeda* accumulated all other isotopes much more efficiently than *A. aurita* (Table 1).

Dissection of *C. andromeda* showed that the vesicles, situated along the arms and containing the endosymbiotic zooxanthellae, always displayed the highest CF for the metals tested. The CFs in vesicles ranged from 110 ± 8 (^{57}Co) to 1080 ± 230 (^{110m}Ag), and were 2 to 17 times higher that those calculated in the other body compartments (viz. umbrella, tentacles, gut and mesoglea). This suggests that autotrophic metabolism of the photosynthetic zooxanthellae is actively involved in metal uptake by this jellyfish. Indeed, all the metals were more readily concentrated by jellyfish under light conditions (Table 1). In contrast, no significant difference was observed in uptake of the radionuclides under light and dark conditions.

Elimination of metals and radionuclides previously accumulated via seawater was also species dependent. Retention capacity for metals in *A. aurit*a was quite weak in that all the accumulated isotopes were rapidly excreted with biological half-lives (Tb1/2) ranging from only 3 to 6 days, whereas *C. andromeda* retained metals much more efficiently with Tb1/2 ranging from 25 to 60 days. Accordingly, zooxanthellae may also be involved in the processes of metal release.

The feeding experiments demonstrated that, except for ^{134}Cs and ^{241}Am, both jellyfish species readily accumulated and assimilated these metals from their prey. Furthermore, heavy metal assimilation efficiency (AE) and resultant retention ($T_{b1/2}$) were always higher in *C. andromeda* (AE, 65 to 94%; $T_{b1/2}$, 28 to 65 days) than in *A. aurita* (AE, 37 to 57%; $T_{b1/2}$, 20 to 29 days).

Table 1. Whole-body concentration factors calculated in jellyfish exposed to radioisotopes for 14 days in sea water.

Isotope	*A. aurita*	*C. andromeda* (in light)	*C. andromeda* (in dark)
^{57}Co	6.0 ± 0.5	82 ± 3.9	64 ± 2.2
^{65}Zn	317 ± 37	412 ± 39	281 ± 23
^{110m}Ag	28 ± 3.2	455 ± 25	305 ± 10
^{109}Cd	20 ± 3.3	224 ± 16	148 ± 11
^{134}Cs	1.6 ± 0.2	3.6 ± 0.4	4.1 ± 0.5
^{241}Am	1.2 ± 0.2	12 ± 1.3	10 ± 0.6

Conclusions

These radiotracer studies have shown that jellyfish take up heavy metals and retain them in their tissues quite efficiently, in particular Zn and Ag. Both sea water and food are important pathways for metal accumulation in their tissues. Metal assimilation from food was particularly elevated in *C. andromeda*. High metal assimilation from ingested prey coupled with a strong retention in jellyfish tissues indicates that over the long term, dietary intake might be the predominant source of metal contamination in this benthic medusa. Jellyfish, which are key representatives of the gelatinous plankton community, constitute an important biomass in the oceans. Given they are also efficient metal bioaccumulators, jellyfish likely play an important role in biological transfer and recycling of heavy metal contaminants in the marine environment.

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BIOGEOCHEMISTRY OF ORGANIC MATTER IN MEDITERRANEAN SEA SURFACE FILMS

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Abstract

Four representative pairs of microlayer (SML) and underlying water (ULW) samples were collected in the Northern Adriatic Sea in early Spring 1996. DOC, POC, surfactant activity, lipid classes and fatty acids were analysed. Organic matter (OM) was derived mainly from diatoms, bacteria and to a lesser extent from higher plants. OM was generally enriched in the SML compared to ULW waters. The highest surfactant activity occurred on sunny days. Fractionation of organic matter and surface active substances on XAD-8 resin showed a great variability in the distribution of hydrophobic basic and neutral, hydrophobic acid and hydrophilic components as a function of environmental conditions.

Key words : sea-surface microlayer, lipids, organic surfactants, Northern Adriatic

At the boundary between the atmosphere and the ocean, the sea surface microlayer (SML) plays a key role in governing transfer processes between these two major reservoirs such as evaporation, gas exchange, emission of aerosols and cloud condensation nuclei and accumulation of pollutants (1-2). All these processes are influenced by the nature and enrichment of organic material in the SML. To support transfer models, it appears that we do not know enough about the chemical composition of the SML and its variability in space and time. We present here data obtained at sea, using combined analytical approaches to assess the variability of the organic composition of the SML under various environmental conditions: biological productivity, sun, wind, rain, etc.

Material and methods

Four pairs of SML and ULW water samples were collected in early spring in the Bay of Piran (northern Adriatic Sea) under different weather conditions between Julian days 85 and 93. Analysis was performed for dissolved and particulate organic carbon (DOC and POC) and surfactant activity using phase sensitive alternating current voltammetry (3). Fractionation of organic matter and surface active substances (SAS) was achieved by sorption on the XAD-8 resin in hydrophobic neutral and basic, hydrophobic acid, and hydrophilic fractions. Lipids were also analysed as lipid classes by thin layer chromatography with flame ionisation detection and free fatty acids by gas capillary chromatography (4).

Results and Discussion

DOC values vary in a very narrow range for all samples (1.29-1.62 mgl^{1}), indicating low enrichment in the microlayer. Total dissolved lipids show high enrichment in the SML for all samples (4.0 - 28.6). Enrichment factors of SAS are 6.4 and 2.2 for the SML samples 85 and 89, respectively. In the SML samples, POC varies between high enrichment and depletion. POC contributes 33.8 and 16.3 % to total organic carbon of the samples 89 and 93, while in the ULW POC varies between 12.4 – 17.8 % of the total organic carbon. Particulate lipids vary between high enrichment (1.70 and 4.19) and marked depletion (0.60 and 0.34). No correlation was observed between the enrichment of POC and lipids, as would be expected due to the highly hydrophobic nature of lipids. Surfactant activity of the POC was estimated as the difference between the concentrations of SAS (equivalent Triton-X-100) of the nonfiltered and filtered samples. Positive values, such as obtained for SML indicate the presence of surface active particulate organic substances in the range between 20 and 30 % of total surfactant activity. Negative values, as obtained for the ULW imply a strong hydrophilic character of this fraction. A positive correlation (R^2=0.9744) is obtained between total lipids and surfactant activity of nonfiltered samples, indicating a significant contribution of lipids to the surfactant activity of natural samples.

The contributions of hydrophobic basic and neutral, hydrophobic acid and hydrophilic fractions to DOC and surfactant activity shown in Figure 1 were highly varying and suggested possible relationships with weather conditions. For SML in the sample 89, collected on a sunny morning, hydrophobic neutral components are largely responsible for the surfactant activity, whereas hydrophilic components largely predominate in the sample 93, marked by heavy rains and their scavenging effect. Fractionation analysis of ULW shows that the hydrophobic acid fraction predominates. The distribution of fatty acids in the dissolved and particulate phases is shown in Figure 2. The main components of fatty acids are given : polyunsaturated fatty acids (PUFA) indicators of plankton activity, branched fatty acids (BrFA) mostly synthesized by bacteria, and long chain fatty acids in the carbon range 24-30 originating from terrestrial higher plants. PUFA are depleted in the particles of SML, indicating that most of the living organisms move out the SML during day. High values of the ratio of saturated fatty acids with 16 and 18 carbon atoms, in the range 3.4 – 9.1, except in the film at station 87, highlight the predominance of diatoms and diatom-derived material in both SML and ULW. BrFA are enriched in the SML, demonstrating the enrichment of both free and attached bacteria in the SML. Long-chain fatty acids indicate pulsed inputs from terrestrial plants (*e.g.* high at station 87).

Conclusion

The selective accumulation of organic substances in surface films is more pronounced during calm sea conditions, especially during sunny days. Organic matter is mainly derived from diatoms and from bacteria attached to particles, with a minor contribution from higher terrestrial plants. A positive correlation is observed between total lipids and surface active substances. Surface active substances show much higher enrichment than DOC in SML, implying the major role of SAS in ocean/atmosphere exchanges.

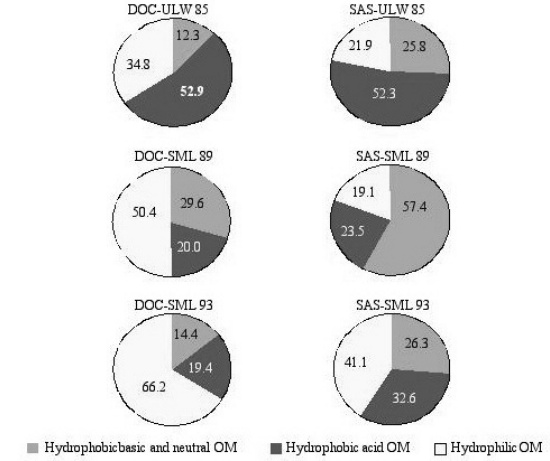

Fig. 1. Fraction of organic matter (OM) by Sportion on the XAD-8resin — SAS = surface active substances

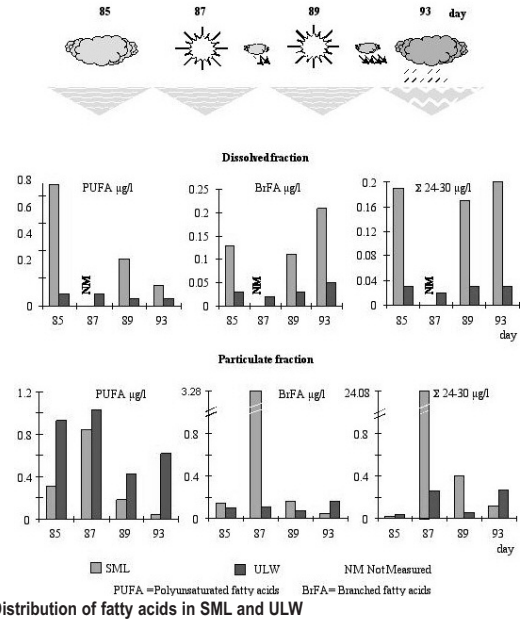

Fig. 2. Distribution of fatty acids in SML and ULW

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ON THE CHEMICAL AND RADIOACTIVE CONTENT OF DANUBE RIVER SAMPLES COLLECTED IN FEBRUARY-MARCH 2000

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Abstract

Water, sediment and fish samples collected from the Danube river mouth in Romania (km 1073) to Giurgiu (km 493) were analysed for heavy metals and radioactivity content. Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn, Cl-, CN-, and ^{3}H in water, ^{137}Cs, ^{226}Ra, ^{228}Ra, and ^{40}K in sediments, fish, and water, as well as ^{90}Sr and ^{238}U in fish samples have been determined. The results obtained were correlated with the gold mining events in N-W Romania, in January 2000.

Key words: Danube river, heavy metals, radioactivity, fish, water, sediment.

Introduction

The aim of this paper was to investigate the contribution of the Tisa tributary river to the heavy metal and radionuclide concentrations in the Danube River in Romania, after the gold mining events at Baia Mare (N-W Romania), in January 2000. Fish species *Alburnus alburnus, Acipenser ruthenus, Carasius auratus, Cyrinus carpio, Ctenopharingodon idaella, Perca fluviatilis, Rutilus rutilus*, and *Silurus glanis* were analyzed along with surface water and bed load sediment samples. The collection sites were: Moldova Noua (km 1073), Bazias (km 1072.4), Port Corabia (km 633), Corabia (km 629.5), and Giurgiu (km 493).

Experimental

Atomic Absorption Spectrometry (AAS) (Varian 250 PLUS spectrophotometer) and Energy Dispersive X-ray Fluorescence (EDXRF) methods were used to determine heavy metal concentrations in water and fish samples, respectively. EDXRF was performed by means of the ^{238}Pu and ^{241}Am excitation sources and an X-ray tube. Man-made and natural radioactivity was investigated by γ-ray spectrometry on sediment, fresh fish, and water residue [1], and by ,-ray spectrometry on ashed fish and water samples [2]. ^{238}U content in calcined fish ash samples was analyzed by fission and alpha track methods [3].

Results and discussion

Table 1 presents Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn, CN- and Cl- concentrations in water samples determined by AAS (in $\mu g\ L^{-1}$). Tables 2 and 3 include ^{137}Cs, ^{226}Ra (^{238}U series), ^{228}Ra (^{232}Th series) and ^{40}K activity concentrations in sediment (in Bq kg^{-1}) and fish samples (in Bq kg^{-1} fresh), respectively. Tables 4 and 5 contain ^{90}Sr and ^{238}U activity concentrations in fish (in Bq kg^{-1} fresh), and of ^{3}H, ^{137}Cs, ^{226}Ra, ^{228}Ra and ^{40}K in water samples (in Bq L^{-1}), respectively. Detection limits in the tables were calculated with a probability of 3σ.

It could be observed (Tables 1-5), that the concentration values obtained are similar to the levels determined in Danube samples during the last few years [1, 3-5].

Ag, Ba, Br, Ca, Cd, Cl, Cu, Fe, Ga, K, Mn, Pb, Se, Sn, Sr and Zn contents of the fish samples were investigated by EDXRF. Concentrations were found to be similar to those obtained by AAS for Cd, Cr, Cu Pb and Zn during July1999 - October 2000 [5].

In conclusion, no pollution with heavy metals and man-made radioactivity was observed in the samples collected along the Danube River, from Moldova Noua (km 1073, the river mouth in Romania) downstream to Giurgiu (km 493), about two months after the gold mining events at Baia Mare.

Table 1. Elemental concentrations in Danube water, determined by AAS (μg L^{-1}).

Sample site/ Date	Cd	Cr	Cu	Fe	Mn	Ni	Pb	Zn
km 1031/ 16.02.00	4	5	34	0	147	0	16	65
km 1073/ 23.03.00	6	22	11	22	43	2	43	18
km 1073/ 29.03. 00	10	0	10	0	1	17	50	10
km 633/ 29.03.00	9	14	20	14	65	14	75	30
km 493/ 28.03.00	14	0	9	0	0	9	64	24
km 493/ 29.03.00	4	15	8	57	0	20	57	15
km 493/ 29.03.00	4	43	11	43	11	7	57	7
km 493/ 30.03.00	22	22	17	24	24	4	22	24

Average concentration values in water samples (in mg L^{-1}): 19.162 (Cl^-), and 0.017 (CN^-)

Table 2. Activity concentrations in Danube sediments, by γ-ray spectrometry (Bq kg^{-1}).

Radio-Nuclide	Km 1073/ 20.03.00	Km 1072.4/ 24.03.00	Km 633/ 29.03.00	km 629.5/ 29.03.00	Km 493/ 28.03.00	Km 493/ 29.03.00	Km 493/ 30.03.00
^{137}Cs	4.4 ± 0.6	1.8 ± 0.3	1.4 ± 0.2	2.4 ± 0.5	0.6 ± 0.2	1.6 ± 0.3	1.6 ± 0.3
^{226}Ra	35.6 ± 1.6	9.6 ±1.1	8.5 ± 0.8	13.3 ±1.3	12.2 ± 1.1	13.5 ±1.5	12.6 ± 1.0
^{228}Ra	33.4 ± 2.7	11.6±0.9	11.9 ±0.7	16.7 ±1.0	15.5 ± 1.0	15.0 ±1.2	13.6 ± 0.9
^{40}K	463 ± 23	270 ± 11	366 ± 12	390 ± 25	350 ± 11	425 ±13	400 ±14

Table 3. Activity concentrations in Danube fish, by γ-ray spectrometry (Bq kg^{-1} fresh).

Fish species / Sample site	^{137}Cs	^{226}Ra	^{228}Ra	^{40}K
Carasius auratus / km 493	0.3 ± 0.3	< 0.9	< 0.7	108 ± 10
Carasius auratus (scales) / km 493	2.3 ±0.8	< 5.7	< 3.7	80 ±28
Alburnus alburnus / km 493	< 0.4	< 1.1	< 0.8	101 ± 10

Table 4. ^{90}Sr and ^{238}U activity concentrations in Danube fish (Bq kg^{-1} fresh).

Radionuclide	Cyrinus carpio (km1073)	Perca fluviatilis (km1073)	Silurus glanis-head (km 1073)	Carasius auratus (km 633)
^{90}Sr	< 0.85	< 1.15	2.3 ± 1.0	< 1.8
^{238}U	0.40 ± 0.08	0.22 ± 0.04	1.03 ± 0.21	0.33 ± 1.4

Table 5. Activity concentrations in Danube water (Bq L^{-1}).

Sample site/ Data	^{3}H	^{137}Cs	^{226}Ra	^{228}Ra	^{40}K
Km 1031 /16.02.00	< 6	0.0127±0.0053	< 0.018	< 0.015	< 0.098

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CHEMICAL CHARACTERIZATION OF DOC AND POC IN SEAWATER: DO PARTICLES PUMP DOC TO THE DEEP OCEAN?

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Abstract
In order to highlight the mechanisms that link the oceanic DOM and POM pools, we studied the chemical structure of: a) surface active POM (foam), produced after bubbling of algal-derived DOM and b) aggregate and sinking POM collected from the surface and the deep ocean. 1H-NMR spectra and molecular level analysis of foam samples resemble those of oceanic high molecular weight (HMW) DOM, showing an important contribution from polysaccharides, along with contributions from lipids, proteins and acetate. Furthermore, bulk and molecular analysis of aggregate and sediment trap material showed that there are two distinct classes of polysaccharides in these samples, the insoluble and soluble ones, which can be distinguished by their neutral sugar composition. The results of our study put additional evidence to two hypothesis: 1) physical removal by macroaggregates could control HMW DOM concentrations in surface seawater and 2) hydrolytic cleavage and release of HMW DOM from sinking macroaggregates might be of importance for the introduction of newly produced DOM to the deep ocean.

Introduction

The deep ocean inventory of dissolved organic carbon (DOC) is approximately 550 GT, comprising one of the Earth's largest carbon reservoirs. Despite its potential significance, many of the basic chemical and dynamic processes that collectively determine the cycling of DOC in the ocean are still poorly understood. Chemical characterization of high molecular weight (HMW) DOC, recovered by ultrafiltration, showed that a large fraction of DOC is a structurally well-defined class of acylated polysaccharides (APS) (1,2).

A possible mechanism for the removal of APS from the euphotic zone is coagulation or adsorption onto settling particles. Previous studies have shown that transparent exopolymer particles (TEP) can be formed from extracellular polysaccharides, which are considered to control the formation of marine snow during diatom blooms (3,4). In order to investigate this mechanism, we focused on the chemical characterization of particulate material produced both naturally and artificially after bubble-stripping of DOM. Two different types of surface-active material have been analyzed: i) particulate material (foam) produced after bubbling of HMW DOM (isolated from an algae culture) and ii) natural foam samples, collected from an enclosed coastal marine site (Salt Pond, Woods Hole, U.S.A.).

Methods and Materials

Foam samples, culture DOM and residual (bubble-stripped) samples were chemically characterized by proton-nuclear magnetic resonance spectroscopy (1H-NMR), elemental analysis, spectrophotometry (bulk carbohydrate and transparent exopolymer particle concentrations) and molecular level analysis (monosaccharides) (5).

Results and Discussion

^{1}H-NMR and molecular level analysis revealed that both mechanically and naturally-produced particles are rich in polysaccharides. ^{1}H-NMR spectra showed that the major resonance in both natural and artificial foam is from polysaccharides (3-4 p.p.m (CHOH), and 1.3 p.p.m (CH_3)). Resonances for low-molecular weight, non-acetate lipids were present at 0.9 p.p.m (CH_3) and 1.3 p.p.m (CH_2), for acetate at 2.0 p.p.m (CH_3COO/N) and for proteins between 2.8-1.5 p.p.m. Proton-NMR spectra revealed that there are strong similarities in the chemical structure of seawater HMW DOC and surface-active particulate material.

Both naturally and artificially produced HMW DOM and foam samples have similar monosaccharide distribution pattern. Galactose was observed to be the most abundant sugar, with mannose, fucose, rhamnose, xylose and glucose being relatively less abundant, and arabinose being the least abundant monosaccharide. Foam samples were enriched in deoxysugars (fucose and rhamnose) and galactose, and were depleted in glucose compared to the HMW DOM. Our results show that POM with similar chemical characteristics to HMW DOM can be produced from algal-derived DOM.

One possible mechanism by which APS may be introduced to the deep ocean is hydrolytic cleavage and release from settling macroaggregates. In order to assess the importance of this mechanism, a second series of experiments has been carried out. Marine aggregates collected during a diatom bloom from Buzzards Bay (Woods Hole, USA), and settling particles collected by sediment traps in the Arabian Sea and the Southern Ocean were chemically characterized. Samples were extracted with 100 mM Na_2EDTA solution in order to separate a 'soluble' carbohydrate fraction, which is associated with the particulate matter.

Neutral monosaccharides in total particulate samples and the 'soluble' Na_2EDTA extract showed different sugar distribution patterns. In the former, glucose was the most abundant sugar (79%), with a low contribution from galactose (7%) and mannose (5%) and with a minor contribution from the rest of the sugars (3%). In the 'soluble' extract, glucose and galactose were found more abudant (34% and 24 %, respectively), with mannose (15%), fucose (9%), rhamnose (9%), xylose (6%) and arabinose (1%) contributing less. The former distribution resembles that of marine POM, while the latter is similar to that of foam and seawater HMW DOM. These results imply that soluble and insoluble polysaccharides are two distinct classes of particulate organic matter, and can be distinguished by their neutral sugar composition.

In accordance with our results, radiocarbon measurements support the hypothesis that newly-produced DOM is introduced to the deep ocean. APS isolated from the deep ocean DOM have a young radiocarbon age (Repeta *et al*., in preparation), while deep-sea total DOM yields very old apparent ages (4000-6000) (6). Moreover, experiments with laboratory-produced soluble polysaccharides suggest that they can spontaneously form microgels and larger aggregates in seawater (7). Further research is needed in order to highlight the DOC pumping through settling particles and the implications of this phenomenon on the estimation of carbon budgets in the ocean.

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LIPID BIOMARKERS AND BULK ORGANIC PARAMETERS IN NORTHEASTERN MEDITERRANEAN SEDIMENTS

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Abstract
This study focuses on two marine sites of the Eastern Mediterranean (north and south Aegean Sea) and aims at assessing the various sources and the diagenetic state of organic matter in recent sediments using the biomarker approach. Mean organic carbon (OC) values in the surface sediments were two-fold higher in the north compared to the south Aegean (0.9% and 0.5%, respectively). The abundance of the various biomarker classes of terrestrial origin (long chain n-alkanes, n-alkanol and fatty acids) was significantly higher in the north site, reflecting the importance of riverine discharges in fueling this area with terrestrially-derived material. Concomitantly, the supply of nutrients leads to a higher productivity in the north compared to the south Aegean Sea, which is reflected by the relative abudance of various marine biomarkers (short chain alcohols and fatty acids, alkenones, sterols, diols and keto-ols). Dispersal pathways of organic matter and the various types of primary producers in the overlying waters were also investigated.

Introduction

The Mediterranean Sea is considered as a unique setting for the investigation of fundamental topics in the biogeochemical cycling of organic matter (OM). While a large body of studies has been carried out in the Western Mediterranean (1,2), there are only scarce data for the Eastern sub-basin (3).

This study is focused on the north and south Aegean Sea and aims at assessing the organic matter sources and highlighting alteration processes during its transport and burial in recent sediments. Biomarker compounds within several lipid classes (hydrocarbons, alcohols, long-chain alkenones, sterols, diols and keto-ols, and fatty acids) have been used in order to address these questions.

The selected marine sites have contrasting hydrological features. The north Aegean Sea receives considerable freshwater inputs from river discharge as well as inflow from the Black Sea, resulting in higher productivity compared to the south Aegean (Cretan Sea). The latter is considered as one of the most oligotrophic regions of the world ocean(4).

Methods and Materials

The analytical methodology comprises the freeze-drying of sediment samples, extraction with organic solvents for the isolation of the total extractable organic matter (TEOM), column chromatography for the separation of the various lipid classes, gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) for the qualitative and quantitative analysis of individual lipid components.

Results and Discussion

Mean organic carbon and total nitrogen values are two-fold higher in the north compared to the south Aegean (0.9% and 0.12% in the north Aegean and 0.5% and 0.08% in the south Aegean Sea, respectively).

The n-alkane concentrations varied from 1.46 to 5.21 mg/g of dry sediment in the north and from 2.23 to 3.22 mg/g in the south Aegean Sea. The predominance in most cases of the high molecular weight homologues (>C23), showing an important odd/even preference as indicated by the values of the CPI ratio in the range C23-C36 (from 3.31 to 4.23), reveals an allochthonous contribution from terrestrial plant waxes.

In the north Aegean sediments, the total concentrations of homologues with more than 23 carbon atoms ranged from 573 to 2257 ng/g, reaching the maximum value at the sampling site N2 (960 m water column depth) located in the Thermaikos Plateau, and the minimum at N4 (87 m water column depth), located in the upper continental shelf of Lesbos Island. The higher concentrations found in the deeper sampling stations of the North Aegean can be partially attributed to different sedimentological characteristics of shallow and deep stations.

In the Cretan Sea sediments, long chain homologues (>C23) ranged from 977 to 1401 ng/g, showing a uniform spatial distribution with slightly lower concentrations in the deeper sampling site (S1). The absence of major differences in the spatial distribution of terrestrially-derived homologues in the open Cretan Sea can be explained by: i) the absence of riverine inputs and ii) the homogeneous sedimentological characteristics of the different sampling sites.

The homologues of n-alkanes with less than 20 carbons (C15-C20) were found in relatively high abundance in both the north and the south sampling sites (from 572 to 2266 ng/g), and showed in most stations a slight even to odd predominance. The low CPI values calculated for all samples (from 0.58 to 0.79) indicate an important contribution of alkanes with bacterial and/or petrogenic origin. Petroleum inputs are further confirmed by the presence of an unresolved compound mixture (UCM), which appears as a hump in the aliphatic fraction as well as a series of hopanes and steranes.

Identifying biomarkers derived from marine sources permits determining the various types of algal species contributing to the overall surface water production. Contribution from coccolithophorids and diatoms, the main primary producer species in the overlying waters, was higher in sediments of the north Aegean as indicated by the spatial distribution patterns of alkenones and C_{28} desmethyl-sterols. The occurrence and distribution of other algal biomarkers, such as dinosterol and long-chain alkyl diols and keto-ols, reflect the same spatial trends, for the contribution from dinoflagellates and other nanoplankton species. Early diagenetic alterations of marine OM through heterotrophic processes, occurring during its transport and burial, are also investigated by means of diagnostic zooplanktonic and microbial biomarkers.

The whole data set is discussed in relation to environmental conditions prevailing in the study area. This allows gaining a better understanding of the biogeochemical functioning of the Aegean Sea, an area that has received increasing attention during recent years due to significant changes in its hydrological regime. The latter is most likely driven by climatic change (5), resulting in a possible impact on the entire Mediterranean Sea.

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MODELLING NITROGEN FLUXES IN A SEMI-ENCLOSED ENVIRONMENT (THE BLACK SEA) : TRANSPORT VERSUS BIOGEOCHEMICAL PROCESSES AND QUANTIFICATION OF THE EXCHANGES AT THE SHELF BREAK

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Abstract

A three-dimensional coupled biogeochemical-hydrodynamical model has been developed to get a better understanding of the biogeochemical functioning of the Black Sea. The influence on the ecodynamics of hydrodynamical and biogeochemical processes is quantified. Nitrogen inputs from the rivers, from the sediments and from the deep sea are estimated and compared in terms of potential fertilization. The exchanges between the north-western shelf and the deep sea are quantified. The results illustrate a highly complex spatial variability of the phytoplankton annual cycle and thus, stress the importance of using a 3D model to capture the essential physical-biological interactions that explain the data.

Keywords : Black Sea, Circulation Models, Primary Production, Mesoscale Phenomena, Ocean Colours.

Recent decades have seen a degradation of the environmental quality in various basins of the world's oceans, caused by eutrophication and pollution problems, with an amplitude depending on the ability of the damaged marine area to be able to adapt to new circumstances. As a result of their small inertia related to their geometry, the various semi-enclosed seas and enclosed inland bodies are particularly sensitive to natural and anthropogenic perturbations of their environment. Also, among the various basins of the world's oceans, the environmental degradation in the Black Sea, and in particular of its north-western continental shelf into which rivers such as the Danube flow, is the most severe, as reflected by the dramatic changes in its ecosystem and living resources. The management of the basin in a sustainable development perspective requires the identification and modelling of the Black Sea's physical and biogeochemical structures and processes that determine the mixing, transport and distribution of pollutants and biogeochemical constituents discharged by the rivers.

Model

The GHER General circulation model which has been used in this study of the Black Sea seasonal ecohydrodynamics is three-dimensional, non-linear, baroclinic and uses a refined turbulent closure scheme (the classical k-l model) (*e.g.* 1, 2, 3, 4). The ecosystem model is defined by a simple nitrogen cycle based on the functional role played in the trophic dynamics by planktonic populations. It is described by a limited number of aggregated variables sufficient to reveal the cogent effects of the three-dimensional time dependent macroscale and mesoscale hydrodynamics on biological fields. Six compartments are defined: the phytoplankton and zooplankton biomasses without reference to species, total detritus (lumping together dissolved and particulate organic matter), nitrate, ammonium and benthic detritus. In the transitional layer between oxygenated and anoxic waters, redox reactions prevent nutrients issued from the deep waters to reach the surface layer, thus constituting one of the main mechanisms whereby the Black Sea basin act as 'nutrients traps'. This implies that the modeling of the pelagic ecosystem will be made without the representation of the complex chemical processes occurring in the deep waters.

The model is forced by monthly mean climatological forcing functions. In particular, this includes the large scale free surface gradients along the Bosphorus strait, the wind stress at the air-sea interface and the outflow of the Danube and the Dnepr rivers on the north-western shelf. The spin-up time of the hydrodynamic model is of about 10 years. The ecosystem model is solved conjointly with the hydrodynamic model. After two years of integration, quasi-equilibrium is almost obtained for the ecosystem model, and the results of an additional annual simulation, which are representative of a situation typical of the mean Black Sea's climatological state, are compared with in-situ and satellite observations collected in the area.

Discussion

The nitrogen cycle in the north-western shelf waters and in the open sea is analysed and compared. The results illustrate a highly complex spatial variability in the phytoplankton annual cycle imparted by the horizontal and vertical variations of the physical and chemical properties of the water column.

In particular, the frontal instabilities of the main boundary current and the seasonal variability of the north-western shelf circulation, induced by seasonal variations in the Danube discharges and wind stress intensity which result in an important modification of the transport of nutrient rich Danube waters, have been found to play a key role in the space-time distribution of the primary production. Annual nitrogen fluxes computed on the shelf area and in the deep sea show the relative importance of transport versus biogeochemical processes. Computing the nitrate fluxes through the shelf break, it has been found that, with respect to the deep sea the margin acts as a source of nitrate most of the time. In agreement with observations, the model results indicated a rapid and efficient recycling of particulate organic matter in the oxygenated layer of the water column. More than 90% of the particulate organic nitrogen produced in the euphotic zone is shown to recycle in the upper 100 m of the water column and about 79% in the euphotic layer.

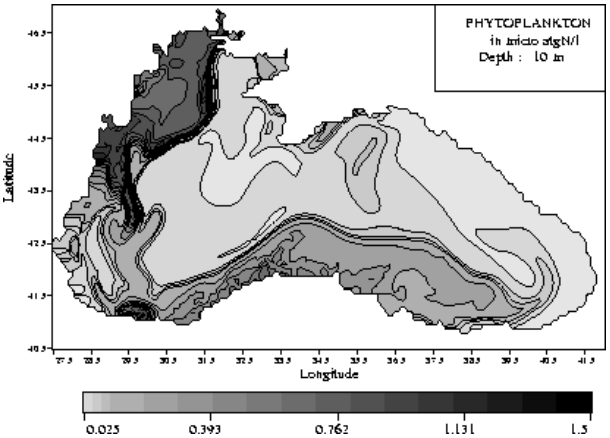

Figure 1 : Simulated phytoplankton distribution at 10 m at the end of May (in micro atgN/l)

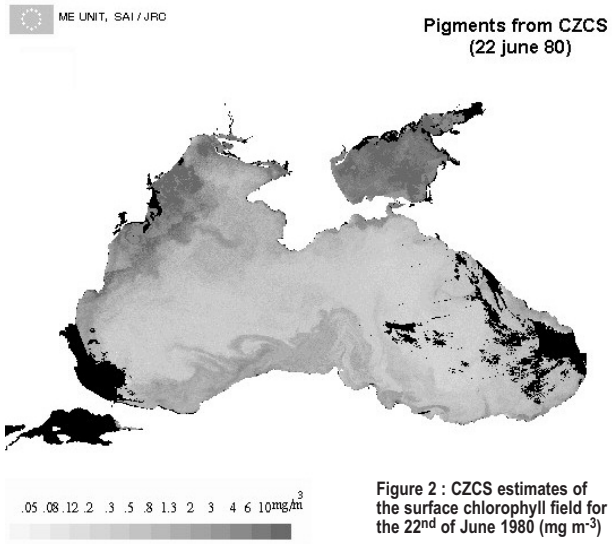

Figure 2 : CZCS estimates of the surface chlorophyll field for the 22nd of June 1980 (mg m-3)

The comparison of the phytoplankton biomass computed by the model with satellite-derived estimates of the surface chlorophyll field suggests that the model reproduces quite well the seasonal plankton productivity cycle in the different areas of the Black Sea but underestimates the phytoplankton biomass in the Danube's discharge area.

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^{210}PO AND ^{210}PB CONCENTRATIONS IN BIOTA FROM THE TURKISH COAST OF THE BLACK SEA AND MARMARA SEA

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Abstract

This paper reports concentrations of ^{210}Po and ^{210}Pb radionuclides from the Turkish marine environment during the period of 1997-2000. According to the findings the natural radionuclide levels have increased in some Turkish biota samples. For this reason, besides assessing anthropogenic radionuclides, efforts should concentrate on the natural radionuclides, especially ^{210}Po.

Key-words:Radioactivity,biota,Black Sea,Marmara Sea

The natural radionuclide ^{210}Po is the main contributor to the radiation dose received by humans from seafood consumption. ^{210}Po and ^{210}Pb concentrations can be locally enhanced by effluents of non-nuclear contamination (use of artificial fertilizer, pesticide, detergent and fossil fuel) adding potential risks for human health. The levels of naturally-occurring ^{210}Po and ^{210}Pb radionuclides in water, biota and sediment samples from the Turkish marine environment have not yet been published in the scientific literature. However, the ^{210}Po concentrations in biota and sediment samples of Turkish sector of the Black Sea are given as ranges (1). On the other hand, there are many papers published on the anthropogenic radionuclides especially ^{137}Cs concentrations in Turkish marine environment after the Chernobyl accident (2-4). This paper reports the results of ^{210}Po and ^{210}Pb concentrations in macroalgae, sea snail, mussel and fish species collected from the Turkish coast of the Black Sea and Marmara Sea stations during the period 1997-2000.

Material and methods

The macroalgae species were: brown; *Cystoseira barbata*, and green; *Ulva lactuca* and *Enteromorpha linza*. The algae samples were washed in distilled water to remove sand and other contaminating materials. They were then dried at 85°C to constant weight and homogenized. Similar sized sea snail (*Rapana venosa*), mussel (*Mytillus galloprovincialis*) and fish species (shad, *Aloso bulgarica*; anchovy, *Engraulis encrasiocolus*; bass, *Dicentrarchus labrax*; whiting, *Merlangius euxinus*; Picarel, *Spicara maena maena*; horse mackerel, *Trachurus trachurus*; red mullet, *Mullus barbatus*; and bonito, *Sarda sarda*) were stored in an insulated ice box with a plastic bag and transferred to the laboratory. The samples were homogenized and analyses were made on wet tissues or of total soft parts of the samples.The measurements of ^{210}Po and ^{210}Pb were made using a standard method. The concentration of ^{210}Po in wet or dry samples were performed starting with a standard addition of a known activity of ^{209}Po as isotopic tracer. Samples were completely dissolved with mineral acids (HNO_3, HCl, H_2O_2). After evaporation, polonium was plated onto silver disc in 0.5 M HCl in presence of ascorbic acid. The silver discs were counted by silicon surface barrier detectors (Model BU-019-300-AS) connected to a PC. After the first deposition of ^{210}Po, the 0.5 M HCl was kept for five months to allow ^{210}Po in-growth from the ^{210}Pb contained in the solution.

Results and discussion

^{210}Po activity levels in brown algae are higher than those found in green algae species collected from Igneada, Kilyos, Amasra and Sinop stations (Table. 1). However, the ^{210}Po concentration in green algae is higher than brown algae at M.Eregli station. In the algae species tested, the highest concentration of ^{210}Po was detected at the Amasra station. ^{210}Pb concentrations in algae samples ranged between 0.51±0.33 and 17.47±1.23 Bq kg^{-1}. The highest concentration of ^{210}Pb was found in brown algae from the Igneada station. The ^{210}Po and ^{210}Pb concentrations in sea snail and mussel samples are given in Table 2. The results showed that the ^{210}Po concentration in soft parts of sea snail and mussel samples were the ranges 20.54±1.19 - 37.47±2.04 and 14.93±1.16 – 14.93±1.16 Bq kg^{-1} wet weight, respectively. However, the ^{210}Po levels in muscle tissue of the sea snails were detected to be about 1 Bq kg^{-1} wet weight. The highest ^{210}Pb concentrations in sea snail soft parts and mussel samples were found to be 5.24±0.39 and 4.62±0.26 Bq kg^{-1} at Persembe and Rize stations, respectively. The ^{210}Po and ^{210}Pb concentrations in fish species are given in Table 3. The levels of ^{210}Po concentration in anchovy were within the range of 27.5±1.2 and 53.4±1.7. The ^{210}Po activity in Marmara anchovy samples are significantly higher than that in Black Sea fish. ^{210}Po concentrations in red mullet and bonito were found to be 10.2±0.90 and 26.1±1.88 Bq kg^{-1} (wet weight), respectively. On the other hand, The ^{210}Po concentrations were lowest in shad, bass, whiting, picarel and horse mackerel. Topcuoglu *et al*. (4) investigated the ^{137}Cs in biota samples from the Turkish coast of the Black Sea and Marmara Sea during the period of 1997-1998. In that study it was found that the ^{137}Cs activity in algae and in soft parts of sea snail and mussels were below the lower limit of detection. At the same time, ^{137}Cs concentrations in fish species were found to be between <3 – 4.8 Bq kg^{-1} wet weight. These results confirm that the dominant contribution at the total radioactivity concentration in biota samples comes from natural radionuclides.

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Table 1. ^{210}Po and ^{210}Pb concentrations (Bq kg^{-1} in dry weight) in macroalgae species ***NM, not measured***

Station	Collection date	Species	^{210}Po	^{210}Pb
Igneada	24.02.98	C.barbata	13.4±0.6	17.5±1.2
		U.lactuca	12.1±0.9	3.6±0.4
Kilyos	5.03.98	C.barbata	25.3±1.5	5.2±0.5
		E.linza	8.0±0.7	5.9±0.6
Amasra	11.11.97	C.barbata	54.7±2.6	11.6±0.8
		U.lactuca	42.3±1.6	11.3±0.6
Sinop	12.11.97	C.barbata	29.4±1.0	0.5±0.3
		U.lactuca	15.3±0.6	0.9±0.1
Persembe	13.11.97	C.barbata	8.3±0.4	2.5±0.1
M.Eregli	22.05.00	C.barbata	36.7±2.5	NM
		U.lactuca	46.5±3.7	NM

Table 2. ^{210}Po and ^{210}Pb concentrations(Bq kg^{-1} in wet weight) in sea snail and mussel species - ***NM, not measured***

Station	Collection date	Name and Tissue	^{210}Po	^{210}Pb
		Sea snail		
R.Feneri	5.03.98	Soft part	22.6±1.2	<0.2
		Muscle	0.9±0.2	<0.2
Amasra	11.11.97	Soft part	20.5±1.2	0.8±0.2
		Muscle	0.9±0.1	1.7±1.1
Persembe	13.11.97	Soft part	37.5±2.0	5.2±0.4
		Muscle	1.1±0.2	<0.3
Rize	26.06.98	Soft part	20.8±0.5	2.3±0.1
		Muscle	0.9±0.1	0.3±0.1
		Mussel		
Igneada	24.02.98	Soft part	18.1±1.1	_
Kilyos	5.03.98	□	18.1±1.0	_
R.Feneri	5.03.98	□	14.9±1.2	_
Amasra	11.11.98	□	18.4±0.7	3.7±0.5
Sinop	12.11.97	□	42.1±1.7	1.8±0.2
Rize	26.06.98	□	16.9±0.8	4.6±0.3
Sarköy	22.05.00	□	22.1±1.3	NM

Table 3. 210Po and 210Pb concentrations (Bq kg-1 in wet weight) in fish species ***NM not measured***

Stations	Collection Date	Name	^{210}Po	^{210}Pb
Igneada	24.02.98	Shad fish	1.4±0.1	<0.1
Amasra	10.11.97	Anchovy	32.0±1.9	_
Sinop	12.11.97	Anchovy	26.9±1.2	_
Persembe	13.11.97	Anchovy	27.5±1.2	_
	13.11.97	Bass fish	0.5±0.1	<0.1
Rize	26.06.98	Whiting fish	1.0±0.1	_
Ordu	17.03.99	Anchovy	46.3±3.4	2.2±0.1
	17.03.99	Whiting fish	5.4±0.4	<0.1
Tekirdag	25.05.00	Picarel fish	2.6±0.5	NM
	25.05.00	H. mackerel	2.0±0.2	NM
	25.05.00	Red mullet	10.2±0.9	NM
Marmara	30.10.00	Anchovy	53.4±1.7	NM
Unye	30.10.00	Bonito	26.1±1.9	NM

210PO CONCENTRATION IN WATERS AND SEDIMENTS OF THE BLACK SEA

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Abstract

The activities of dissolved and particulate ^{210}Po in the water and in the surface sediment samples from the Black Sea were determined. In all the water samples collected from 4-m depth, the dissolved ^{210}Po activities are less than those of the particulate ^{210}Po activities, showing the particle-reactive nature of Po. In a 100-m deep water sample from central part of the western Black Sea, however, the dissolved ^{210}Po activity is 6 times more than that of the particulate ^{210}Po activity. Moreover in this deep-water sample, the dissolved and especially the particulate ^{210}Po activities are several times lower than those in the surface water at the same station, strongly suggesting a redox control on the partitioning of the ^{210}Po between particulate matter and water. This result, together with a high ^{210}Po activity of 1930 Bq/kg DW in the surface sediment in this location, implies that ^{210}Po is being effectively transferred from the water column to the surface sediments under the cyclonic gyres.

Key-words: Black Sea, ^{210}Po activity, Water; Suspended solids; Sediment

The Black Sea is a semi-isolated sea subjected to various types of pollution, including heavy metals, artificial and natural radionuclides, pesticides, fertilisers and other organic pollutants. It has a layered water column, consisting of brackish (~18 ‰), oxic surface waters and anoxic H_2S-rich, more saline deep waters (~22.5 ‰) separated by a 100-150 m deep pycnocline (Fig. 1). Near and at the pycnocline is a few tens of metres-thick suboxic zone, which is the location of important redox and biogeochemical reactions (1). The water circulation in the Black Sea is characterised by a cyclonic boundary (rim) current which encloses two main cells (gyres) over the eastern and western deep basins (2) Natural radionuclides of various sources contributing to the total radioactivity have recently received increasing attention in aquatic environments. ^{210}Po is one of these natural radionuclides which is derived mainly from phosphate fertilizers, The main product of phosphate fertilizer industry is phosphogypsum. This product is produced during the wet phosphoric acid process from the raw material phosphate rock, which is enriched in various trace elements, rare-earth elements and certain naturally occurring radionuclides, including ^{210}Po. The activity of ^{210}Po in the phosphogypsum originates mainly within the ^{238}U and ^{232}Th decay series. Previous work on ^{210}Po in the Black Sea is very limited (3). The present work involves study of ^{210}Po distribution in water and surface sediment samples collected during a IAEA cruise between 21 September-15 October 2000 (Fig. 1). The water samples were collected from 4 m depth, except at Station 37, where a water sample was also recovered from 100 m depth. Water samples were analysed for both dissolved (<0.45 mm) and particulate ^{210}Po (>0.45 mm).

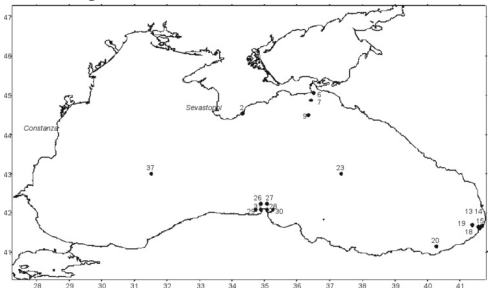

Fig. 1. Map showing the water and sediment sampling stations.

Results and discussion

The activities of dissolved and particulate ^{210}Po in the water samples recovered from the various stations are given in Table 1. In all the water samples collected from the surface euphotic zone, the activities of dissolved ^{210}Po are less than those of the particulate ^{210}Po, showing the particle-reactive nature of Po. In the 100-m deep-water sample from Station 37, however, the activity of the dissolved ^{210}Po is about 6 times that of the suspended solids. Moreover in this deep water sample, the dissolved and particulate ^{210}Po activities are about 2.7- and 24.5 times lower than those in the upper water layers at the same station. This strongly suggests that the deep-water sample is from the suboxic zone which appears to have imposed a redox control on the partitioning of the ^{210}Po between particulate matter and water. (4). It seems that ^{210}Po bound to different types of organic and inorganic suspended particulate matter is mobilised under reducing conditions, and again quickly transferred from this zone to the sediment by adsorption and particle-particle interactions (5,6). The rapid influx of ^{210}Po to the sediment appears to be especially more effective under the eastern gyre, as evidenced by highest level of ^{210}Po activity in the surface sediment sample from this area (Table. 2). This tentative conclusion needs further investigation with more detailed sampling and ^{210}Po analysis of the water column and surface sediments in the central part of the eastern and western Black Sea deep basins.

Table 1: Dissolved and particulate ^{210}Po contents in sea water samples.

Station no	Dissolved (Bq/m3)	(Bq/m3)
2	357±36	370±32
6	224±18	413±34
13	525±43	607±54
14	231±28	-
15	214±53	414±35
20	203±28	426±38
23	157±12	-
26	190±29	299±22
27	176±43	254±23
28	159±26	404±30
31	222±26	231±25
37s	315±37	472±27
37b	118±40	19±20

Table 2: ^{210}Po contents in surface sediments.

Station name	Act. ± 1σ	Depth (m)
2 (0-1 cm)	129±88	33
7 (0-1 cm)	205±1	38
9 (0-1 cm)	748±40	611
14 (0-1 cm)	39±4	12
15 (0-1 cm)	51±7	14,8
18 (0-1 cm)	87±7	71
19 (0.0-0.5)	294±19	860
19 (0.5-1.0)	244±16	860
20 (0.0-0.5)	594±31	1530
20 (0.5-1.0)	262±31	1530
23 (0.0-0.5)	1931±98	2168
23 (0.5-1.0)	1780±299	2168
26 (0-1 cm)	381±29	71
27 (0-1 cm)	237±16	57
29 (0.0-0.5)	301±18	91
29 (0.5-1.0)	195±13	91
30 (0.0-0.5)	137±13	54
30 (0.5-1.0)	164±15	54
31 (0.0-0.5)	242±13	69,5
31 (0.5-1.0)	273±17	69,5

The ^{210}Po activities in the bottom sediments range from 39 to 1930 Bq/kg DW (dry weight), with the highest activity being at Station 23 under the eastern Black Sea gyre. The low values were determined in the samples from Stations BS14, BS15 and BS18 located near mouth of the Çoruh River. The activity levels of these stations are 39.3, 51.3 and 87.1 Bq/kg DW, respectively.

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DISTRIBUTION AND ORIGIN OF HYDROCARBONS AND CHLORINATED COMPOUNDS IN SEDIMENTS FROM STRYMONIKOS GULF IN NORTHERN AEGEAN SEA, GREECE

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Abstract
Hydrocarbons and chlorinated compounds were studied in surface sediments collected from the greater area of Strymon river estuary, in Northern Greece. Total hydrocarbon concentrations ranged from 19.2 to 95.9 μg/g, while total polycyclic aromatic hydrocarbon (PAH) values varied between 107.2 and 1019 ng/g. The application of different diagnostic criteria suggests a rather natural terrestrial origin for aliphatic hydrocarbons and pyrolytic origin for the PAHs. DDTs displayed the highest concentrations of all the organochlorines determined, varying between 0.6 and 48.1 ng/g. Polychlorinated biphenyl (PCBs) concentrations were lower and ranged between 0.09 and 3.0 ng/g.

Keywords: Aegean Sea, sediments, chlorinated compounds, petroleum, PAH

Introduction

It is known that estuaries can receive and retain large quantities of organic pollutants. The objectives of this work were: (1) to quantify the extent of hydrocarbon and organochlorine pollution in the area around the estuaries of Strymon river, one of the major rivers flowing into the Northern Aegean Sea; (2) to identify the nature and origin of these organic contaminants and associated types of pollution; and (3) to elucidate the importance of Strymon river in the fate and transport of these organic contaminants.

Materials and methods

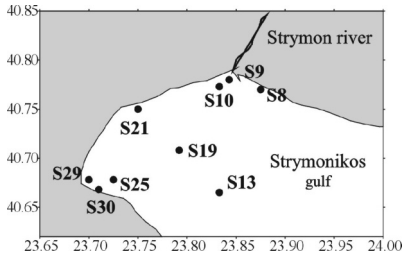

Figure 1. The sediment sampling locations

Surface sediment samples (0-2 cm) were collected from 9 stations during December 1997 and May 1998 (Fig. 1). The aliphatic and polycyclic aromatic hydrocarbons were determined by gas chromatography/mass spectrometry after extraction, saponification, cleanup and fractionation [1]. The organochlorines were determined by gas chromatography/mass spectrometry in SIM mode after extraction and cleanup [2].

Results and discussion

Total hydrocarbon concentrations (THC) ranged between 19.2 and 95.5 μg/g (Figure 2). These values are generally higher than those reported in open sea sediments of the northern Aegean Sea [3]. The lowest value was observed at station S13 in the middle of the gulf, while the highest values were measured at stations S9, S10, S8 close

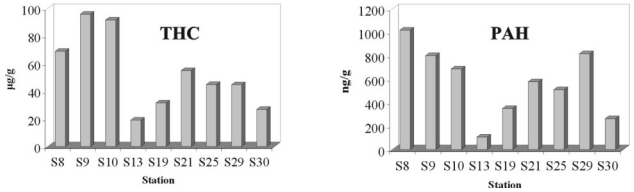

Figure 2. Total hydrocarbon (THC) and polycyclic aromatic hydrocarbon (PAH) concentrations in the sediments of Strymonikos gulf.

to the Strymon river mouth. This feature underscores the fact that riverine inputs are the major hydrocarbon supplier to the sediments of this area.

In all samples the gas chromatographic traces of the aliphatic fraction were characterized by two general features: resolved compounds and a unimodal hump corresponding to a mixture of unresolved compounds (UCM). The ratio unresolved/resolved compounds (U/R), which is widely used in order to identify the origin of the hydrocarbons, gives values indicative of petroleum contamination only at S9 (4.1), S10 (4.0) and S13 (3.7), while in the remaining stations they are below 3, suggesting the absence of important petroleum-related residues. N-alkanes presented a strong predominance of odd numbered carbon compounds in the range C25-C33, clearly indicating their terrestrial origin. Polycyclic aromatic compounds (PAHs) determined in this study include the parent compounds with two to six aromatic rings, dibenzothiophene, retene and the alkylated products of naphthalene, phenanthrene and dibenzothiophene. Their total values ranged between 107.2 and 1019 ng/g (Figure 1). Station S13 presented again the lowest value, similar to those measured in open sea sediments [3]. At the other stations the PAH concentrations are elevated but comparable to those found in other Mediterranean coastal or estuarine sediments [4]. In Figure 3 the percentages of pyrolytic, biogenic and petrogenic origin PAHs are presented. As can be seen, in most cases the pyrolytic PAHs predominate. Exceptions are the river-influenced stations S9, S10 and S21, where the

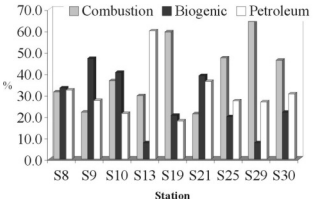

Figure 3. Distribution of combustion, biogenic and petroleum PAHs.

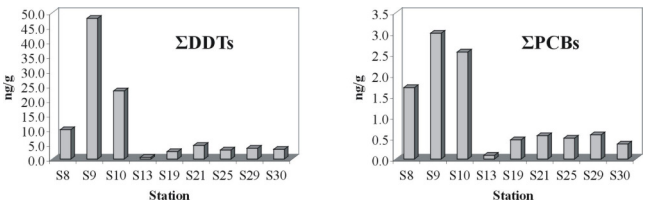

Figure 4. Total DDT and total PCB concentrations in the sediments of Strymonikos gulf.

terrestrial/biogenic retene and perylene are by far the dominant compounds, and S13, which seems to be affected by some petroleum residues.

p,p'-DDT and its metabolites p,p'-DDE and p,p'-DDD were present in the highest concentrations of all the organochlorine compounds. The sum of the concentrations of these compounds (_DDTs) ranged from 0.6 to 48.1 ng/g (Figure 4), but values higher than 10 ng/g were recorded only at stations S9, S10 indicating the importance of Strymon river in transporting these compounds. Similar DDTs values have been measured in other relatively non-polluted coastal Mediterranean areas [5].

Concentrations of PCBs (the sum of 15 congeners) were lower than those of DDTs, ranging between 0.09 and 3.0 ng/g. These concentrations are relatively low and indicate that no significant pollution from PCBs has occurred in the area. Hexachloro- substituted compounds (CBs 138, 153) dominated the congener distributions.

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MYTILUS GALLOPROVINCIALIS AS AN ENVIRONMENTAL INDICATOR OF METAL POLLUTION IN COASTAL AREAS OF E ADRIATIC

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Abstract

The isotopic composition of carbon and oxygen in carbonate, as well as the concentrations of 24 major, minor and trace elements in recent shells of *M. galloprovincialis* from 22 locations were analysed for the purpose of monitoring the environmental conditions along the entire Eastern Adriatic coast. Lower salinity and temperature in areas influenced by inflows of freshwater tributaries are reflected in lower $\delta^{13}C$ and $\delta^{18}O$ values of shell carbonates. Increased metal concentrations were observed in areas exposed to industrial and urban pollution sources.

Key words: Adriatic Sea,bivalve,metals

Introduction

Mollusc shells are considered to be a powerful tool for monitoring environmental conditions. The variability of shell element chemistry between individuals strongly influences the precision of environmental information inferred from shell composition, and therefore the relation of chemical parameters to the shell stable isotope profiles is of great value to obtain better insight into the environmental factors governing the distribution of metals in the shell (1). The aim of this work was to check whether bivalve shells are good environmental indicators of metal pollution of coastal waters of E Adriatic.

Materials and methods

Samples of M. galloprovincialis were taken at 22 sampling locations along the E Adriatic coast in October 1998 (Fig. 1). At each site, 5 samples ranging from 2.5 to 5.9 cm in length were collected.

For isotopic analysis, the aragonite and calcite layers of the shells were separated by careful grinding with emery paper. $\delta^{18}O$ and $\delta^{13}C$ of both layers were determined using a dual inlet Varian Mat 250 mass spectrometer. The carbonate was transformed into CO_2 by reacting with anhydrous H_3PO_4 at 55°C under vacuum. NBS 18 and NBS 19 were used as standards to report all isotopic signatures in ‰ relative to the V-PDB (2). Precision determined by repeated analyses of the working standard was better than ±0.05 ‰ for $\delta^{18}O$ and ±0.1 ‰ for $\delta^{13}C$. Multielemental analysis was performed at ACTLAB in Ontario, where concentrations of major (Ca, Na, Mg, Fe), minor (P, Mn, Ba) and trace elements (Ni, As, Sr, B, Cr, Cu, Pb, Zn, Li, Zr, Se, Te, Sn, Mo, Hg, Ag, Sb) of the bulk shells were analysed using ICP - MS. The accuracy of the analyses was checked using the MAG – 1 standard. The reproducibility was sufficient for an analysis of spatial variations of these elements in the shells.

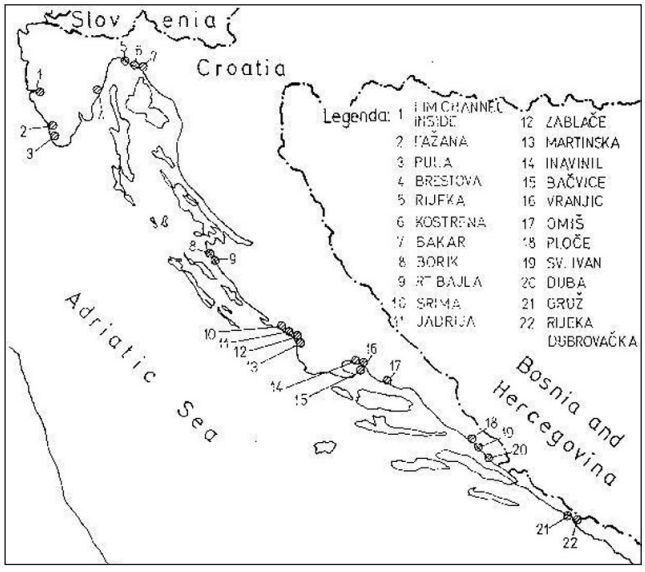

Figure 1: Sampling sites.

Results and discussion

Biogenic aragonite was systematically enriched by 0.15 ‰ in ^{18}O and by 1.07 ‰ in ^{13}C relative to calcite. The temperatures of excretion of both phases were calculated (3,4), ranging from 17.7 to 24.7°C for calcite and from 20.5 to 28.3°C for aragonite, which are in good agreement with the observed sea temperatures. According to the $\delta^{18}O$ and $\delta^{13}C$ values of shells, locations in the investigated area can be separated into three groups with respect to varying freshwater influence (Fig.2). Only a weak correlation was observed between δ values and metal concentrations. To prove these correlations, separate growth bands of the shells should be analysed (1). The highest concentrations of Mn, Ba, B, As and Ni were determined at sites of Omis, Zablace and Bacvice (sites 12, 15, 17), where both sewage sludge from cities, as well as contaminants from chemical and metallurgical industries are released to the coastal sea with poor or no pre-treatment. The high Mn concentration at Sv. Ivan (site 19) in the Neretva delta is due to the mining and metallurgical industry in the wider Mostar area in Bosnia and Herzegovina. Increased Pb, Zn and Cu are typical of industrial areas with the large ports of Pula, Rijeka and Gruz (sites 3, 5, 21). The results of preliminary monitoring showed that shells are good biomonitors for environmental conditions that can be successfully applied for monitoring urban and industrial pollution of coastal seas.

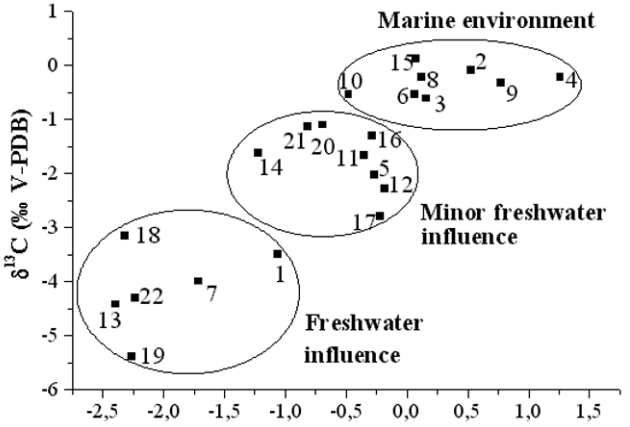

Figure 2: $\delta^{18}O$ vs. $\delta^{13}C$ of aragonite layer of the shells; grouping of the results is due to the varying freshwater influence.

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DETERMINATION OF VARIOUS SPECIES OF COPPER, ZINC AND CADMIUM IN THE GULF OF ELEFSIS, GREECE, USING DGT IN COMBINATION WITH DPASV

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Abstract

In this work we examined the speciation of dissolved Cu, Zn and Cd in seawater in the Gulf of Elefsis, Greece. We used two powerful techniques for determining the speciation of heavy metals in complex systems such as coastal seawater: the DGT (Diffusive Gradients in Thin films) assemblies and the DPASV (Differential Pulse Anodic Stripping Voltametry). With the use of DGTs we determine the labile dissolved fraction of heavy metals fixed on a chelex-100 resin 'in situ', while with DPASV we measured the kinetically labile fraction of metals which includes mostly inorganic species of these metals. From the difference of these determinations we may conclude that in the Gulf of Elefsis, the predominant fractions of labile dissolved Cu, Zn and Cd are complexed with organic ligands. In particular, more than 92% of DGT labile Cu, 79% of DGT labile Zn and 50% of DGT labile Cd were found to be DPASV inert.

Keywords: metals, speciation

Introducion

The determination of the various chemical species of trace metals in natural waters has been recognised as of particular importance for the understanding of their geochemical and biological behaviour, toxicity etc [1]. In this work the chemical speciation of dissolved copper, zinc and cadmium was studied throughout the Gulf of Elefsis, a geomorphologically very interesting and intensely industrialized embayment in the vicinity of Athens metropolitan area which has been a site thoroughly examined by our laboratory in the last 25 years [2, 3]. The speciation measurements were carried out by combining two powerful techniques: the DPASV (Differential Pulse Anodic Stripping Voltametry) and DGT (Diffusive Gradients in Thin films) which is a relatively new 'in situ' speciation measurement technique for dissolved trace metals which involves the use of polyacrylamide diffusive gels [4, 5].

Methodology

This research was carried out during the second half of 2000. Sea water samples were collected with GO-FLO polypropylene sampling bottles while at the same time a number of DGT assemblies were immersed at approximately 30 cm below the surface, for three consecutive days, at selected coastal sites identified as 'hot spots' through the MED-POL/UNEP monitoring programme at the Gulf of Elefsis (Figure 1). The water samples were filtered immediately after sampling through 0.45 μm Millipore membrane filters. Measurements of kinetically labile metal fractions were performed by using DPASV. The deposition potential applied for Cu was –0.45 V (Ag/AgCl) and for Cd and Zn -0.80 V and –1.2 V, respectively [6]. Metal concentrations were determined by using the 'standard addition' technique.

Recovery of the metals from each DGT assembly was obtained by using 1 ml nitric acid (supra pure). The concentrations of all metals (copper, zinc and cadmium) were measured in a flameless atomic absorption spectrophotometer (VARIAN SpectrAA 640 Z) equipped with a Zeeman background correction. The treatment of all samples was carried out inside a positive pressure chamber and all apparatus used were plastic very carefully cleaned.

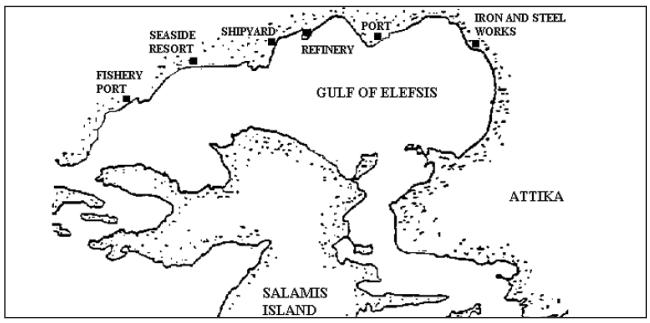

Figure 1 : Sampling stations at the Gulf of Elefsis

Results and discussion

It is clear that in the specific period and coastal stations studied, more than 92% of DGT labile Cu, 79% of DGT labile Zn and 50% of DGT labile Cd were DPASV inert corresponding mainly to metal complexed with organic ligands (Table 2).

Table 1 : Mean values of physical and chemical parameters at selected sampling stations

	Temperature (°C)	Salinity (psu)	pH	DOC[1] (mg/lt)
Iron and steel works	20	38.5	7.77	1.22
Port	20	38.7	7.85	1.12
Refinery	20	38.6	7.58	1.07
Shipyard	20	36.9	7.65	2.17
Seaside resort	20	36.7	8.06	1.10

[1] Dissolved organic carbon

Table 2 DGT and DPASV labile species of Cu, Zn and Cd at coastal sampling stations in the Gulf of Elefsis (in µg/lt)

	C_{DGT-Cu}	Cu'[1]	C_{DGT-Zn}	Zn'	C_{DGT-Cd}	Cd'
Iron and steel works	0.63	N.D.2	15.4	1.64	0.028	N.D.3
Port	7.20	N.D.	26.3	0.45	0.029	N.D.
Refinery	0.70	N.D.	11.9	2.49	0.010	N.D.
Shipyard	1.41	N.D.	20.8	2.40	0.022	N.D.
Seaside resort	0.66	N.D.	25.0	0.03	0.021	N.D.

[1] DPASV labile Cu
[2] Not detected, <0.05 µg/lt
[3] Not detected, <0.005 µg/lt

It is noteworthy that in coastal areas identified as 'hot spots' such as refineries, shipyards and iron and steel works the DPASV labile zinc fraction which corresponds largely to ions and ion pairs and therefore is easily bioavailable, is considerably higher than in other sites which do not receive direct input from land based pollution sources (Table 2).

In conclusion it is clear that the combined application in seawater of both techniques, DGT and DPASV, could help in determining in a relatively simple way the prevailing forms, species of trace metals in marine waters.

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ENVIRONMENTAL ASPECTS OF THE USE OF DEPLETED URANIUM ORDNANCE DURING THE KOSOVO CONFLICT

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Abstract

The NATO airstrikes on Kosovo (Yugoslavia) early in 1999 have caused considerable environmental damage to the broader region. Increased public concern regarding the dumping of unspent ordnance and the use of depleted uranium munitions during military operations, has resulted in several field campaigns by international organizations aimed at assessing possible risks to humans and the environment. Preliminary investigations have shown that some components of DU ordnance contain trace amounts of transuranics and fission products indicating the use of reprocessed uranium in the manufacture of these components. This study gives a summary of publicly available information on the environmental aspects of DU expenditure in Kosovo and the Adriatic region.

Keywords – Adriatic Sea, diseases, radioactivity, trace elements

Introduction

The 11 weeks of North Atlantic Treaty Organization's (NATO) airstrikes in Kosovo (Yugoslavia) seem to have caused considerable environmental damage. A large number of industrial facilities were reportedly attacked and destroyed. As a consequence of this, significant amounts of hazardous chemicals have been released into surface waters, ground waters, air and soil, affecting the wider Balkans region. However, these transboundary pollution events have caused less public concern than subsequent admittance that the alliance had used depleted uranium (DU) ammunition both in Kosovo and during the earlier military operations in Bosnia and Herzegovina. Reports in public media have often echoed anger and dismay regarding the use of DU, suggesting that depleted uranium ordnance contributed to the "Balkan syndrome". In contrast, government contractors and the army itself have issued a series of reports and studies suggesting that depleted uranium represents no real threat to health and safety. Moreover, serious concerns were raised over the possibility that ordnance, mainly aviation bombs, dumped in various parts of the Adriatic sea by aircraft returning to their bases in Italy, contained depleted uranium.

In this study, we have surveyed publicly available reports in an attempt to put these apparent controversies into perspective and summarize the environmental aspects of DU deployment during the NATO air campaign in Yugoslavia (Kosovo).

Depleted uranium and use of DU-ammunitions in Kosovo

Depleted uranium (DU) is a by-product (or waste) of the enrichment process used in the production of fuel rods for nuclear power plants and nuclear powered ships, as well as from the production of highly enriched uranium (U-235) for nuclear weapons. Chemically and toxicologically DU behaves in the same way as the metallic form of natural uranium. Fine particles of the metal ignite easily, producing oxides. According to technical literature (referenced in 2), uranium in a DU projectile upon impact vaporizes in the form of a uranium oxide aerosol, which presents an additional health risk to personnel within the armored vehicle, as well as rescue teams. DU particles released as aerosols and dust may be carried by wind over considerable areas, and will eventually settle on the ground surface. It is dispersed in soil, particularly in areas of high rainfall. Cultivation of contaminated soil and use of contaminated water and food may pose health risks, but these are expected to be limited. Radiochemical toxicity would be expected to be the main health concern, rather than external radiation exposure (3).

During the spring 1999 airstrikes in Yugoslavia (Kosovo), NATO fired some 31.000 depleted uranium shells (4). The alliance has recently released detailed grid locations where their aircraft engaged targets in Yugoslavia and earlier in Bosnia 1993-1995 (5,6). Reportedly all DU ordnance was 30mm aircraft-cannon munitions fired from A-10 "Warthog" anti-tank combat aircraft and AH-64 Apache helicopters used in air-to-ground missions. The ammunition was of the *PGU-14/B API Armor Piercing Incendiary* type. It consists of a lightweight body with a subcalibre high-density DU penetrator weighing 0.3 kg. In addition to its penetrating capability, the DU is a natural pyrophoric material which enhances incendiary effects. A total of 10 tons of this ammunition still litters various parts of the area, causing concerns about environmental contamination and human health risks.

Following an apparent policy of information transparency and full disclosure, much data including maps of targeted areas have been made publicly available and accessible on the NATO websites (4). According to available reports (4), aviation bombs (both smart weapon systems and "dumb" bombs) used in operations against unarmored ground targets (military installations, industries and other structures) contained no DU components. Undeployed ordnance was discarded in waters of the Adriatic sea by aircraft returning to their bases (mainly in Italy, and carrier vessels stationed in the Adriatic).

Results of analyses on samples from depleted uranium sites in Kosovo

UNEP's Depleted Uranium Assessment Group, during its field assessment mission in November 2000, visited 11 of the 112 sites that were identified as being targeted by DU ordnance. Altogether, 340 samples were collected for analysis in 5 european laboratories. The samples include 247 soil samples, 30 vegetation samples, 10 smear tests, 8 parts of munition parts (sabots and penetrators). The final report is scheduled for publication in March 2001, but preliminary reports state that in addition to the "expected" uranium isotopes, parts of DU ordnance contained U-236 (0.0028 % of the total uranium content) and traces of other fission products, implying that these components were made from reprocessed uranium (7). Following this disclosure, a report by the Department of the Army of the United States of America, dated January 2000, was made public (8). The report states that DU components used by the US armed forces may contain trace amounts of transuranics (TRU) and Tc-99. The TRU may contain Am-241, Np-237, Pu-238, Pu-239 and Pu-240. However, the TRU contamination of DU components contributed an additional 0.8 % to the radiation dose from the DU itself, considering this a very low radiological hazard associated with the primary DU material.

Conclusions

Ammunition containing DU components leave behind a long-lasting contamination on the battlefields, which is incompatible with civil radiation protection norms. Transuranium elements and other fission products possibly contaminating DU ordnance cause additional concerns over risks to the health of humans and the environment.

Ordnance dumped in the Adriatic Sea reportedly contained no DU munitions. An understanding of the biogeochemical uranium cycle in the marine environment provides no apparent reason for concerns regarding radiological hazards of DU - even if moderate quantities of DU ordnance were dumped in the sea, this would not be the cause of hazardous uranium levels in the marine environment

Complete reports with full disclosure of the relevant facts regarding DU deployment in the Balkans and in the Adriatic region will be welcomed by the scientific community and civilian population living in affected regions.

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MONITORING OF REACTIVE MICROPARTICLES DISTRIBUTION IN THE NORTHERN ADRIATIC SEA

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Abstract
The purpose of this study is monitoring of reactive microparticles in seawater and design of an early warning system for critical evolution in particle aggregation. Dropping mercury electrode was used as the adhesion sensor for the monitoring of microparticles distribution in the seawater samples from the Northern Adriatic Sea. The technique we used was chronoamperometry of oxygen reduction at the potential of maximal attraction. *Dunaliella tertiolecta* cells were used as model particles.

Keywords: Adriatic Sea, electrochemistry, monitoring, particle aggregation

Introduction

A major characteristic of a seawater sample containing colloidal particles is its intrinsic instability due to continuing aggregation processes and microbial activity. Sampling and sample processing should be shortened as much as possible (1). The electrochemical particle analysis, being direct, rapid and simple, meets these requirements and also offers the possibility of single particle analysis (2,3). Electrochemical adhesion sensor enables direct and simple recording of attachment signals (millisecond duration) of reactive particles in seawater samples over a time interval. A simple biological standard (a cell suspension) can be used for calibration (4).

Material and methods

The electrochemical technique is based on the chronoamperometric measurement of single events and attachment and spreading of surface-active particles at the dropping mercury electrode/seawater interface. This is a modification of a widely used polarographic technique for measurements of surface-active organic matter in aquatic environment.

Laboratory culture of the marine nanoflagellate *Dunaliella tertiolecta* Butcher was used as a source of model particles. *Dunaliella tertiolecta* cells (6-10 μm) do not possess a cell wall, only a flexible outer membrane, and because of that behave as fluid particles.

Results and discussion

Adhesion of reactive organic microparticles at the electrode result in attachment signals of millisecond duration. Characteristic electrical signals appearing as sharp spikes on current-time curves are the result of random attachment of surface-active particles. The attachment signals appear at irregular intervals and with different amplitudes. The amplitudes of attachment signals reflect particle size, while the average signal frequency is directly proportional to the particle concentration in a sample. To interpret the recorded I-t curves in terms of particle abundance in the sample we conducted the series of calibrating experiments using suspensions of *Dunaliella tertiolecta* cells in seawater under identical experimental conditions. The plots of frequency of attachment signals as function of cell density are used as calibration curve. The calibration curves are used to determine the abundance of surface-active particles (≥ 1 μm).

Monitoring of reactive particle abundance in Northern Adriatic was undertaken after the dramatic event of massive macroaggregation in summer 1997 (5). Figure 1a presents the depth distribution of microparticles at an off-shore station in Northern Adriatic in July 1997 and in the same period 1998 (6). The range of particle abundance in 1997 is an order of magnitude higher than in the same period during summer 1998 (figure 1b).

Maximum microparticle concentration in seawater before the phenomenon reached $5x10^7$/l which can be taken as a critical treshold for the onset of the macroscopic phase formation (3).

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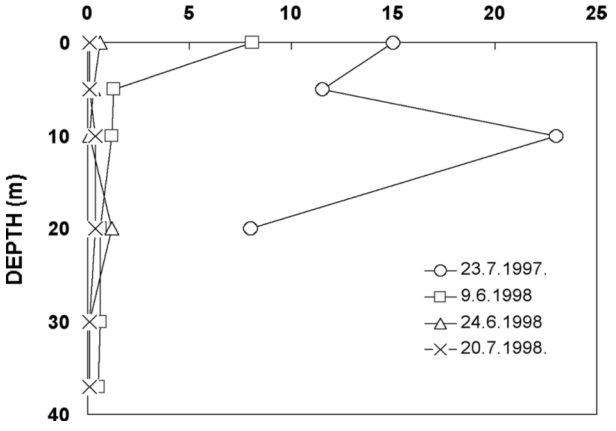

Figure 1a. Depth distribution of microparticle concentration (N) in seawater samples from a Northern Adriatic station (SJ 107; 45°02.8' N, 13°19.0' E) (5).

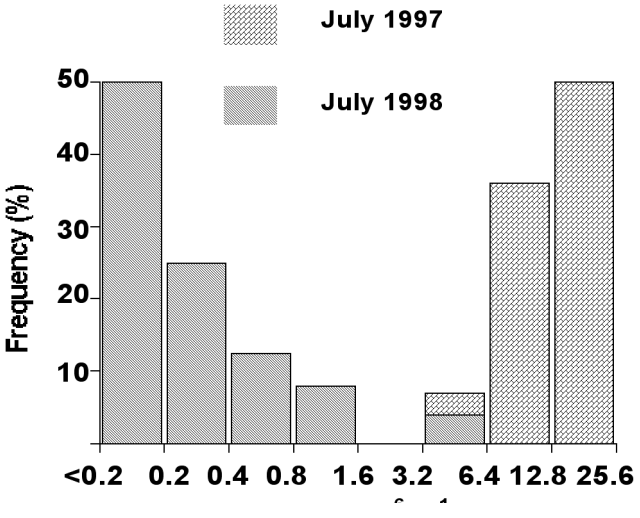

Figure 1b. Comparision of frequency distributions of organic microparticle concentrations in Northern Adriatic in summers of 1997 and 1998. The seawater samples were taken at standard depths at six equidistant stations along the transect Rovinj (Istrian coast) - the Po delta (5).

TRACE METAL CONCENTRATIONS IN EDIBLE FISHES FROM IZMIR BAY, EASTERN AEGEAN

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Abstract

The levels of Hg, Cd, Pb were determined in edible fish of Izmir Bay in the framework of a 'Izmir Bay Marine Research Project' during 1996-1998 supported by Izmir Metropolitan Municipality. The concentrations of trace metals found in fish varied for Hg: 5.2-829, Cd: 0.10-10 and Pb: 7.1-918 μg kg^{-1} fresh weight in Izmir Bay. There was no significant seasonal variation in trace metal concentrations. The relationships between Hg concentration and fork length were significant in *Mullus barbatus, Pagellus erythrinus* and *Merluccius merluccius* in the Bay. Trace metal levels were lower than the results in fish tissues reported from polluted areas of the Mediterranean Sea.

Key words: Mercury, cadmium, lead, fish, Eastern Aegean

Introduction

Izmir Bay is located in the western part of Turkey and surrounded by a densely populated community. This bay has been divided into three sections (Outer, Middle and Inner) according to its physical characteristics as they relate to the different water masses. Monitoring of Hg, Cd and Pb levels in edible fishes (*Mullus barbatus, Pagellus erythrinus, Merluccius merluccius, Diplodus annularis, Solea vulgaris*) was conducted in Izmir Bay during 1996-1998. A number of studies have been carried out on the concentrations of trace metals in the Bay during a year with a few different species (1-3) but no long-term data are available on trace metal concentrations in the Bay during a 3 year period. The main aim of this study was to monitor levels, temporal variability and distribution of trace metals in edible fishes of Izmir Bay.

Material and Methods

The locations of sampling areas are given in Figure 1. Biota samples were collected by trawling and approximately 5-7g of fish muscle was digested with HNO_3:$HClO_4$ in microwave digestion system (4). All the analyses were performed by Varian AAS. Hg concentration was measured by cold vapor technique and Cd, Pb were determined by graphite furnace and background corrections were used as required. The detection limits were Hg:0.05 μgl^{-1}, Cd:0.10 μgl^{-1}, Pb:0.10 μgl^{-1}. Intercalibration fish homogenate samples (from IAEA, Monaco) were used as a control for the analytical methods. The values obtained (in μg g^{-1} dry wt.) for the analysis of six replicates of this sample

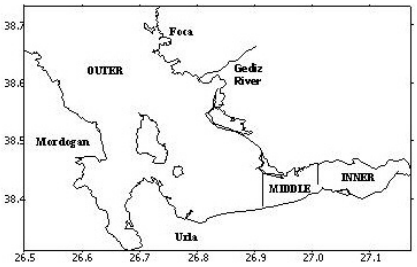

Fig. 1. The location of sampling sites.

were as follows: Hg (certified 2.69±0.17; measured 2.77), Cd (certified 0.015±0.012; measured 0.018), Pb (certified 0.074±0.015; measured 0.064).

Results and discussion

The concentrations of trace metals found in biota varied, with Hg ranging from 12-829 and 5-315, Cd from 0.10-10 and 0.44-3.1 and Pb from 14-918 and 7-713 μg kg^{-1} fresh weight in the Outer and Middle Bays, respectively (Table 1). High levels of trace metals were measured in *Pagellus erythrinus* for Hg and Cd, and in *Mullus barbatus* for Pb in the outer part of the Bay. Minimum values were found in *Merluccius merluccius* (Hg), *Mullus barbatus* (Cd) and *Diplodus annularis* (Pb) in the Outer Bay. The levels were significantly lower in *Solea vulgaris* than the other species from the Middle and Inner Bays. There was no significant seasonal variation in trace metal concentrations. The relationship between Hg concentration and fork length was significant in *Mullus barbatus* (R=0.491), *Pagellus erythrinus* (R=0.673) and *Merluccius merluccius* (0.440). Cd and Pb concentrations in muscle tissue showed no relation to fork length. A person consuming 2, 150 and 10 meals per week of edible fishes in the human diet would reach the tolerable weekly intake of Hg, Cd and Pb, respectively (5,6). As a general conclusion, the values are higher than the reported mean concentration of trace metals in marine organisms from the Aegean and Mediterranean Sea (7-9). However, the levels of trace metals determined in the different fish from Izmir Bay are considerably lower than those in polluted areas of the Mediterranean Sea (10).

Table 1. Trace metal concentrations in fish from Izmir Bay (mg kg-1 fresh wt.)

Sampling location	Organism	Length (mm)	Number of sample	Hg	Cd	Pb
06/96	Mullus barbatus	125-153	20	259	2.4	918
Outer	Pagellus erythrinus	250-280	4	829	2.6	83
	Merluccius merluccius	260-295	2	65	1.9	155
	Diplodus annularis	130-170	10	220	2.1	14
	Solea vulgaris	159-230	4	159	1.6	203
Middle	Merluccius merluccius	190-386	2	92	2.4	713
	Diplodus annularis	105-142	8	315	1.9	7.1
	Solea vulgaris	199-210	3	68	1.8	388
Inner	Solea vulgaris	156-171	3	17	2.2	97
10/96 Outer	Mullus barbatus	118-153	10	182	0.13	125
	Diplodus annularis	118-129	10	162	0.16	205
	Solea vulgaris	158-182	3	17	0.41	46
Middle	Solea vulgaris	157-188	4	22	0.44	115
01/97 Outer	Mullus barbatus	110-150	19	94	0.93	209
	Mullus barbatus	150-165	6	77	0.53	39
	Pagellus erythrinus	150-230	6	263	0.21	150
	Merluccius merluccius	260-295	2	53	0.25	17
	Diplodus annularis	135-170	10	370	1.0	30
04/97 Outer	Mullus barbatus	144-175	4	66	1.9	29
	Pagellus erythrinus	141-197	6	181	3.2	146
	Merluccius merluccius	387	1	96	4.0	455
	Diplodus annularis	126-160	10	91	4.5	175
Inner	Solea vulgaris	170-205	3	7.7	2.3	270
07/97 Outer	Mullus barbatus	111-143	10	87	3.5	780
	Mullus barbatus	206	1	399	5.7	943
	Pagellus erythrinus	245-270	2	316	10	376
	Merluccius merluccius	365-384	4	27	1.5	431
	Diplodus annularis	118-145	20	92	1.7	697
Middle	Diplodus annularis	101-143	9	74	1.9	169
	Solea vulgaris	161-246	12	5.2	1.2	364
10/97 Outer	Mullus barbatus	163-184	10	345	1.5	120
	Mullus barbatus	128-162	8	75	2.0	349
	Pagellus erythrinus	151-218	6	369	1.2	58
	Merluccius merluccius	346-444	5	53	2.0	120
	Merluccius merluccius	221-285	10	12	1.6	315
	Diplodus annularis	106-143	10	285	1.0	428
Middle	Solea vulgaris	157-173	4	5.2	1.3	110
Inner	Solea vulgaris	159-224	4	9.5	1.1	217
01/98 Outer	Mullus barbatus	150-160	10	84	0.93	16
	Pagellus erythrinus	127	1	144	5.4	89
	Pagellus erythrinus	207	1	419	0.66	28
	Merluccius merluccius	313-361	9	17	0.48	240
	Diplodus annularis	109-134	20	164	0.90	175
	Solea vulgaris	220	1	46	1.2	78
Inner	Solea vulgaris	130-140	2	11	3.2	341
04/98 Outer	Mullus barbatus	130-161	8	83	1.2	359
	Mullus barbatus	114-139	10	27	0.53	256
	Pagellus erythrinus	268	1	175	0.77	88
	Merluccius merluccius	284-320	3	37	1.1	375
	Diplodus annularis	127-153	10	184	0.58	326
10/98 Outer	Mullus barbatus	140-157	10	41	0.10	44
	Mullus barbatus	168-186	9	285	0.88	478
	Pagellus erythrinus	147-152	3	279	2.2	203
	Pagellus erythrinus	186-201	2	342	0.61	48
	Merluccius merluccius	251-273	2	34	0.58	116
	Diplodus annularis	117-144	10	174	1.2	594
	Solea vulgaris	250	1	212	5.2	220

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BENTHIC FLUXES OF NUTRIENTS IN THE MIDDLE AND SOUTHERN ADRIATIC SEA

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Abstract

Benthic fluxes of nitrogen-, phosphorus- and silica salts were determined during the period June 1997 – October 2000 in the area of middle and south Adriatic Sea. The established fluxes (mmol m^{-2} day^{-1}) were in the range from 0.16 to 1.97 for silicate; -0.038 to 0.215 for phosphate and –1.50 to 2.88 for the sum of nitrate, nitrite and ammonia. Temporal and spatial flux variation showed increased values both in the coastal zone and during the warm period of year.

Keywords: Adriatic Sea, Benthic-Pelagic coupling, Geochemical cycles

Introduction

In the last decades benthic nutrient fluxes have been intensively studied in major oceans as well as in many coastal areas of the world. On a global scale continental slopes have been found to be the major deposition centres of organic matter and areas of intensive remineralisation (1), while in coastal areas the nutrient flux can be an important source of nutrients for primary production (2). The study of benthic nutrient fluxes in the Adriatic Sea has been limited so far to the northwestern part of the Adriatic (3).

Material and methods

Flux measurements were performed during June 1997 – October 2000 at 12 stations in the Adriatic Sea: 3 stations were located in eutrophic bays and estuaries (EB: 20-38 m), 5 in island channel waters (CW: 38-82 m), and 4 in the open sea area (OS: 100-1010 m). Sediment sampling (with overlying water) was performed by gravity corer (Plastic tube, i.d. = 6 cm, l = 100 cm) in triplicate, while bottom-layer seawater was sampled by a Niskin sampler. After the exchange of sediment overlying water with collected bottom water, sediment samples were incubated on board at the bottom layer temperature for 9-12 h. The development of concentration gradients above the sediment surface was prevented by water circulation using a peristaltic pump. Nutrient concentration changes during the incubation were determined by standard photometric methods using an AutoAnalyzer II (4).

Results and discussion

Obtained average nutrient fluxes (J) and related standard deviations (SD) for the investigated areas are given in Table 1. Total nitrogen (ΣN) in Table 1 denotes the sum of inorganic nitrate, nitrite and ammonia fluxes. From Table 1 it is obviously that the silicate and ΣN fluxes increase from the open sea area to the coastal zone, while the phosphate flux is approximately equal in all the areas studied. Comparing the values obtained with established fluxes in other regions, fluxes in the Adriatic are in the same order of magnitude or lower than elsewhere.

Table 1. Average nutrient fluxes in different areas of the Adriatic Sea.

Area	J ± SD (mmol m^{-2} day^{-1})		
	SiO_4^{4-}	PO_4^{3-}	ΣN
EBE	1.45±0.65	0.027±0.051	0.15±0.64
CW	1.02±0.53	0.030±0.054	0.22±0.70
OS	0.87±0.47	0.026±0.050	-0.09±0.59

Temporal changes in benthic fluxes were also evident in all areas, but the most prominent are in the EB area. By spliting a year into the warm period from May to October (WPY) and the cold period from November to April (CPY), the ratios of $J_{CPY} : J_{WPY}$ for this area are 1 : 1.30 for silicate, 1 : 1.19 for phosphate and 1 : 2.64 for the ΣN - flux. The spatial and temporal variations of benthic flux can be explained by an existing trophic gradient from the open sea to the coastal zone (5) as well as by temporal fluctuations of particulate organic matter density in the water column.

Measurements of redox conditions in the sediments showed the strong influence of redox potential on the phosphate flux. Extreme situations were found at two coastal stations where the phosphate flux from sediments with positive Eh values was tenfold lower than the flux from sediments with negative redox potentials. This phenomena probably can be explained by the buffering properties of Fe (III) hydroxides in oxidized surface sediments (6). Beside an increase from the open sea to the coast (Table 1), the ΣN flux also showed a changing composition of nitrogen species (Fig. 1).

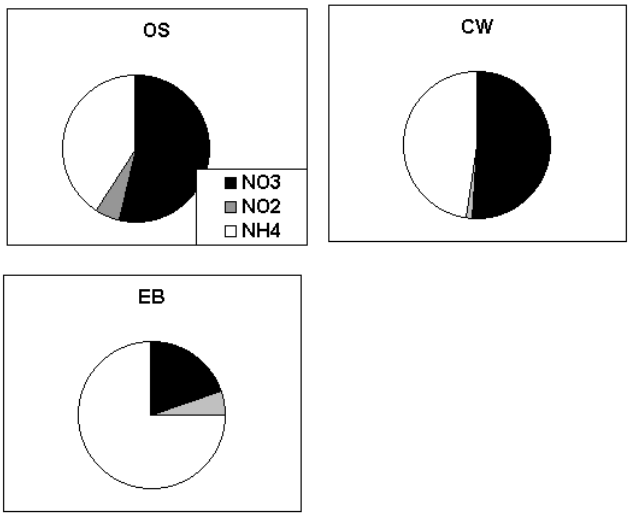

Figure 1. Partial nitrate, nitrite and ammonia flux in different areas of the Adriatic Sea during the warm period of year

In the open sea area (OS) the nitrate flux dominates in the ΣN-exchange throughout the year, while in the coastal zone (EB, CW) the ammonia flux is more important, especially during the warm period of year. As for the reason for nitrate dominated ΣN-exchange in the open sea area (100 – 1010 m), it is assumed that, due to reduced oxygen saturation in the bottom layer, nitrate in this area is an important electron – acceptor for the oxidation of organic matter in the sediment.

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OCCURENCE OF DIMETHYLMERCURY IN THE POLLUTED PART OF KASTELA BAY (EASTERN ADRIATIC COAST)

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Abstract

Dimethylmercury $(CH_3)_2Hg$, a highly volatile mercury compound, was initially detected in sediments and seawater samples of the Kastela Bay (Eastern Adriatic coast) in the vicinity of a chlor-alkali plant. An adequate sampling procedure followed by immediate measurements enabled the detection of dimethylmercury. Prior to measurements by a cold vapour atomic absorption spectrometry, the dimethylmercury $(CH_3)_2Hg$ was preconcentrated in a cryogenic trap, eluated and pyrolitically decomposed on a gold wire, with the detection limits of 0.005 ng L^{-1} and 0.002 ng g^{-1} in seawater (1000 ml of the water sample) and sediment (10 g of the sediment sample), respectively. The dimethylmercury was found in sediment and seawater samples between 0.01 and 0.15 ng g^{-1} and 0.02 and 0.12 ng L^{-1}, respectively, only in a very limited area of the Kastela Bay. The results obtained indicate that dimethylmercury occurs under very specific biogeochemical redox conditions which probably lead to a decrease of a high content of total mercury from the sediments which has been accumulating for years in such a highly polluted area of the Adriatic Sea.

Key words: mercury, sediments, sea water, Adriatic Sea

Study area

Kastela Bay is situated in the central part of the eastern Adriatic coast in the vicinity of the town of Split (Fig.1). It is the largest bay in central Dalmatia with the surface of $61x10^6$ m (14.8 km in length and 6.6 km in width) and the volume of $1400x10^6$ m^3. The contamination with mercury discharged from a PVC plant endangered this aquatorium for 40 years (the plant was shut down in 1990) (1).

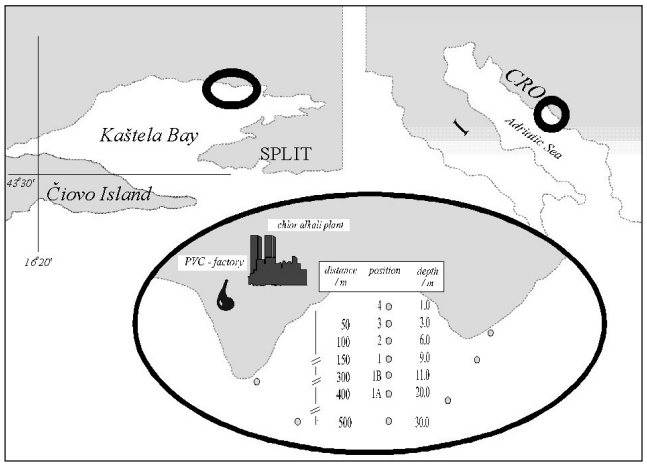

Figure 1. Map of sampling area

Sampling and analysis

The sediment and water samples were collected by a diver using an acrylic glass tube (20 cm long and 6 cm i.d.) and one-liter Pyrex glass bottles, respectively. The analyses were performed 2 to 3 hours after the sampling (2-4).

Dimethylmercury was analysed in unfiltered seawater samples and in wet and total sediment samples collected from the surface (0 cm) and a depth of 10 cm in the sediment column. After the separation from liquid and solid samples, preconcentration in a cryogenic trap, elution and pyrolitical decomposition on a gold wire, dimethylmercury was measured using a cold vapour atomic absorption spectrometry (5, 6). In each sample a known amount of a standard dimethylmercury solution was added for the calibration purposes.

Results and discussion

Fig.1 illustrates that dimethylmercury was detected only in a very restricted area of the Kastela Bay (about 400 m from the coast) in the vicinity of the outlet of the chlor alkali plant which was shut down in 1990. Dimethylmercury in water was detected at sites 1 and 4, whereas in sediments, mostly it was found at site 1. The only exception was site 4 (shallow waters), where, the highest concentration of total mercury was found in sediments (up to 85 mg kg^{-1}).

The concentrations of dimethylmercury and monomethyl mercuy in water were in the range between 0.02 and 0.120 ng L^{-1} and 1 and 4 ng L^{-1}, respectively. The concentration of total mercury at the same locations ranged between 200 and 400 ng L^{-1}. However in unpolluted waters of the Adriatic Sea normally range between 0.05 and 5 ng L^{-1}. Recovery efficiency of dimethylmercury for brackish and seawater is between 94 and 106%.Dimethylmercury concentrations in the sediment column (0 cm and 10 cm) are in the range between 0.02 and 0.150 ng g^{-1}. The values are significantly higher at the surface (several orders of magnitude) than those at a depth of 10 cm. At the same locations the concentrations of total mercury in sediments are in the range from 10 000 ng g^{-1} (location 1) to 85 000 ng g^{-1} (location 4). The concentrations of monomethyl mercury in sediments ranged between 5 and 18 ng g^{-1} (location 1).

Table 1. Dimethylmercury concentration in the seawater (ng L^{-1})

	Date of sampling and determination			
Position	6.05.1997.	7.07.1997.	10.07.1997.	25.07.1998.
1a	N.D.	N.D.	N.D.	N.D.
1b	N.D.	N.D.	N.D.	N.D.
1	0.04 0.04	0.03 0.03	0.04 0.04	0.05 0.04
2	0.050 0.04	0.02 0.02	0.04 0.06	N.D.
3	0.120 0.100	0.02 0.04	0.04 0.05	0.03 0.03
4	N.M.	N.M.	0.05 0.05	0.06 0.06

N.D. not detected; N.M. not measured

Table 2. Dimethylmercury concentration in the sediment (ng g^{-1})

	Date of sampling and determination			
6.05.1997.	7.07.1997.	10.07.1997.	25.07.1998.	
Position	(0 cm 10 cm)	(0 cm 10 cm)	(0 cm 10 cm)	(0 cm 10 cm)
1a	N.D.	N.D.	N.D.	N.D.
1b	0.02 0.003	0.01 0.005	0.03 0.006	0.005 N.D.
1	0.14 0.030	0.08 0.01	0.150 0.007	0.005 N.D.
2	N.D.	N.D.	N.D.	N.D.
3	N.D.	N.D.	N.D.	N.D.
4	N.D.	N.D.	N.D.	0.002 N.D.

N.D. not detected

Conclusion

The modified method for the determination of highly volatile mercury compounds in the pico and femto concentration range has successfully been tested on natural water and sediment samples. The presence of harmless, volatile and hydrophobic dimethylmercury in the sediments and water column of Kastela Bay, leads to the natural removal of the total of mercury and consequently selfpurification of the polluted part of the Bay.

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ATMOSPHERIC INPUT OF RADIONUCLIDES TO THE NORTHWESTERN MEDITERRANEAN SEA

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Abstract

^{137}Caesium, ^{238}Pu, ^{239,240}Pu and ^{241}Am were determined in total monthly deposition (wet + dry) to elucidate the delivery behaviour of anthropogenic radionuclides into the northwestern Mediterranean Sea. The results show that the concentrations of ^{239,240}Pu in precipitation were similar to those found in Mediterranean surface water while the concentrations of ^{241}Am in precipitation were higher. The annual contribution of transuranics from the atmosphere to northwestern Mediterranean was much lower than their mean annual loss. However, many particles loaded in precipitation in February and August probably played important roles in enhancing the scavenging of transuranics in the northwestern Mediterranean Sea.

Keywords: radionuclides, precipitation, atmosphere, Mediterranean Sea

Introduction

Atmospheric input of anthropogenic radionuclides to the ocean has been regarded as one of the most important of the various input sources such as river input, discharges from nuclear industrial activities and accidents, etc. For this reason, in order to study the fluxes of anthropogenic radionuclides, their biogeochemical behaviour and the high scavenging rates of transuranics in the Mediterranean Sea, as well as for monitoring possible accidental discharges of radionuclides to the sea, we regularly collected rainwater (wet and dry deposition) to estimate the amounts of delivery and to measure the concentrations of anthropogenic radionuclides.

Methods and Materials

Precipitation was collected monthly in a 2.35 m^2 plastic container placed on the roof of the building which houses IAEA-MEL in Monaco. Preconcentration of radionuclides in rainwater, radiochemical separation, purification steps and α-spectrometry measurements have been described elsewhere [1].

Results and discussion

Radionuclide concentrations in precipitation and monthly deposition rates are presented in Table 1 and Figure 1, respectively. The monthly deposition of radionuclides into the northwestern Mediterranean Sea shows that a significant amount was delivered from September to October when high precipitation rates were observed. A strong spring peak observed in previous studies [2] was not observed in the recent study; only a small sub-peak was noted at this time. The annual delivery of anthropogenic radionuclides into the Sea was calculated to be 0.51 ± 0.06 mBq m^{-2} for ^{238}Pu, 16.5 ± 0.4 mBq m^{-2} for ^{239,240}Pu, 6.8 ± 0.4 mBq m^{-2} for ^{241}Am and for ^{137}Cs 1.17 ± 0.12 Bq m^{-2}. These amounts correspond to 8% for ^{238}Pu, 6% for ^{239,240}Pu and 32% for ^{241}Am of those measured previously by Thein *et al*. [2] in Monaco during 1978-79.

These results demonstrate that the transport of anthropogenic radionuclides from the stratosphere to the troposphere and then to the sea, which was observed previously, has been replaced by resuspension of radionuclides from soil and their wash-out from air to seawater. Therefore, at present, delivery patterns of radionuclides are dependent on the amounts of precipitation. The recent annual discharges of radionuclides to the Mediterranean Sea through the adjacent rivers are poorly known and only approximate data and gross activities have been reported [3, 4]. If we assume that the same amounts of radionuclides as estimated by Fukai *et al*. [3] are discharged into the Mediterranean Sea (in reality, the present amounts should be lower), the observed deposition amounts of ^{239,240}Pu and ^{241}Am are slightly higher than annual discharges by rivers. The observed deposition amounts are only 4% for ^{239,240}Pu and 5% for ^{241}Am of the mean annual transuranic loss in surface waters measured in the northwestern Mediterranean [5]. Therefore, the total inputs from both the atmosphere and rivers are less than 10% of the annual loss in surface water of the northwestern Mediterranean.

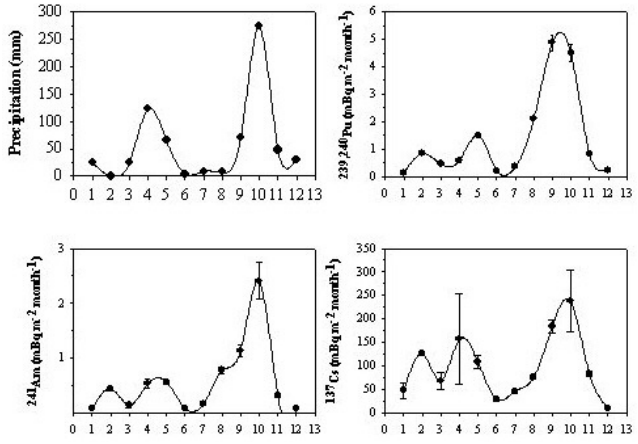

Fig. 1. Monthly deposition (mBq m^{-2} month^{-1}) of radionuclides and precipitation (fallout) into northwestern Mediterranean Sea, 1999.

Table 1. Concentrations and activity ratios of anthropogenic radionuclides in precipitation over Monaco, 1999.

Month	Precipitation (mm)	^{238}Pu (μBq L^{-1})	^{239,240}Pu (μBq L^{-1})	^{241}Am (μBq L^{-1})	^{137}Cs (μBq L^{-1})
January	25	1.4 ± 0.3	4.9 ± 0.7	3.6 ± 0.7	1.9 ± 0.7
*February	-	116 ± 31	3300 ± 180	1780 ± 130	126 ± 1
March	25	2.1 ± 0.6	18 ± 2	5.8 ± 1.6	2.7 ± 0.7
April	123	0.4 ± 0.2	4.7 ± 0.7	4.4 ± 0.7	1.3 ± 0.8
May	65	0.5 ± 0.1	23 ± 1	8.7 ± 0.7	1.7 ± 0.2
June	3.8	2.3 ± 0.6	530 ± 30	23 ± 2	7.4 ± 1.0
July	8.3	1.3 ± 0.3	42 ± 2	21 ± 2	5.6 ± 0.5
August	7.5	7.4 ± 1.5	280 ± 10	105 ± 8	10 ± 1
September	70	1.4 ± 0.6	70 ± 4	16 ± 1	2.6 ± 0.2
October	275	-	16 ± 1	8.8 ± 1.2	0.9 ± 0.2
November	48	2.6 ± 0.4	17 ± 1	6.7 ± 0.8	1.8 ± 0.1
December	30	0.2 ± 0.1	7.0 ± 0.7	2.8 ± 0.3	0.29 ± 0.04

Month	Precipitation (mm)	^{238}Pu/ ^{239,240}Pu	^{241}Am/ ^{239,240}Pu	(^{239,240}Pu/^{137}Cs)* 1000
January	25	0.286 ± 0.081	0.73 ± 0.17	2.6 ± 1.0
*February	-	0.035 ± 0.010	0.54 ± 0.05	26.3 ± 1.5
March	25	0.119 ± 0.036	0.33 ± 0.10	6.6 ± 1.9
April	123	0.089 ± 0.046	0.93 ± 0.20	3.7 ± 2.4
May	65	0.023 ± 0.005	0.38 ± 0.03	14 ± 2.0
June	3.8	0.044 ± 0.011	0.44 ± 0.04	7.1 ± 1.0
July	8.3	0.031 ± 0.008	0.49 ± 0.04	7.5 ± 0.7
August	7.5	0.026 ± 0.006	0.37 ± 0.03	28 ± 2
September	70	0.021 ± 0.009	0.23 ± 0.02	26 ± 2
October	275	-	0.54 ± 0.08	19 ± 5
November	48	0.155 ± 0.025	0.39 ± 0.05	10 ± 1
December	30	0.034 ± 0.017	0.40 ± 0.06	24 ± 4

** Dry deposition (no rain): values are in μBq*

The activity ratios of ^{238}Pu/^{239,240}Pu show that plutonium in total deposition originates mainly from global fallout. Noticeable exceptions are in January, March and November and the high deviations from the global fallout ratio (0.024) for these months will require careful interpretation when additional results become available. The ^{241}Am/^{239,240}Pu ratios (weighted mean 0.38), do not reveal any signature of a special input source compared to that of global fallout (0.37). The observed mean activity ratio of ^{239,240}Pu/^{137}Cs is 0.015. When taking decay correction into account, our result is in good agreement with that (0.023) of Thein *et al*. [2].

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SULPHUR GEOCHEMISTRY IN ORGANIC-RICH RECENT SEDIMENT (MAKIRINA BAY, CROATIA)

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Abstract

The concentration and speciation of sedimentary sulphur, as well as sulphate and sulphide in pore water in the organic-rich sediment of Makirina Bay were studied. The most abundant sedimentary S species is disulphide (predominantly pyrite) comprising up to 85% of total S, and in some horizons organosulphur compounds (S_{org}), whereas sulphate is much lower. Isotopic signatures of sedimentary sulphide and S_{org} indicate that sulphate reduction is the governing process in the S-geochemistry, along with syngenetic pyrite and S_{org} formation.

Keywords: sediments, sulphur, speciation

Introduction

Pyrite and S_{org} compounds are major end-products of the S cycle in anoxic sediments. The reaction rates of S_{org} are slower that those of pyrite formation. Delayed S_{org} formation is suggested by enrichment of bulk organic sulphur in ^{34}S relative to co-existing pyrite [1]. Active incorporation of dissolved sulphide into the humic fraction was observed in salt marsh sediments, representing over 50% of sedimentary sulphur in some cases, and pointing to simultaneous early diagenetic formation of S_{org} and pyrite [2].

Makirina Bay is a small, shallow (0.2-1 m deep) lagoon in Central Dalmatia, Croatia, 17 km N of Sibenik, with a small freshwater tributary in the south. In medieval times, salt was produced in the southern part of the bay, The water depth in the investigated area is between 0.2 and 0.8 m. The carbonate bottom of the bay is covered by a thick lens-shaped layer of clayey silt (up to 3 m), mostly covered by seagrass and algae.

Materials and methods

Sediment cores were collected at three sampling sites approximately 100 m distance from each other, with increasing freshwater influence toward the south. They were immediately transferred to the laboratory and sectioned in a glove bag filled with nitrogen. Pore water was extracted under a pressure of 0.4 MPa through a 0.45μm membrane filter. Water samples for sulphide analysis were mixed with an equal volume of 6% Zn-acetate. Dissolved sulphate was determined turbidimetrically, while dissolved sulphide was determined colorimetrically. The precision of both methods was ±2%. Total S and organic C concentrations in the sediment were determined using an IR-212 LECO Organic Carbon Determinator and an SC-132 LECO Sulfur Determinator. The accuracy (±3%) was determined by replicate measurements. Sedimentary sulphate, Cr-reducible sulphide (disulphide) and Sorg were extracted as described previously [3]. Isotopic analyses of sulphide were performed on a Europa 20-20 continuous-flow isotope ratio mass spectrometer with a precision of ±0.2‰, while sulphate and S_{org} were analysed on a dual-inlet IRMS (modified MI-1305) with a precision better than ±0.15‰. Results are reported as parts per thousand (‰) deviation from Canyon Diablo Troilite (CDT) reference standard.

Results and discussion

Sub-sampling of the sediment cores revealed a high heterogeneity with pocket-like structures of different grain-size and colour, reflected in scattered depth profiles of all observed species, especially in the central part of the bay. In the pore water, the sulphate concentration decreased rapidly from 35mM in the supernatant down to 20 mM at a depth of 1 cm, indicating intensive sulphate reduction immediately below the sediment/water interface. The low sulphide concentration (>0.1 mM) is attributed to the simultaneous precipitation of Fe-sulphide and incorporation of S^{2-} into organic S [4]. Concentrations of sedimentary organic carbon and total sulphur ranged between 2.5-5% and 0.1-2%, respectively. They were higher in the central part of the bay, decreasing toward the south due to the increasing freshwater influence. Except in the uppermost sediment layer, disulphide (mostly in the form of pyrite) was the predominant S species, reaching up to 1.1 wt.% or 85% of total S (Fig. 1). S_{org} was between 0.03 and 0.8 wt% (2-50% of the total S), while sulphate ranged between 0.03 and 0.35 wt.% (13-33%). S_{org} was generally bellow 10% of total S; however, it increased with depth and in some lower horizons even exceeded disulphide, indicating that formation of S_{org} is an important sink for dissolved sulphide. Intensive sulphate reduction in the uppermost sediment segment just below the sediment/water interface is most probably driven by the oxidation of upwelling methane, which is produced in the sediment [5]. The low $\delta^{34}S$ of disulphide (between –33 and –29‰ CDT) suggest that bacterial sulphate reduction is the governing process in the sulphur geochemistry of the sediment. S_{org} is depleted in 34S compared to marine sulphate as well (d34S between –4 and –2‰), indicating that Sorg is formed from dissolved sulphide, which is derived from sulphate reduction. No correlation between disulphide and organic C was observed in the sediment, which would be typical of "normal" marine sediments with diagenetic pyrite formation [6]. Furthermore, disulphide and S_{org} depth profiles are mirror-images, indicating that both are formed syngenetically, maybe even in competitive processes.

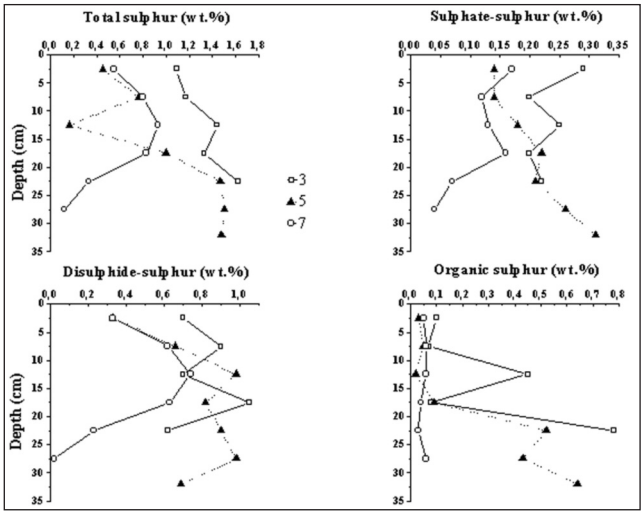

Figure 1: Depth distribution of sulphur concentration in the sediment; freshwater influence increases from 1 to 3

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PHOSPHORUS CONCENTRATION IN THE MIDDLE ADRIATIC SURFACE SEDIMENT LAYER

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Abstract
Organic and inorganic sediment phosphorus concentrations, organic matter content, and the granulometric composition of sediments were investigated in sediment samples from 15 middle Adriatic stations. Cluster analysis of the results obtained has confirmed differences in phosphorus concentrations in sediment at different stations depending on hydrographic properties, sediment type and sediment organic matter content. Statistically-significant correlations between the investigated parameters indicate that phosphorus in the middle Adriatic sediments is a result of sedimentation of organic matter produced in the water column.

Keywords: Adriatic Sea, sediments, phosphorus, organic matter

Introduction

The primary input of dissolved phosphorus (P) into the sea is from continental weathering carried by the rivers (1), but certain anthropogenic influences have also become important. P concentrations in the middle Adriatic waters are relatively low (2) and there are a relatively small number of freshwater inputs from the eastern coast to these waters (compared to northern Adriatic waters). These facts indicate that marine sediments could be an important source of P in this area. To determine the role of sediment in the phosphorus regeneration cycle it is necessary, firstly, to investigate phosphorus concentration, organic matter content and granulometric composition of the sediments at different stations. The aim of this paper is to determine the distribution of organic and inorganic phosphorus in sediments at different stations, as well as to estimate possible correlations between organic and inorganic phosphorus in the superficial sediment layer (0-2 cm), and chl a in the water column, sediment organic matter and P concentration in the water column.

Materials and methods

Sediment sampling was performed during 1997/98 and in June 1999 at 15 different stations in the middle Adriatic: 3 stations in semi-enclosed bays and estuary (EBS) (areas with the highest nutrient concentrations and primary productivity with a high urban nutrient loading), 2 channel stations (CWS), and 8 open sea stations (OSS).

The surface sediment layer (0-10 cm) was sampled with a plastic gravity corer (ø 3.5 cm). Analyse of phosphorus content in sediment samples were done according to Aspila (3). Phosphorus concentrations were determined colorimetrically using an AutoAnalyzer (4). The accuracy of analytical method was tested using standard reference material PACS - 2 (INMS - CNRC). Organic matter content was measured gravimetrically after oxidation with 30 % H_2O_2, and granulometric composition of the sediment was determined according to Shepard (5).

Results and discussion

The sediment organic phosphorus concentrations (OP) were from 0.54 to 25.85 mmol P kg^{-1} (dry sediment), and for inorganic phosphorus (IP) from 2.94 to 38.62 mmol P kg^{-1}. The obtained results showed very important differences in phosphorus concentrations in sediment at different stations depending of hydrographic properties and sediment type (from silty to clayey or sandy sediments) and sediment organic matter content (from 1.1 % to 10.9 %). The concentration of total phosphorus, (OP + IP), at EBS1 station in the Krka river estuary (exposed to long term contamination by phosphate ores and fertilizers) was 1.6 times higher than at the stations in semienclosed bays (EBS2, EBS3), 2 times higher concentration than at the open sea stations (OSS) and 3.5 times higher than at the channel stations (CWS1, CWS2). Cluster analysis of investigated parameters (sediment OP concentrations, chl a concentration in the water column, granulometric composition of the sediments) has confirmed the grouping of stations on the basis of hydrographic properties (Figure 1).

A statistically significant correlation has been estimated between the chl a concentration in the water column and OP concentration in the superficial sediment layer (0-2 cm) ($R = 0.59$, $p<0.01$), as well as the correlation between OP concentrations and organic matter content in the same sediment layer ($R=0.357$, $p<0.05$). There has also been estimated a statistically significant correlation between the flux of phosphate (J PO4) at the sediment / water interface and the concentration gradient of IP in the superficial layer of sediment (Figure 2). Jensen (6) also found a significant correlation between phosphate flux and one inorganic phosphorus form (Fe-bound P).

Conclusion

The differences in phosphorua sediment concentrations between the investigated stations (estuary, bays, channel and open sea stations) indicated a strong anthropogenic influence on the estuary and bay stations. Estimated correlations of investigated parameters (OP concentrations, sediment organic matter content and chl a concentration in the water column) indicate that the phosphorus in the middle Adriatic sediments is a result of sedimentation of organic matter produced in the water column.

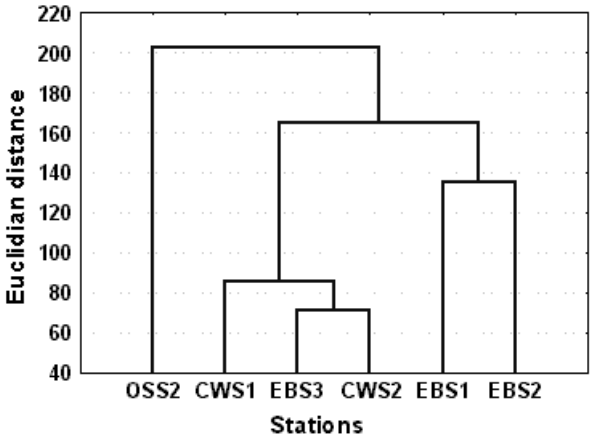

Figure 1. Cluster analysis of investigated parameters at the middle Adriatic stations

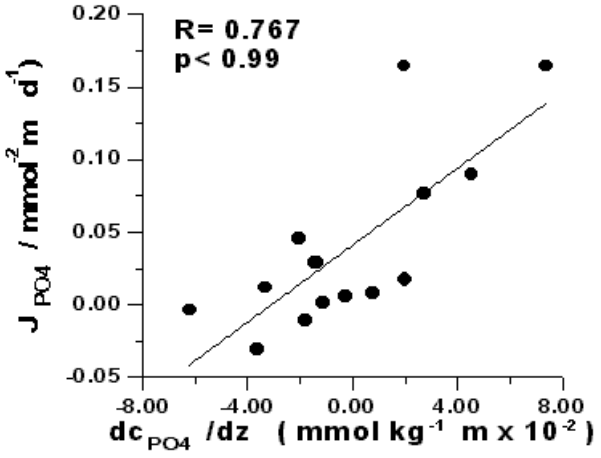

Figure 2. Correlations between phosphate flux (J_{PO4}) and the IP concentration gradient in the surface sediment layer (0-2 cm)

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DISSOLVED ORGANIC MATTER AND NUTRIENT ENRICHMENT IN THE ESTUARINE MIXING ZONE OF THE PO RIVER DELTA (ITALY)

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Abstract

Dissolved organic matter (DOM) was investigated in the estuarine mixing area of the Po River-Adriatic Sea. The linear decreasing trend which was observed with salinity underscored the role of riverine input as a major source of humic-type DOM. However, laboratory experiments undertaken on field samples to evaluate the contribution of phytoplankton to the DOM showed an increased extracellular production following nutrient enrichments. These results suggest that the Po River input can be regarded not only as a direct source of terrigenous DOM, but also as a trophic source enhancing the potential of autochthonous DOM production in North Adriatic waters.

Key-words: Dissolved Organic Matter, Extracellular Organic Matter, estuarine waters

Introduction

Dissolved organic matter (DOM) in the ocean is the largest pool of organic carbon in aquatic environments, and as such represents a major reservoir of reactive carbon in the global carbon cycle. While riverine inputs of terrestrial humic substances provide DOM enrichments in estuarine and coastal zones, they still can be regarded as localized sources, representing a probably insignificant contribution to the marine DOM on a global scale. By contrast, biological production, which can significantly contribute to the *in situ* DOM formation, is rarely documented or quantified (1).

Fluorescence spectroscopy has been suggested as an useful approach to investigate the behavior of DOM in marine and estuarine waters (2). The same technique has been recently proposed to evaluate the phytoplankton production of extracellular organic matter (EOM) in laboratory experiments (3,4). In the present investigation DOM was studied in the estuarine system of the River Po using fluorescence spectroscopy.

Since relationships linking the nutrient loads carried by the Po River with the amounts of organic matter involved in the mucilage formation are still unclear (5), field and laboratory investigations have been coupled in this study to evaluate interactions between trophic potential and phytoplankton EOM production.

Methods and Materials

Surface water samples were collected from eight stations in the estuarine mixing zone (riverine St.0 and marine St. 1 to 7) with a salinity range of 0.2-35 psu. DOM was analyzed by synchronous fluorescence spectroscopy in unconcentrated filtered samples using a Spex FluoroMax spectrofluorimeter (4). Fluorescence intensity maxima were recorded in the excitation wavelength band of 340-350 nm with 25 nm $\Delta\lambda$. Dissolved phosphorus (DP) and total dissolved nitrogen (TDN) were analyzed to characterize the nutrient content using a Tracs 800 autoanalyzer. Chlorophyll *a* was measured *in situ* at marine stations using a Sea Tech fluorimeter connected with a multiparameter Idronaut probe.

Laboratory experiments were undertaken to monitor the EOM production in the samples from marine stations (St. 1-7; 10.1-35 salinity range). The unfiltered samples containing the natural phytoplankton were incubated without any further enrichment and subsamples were taken for the fluorimetric characterization of the extracellular medium according to previously described procedures (4).

Results and Discussion

The analyzed concentrations are plotted in Fig. 1 as a function of salinity. As previously found in most estuarine waters (2,4), the fluorescence intensity in the humic-like band was found to decrease linearly with salinity (r^2=0.97), thus behaving as a good tracer of the terrestrial DOM in marine waters. Linear relationships were also found between salinity and dissolved P, N and Chl *a* (r^2=0.98, 0.99, 0.94, respectively). While it seems clear that the trophic potential of Po River input can control the productivity of the marine system, no evidence can be provided by these results for any increased production of organic matter of autochthonous origin.

In laboratory experiments undertaken on natural phytoplankton, fluorescence intensity was observed to linearly increase over time in all the incubated samples. The production rate of EOM was higher in the lower salinity samples (3.1, 2.6 FU/day, St. 1 and 2 respectively), while lower values (in the 0.9-1.4 FU/day range) were measured in the higher salinity samples (St.3-7, sal.>25 psu) which were characterized by significantly lower nutrient levels (Fig.1).

To confirm the relationship found between trophic level and EOM production, a further experimental evaluation was made during the incubation (day 19) by enriching one (St.6, 33 psu) from the last group of samples with algal culture medium (CM).

In Fig.2, where some of the incubated samples (St.3, 5, 6, 7) are compared, a significant change in the EOM production rate can be observed in sample 6 after the CM enrichment. According to the highest nutrient level, the measured new rate (6 FU/day) was largely exceeding all the others.

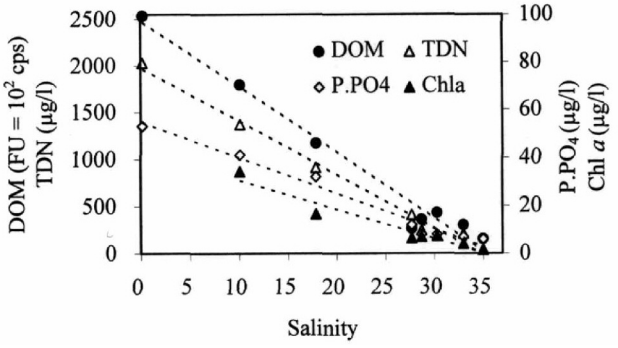

Fig. 1 - DOM and nutrients as a function of salinity

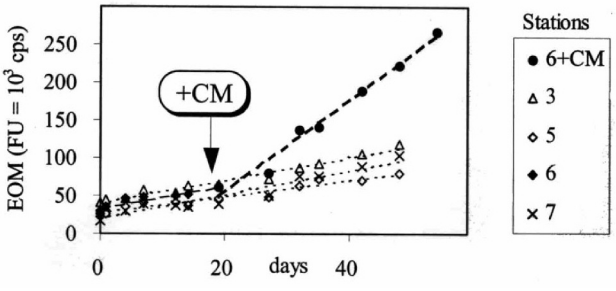

Fig. 2 - EOM production over time in untreated and nutrient enriched (+CM) samples

Our results suggest that the Po River input, as a nutrient source, can largely affect the potential of autochthonous DOM production in North Adriatic waters. Since in estuarine waters the concentrations of both terrigenous DOM and parameters stimulating algal growth and EOM enrichment are generally following the same dilution trend, coupling laboratory experiments with field-based investigations can be an useful approach to study the potential contribution of phytoplancton to the DOM pool.

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^{234}TH:^{238}U DISEQUILIBRIA AND SEDIMENT TRAPS: A DUAL APPROACH TO ESTIMATING CARBON EXPORT FROM THE UPPER WATER COLUMN OF NW MEDITERRANEAN COASTAL WATERS

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Abstract

Experiments were carried in coastal waters off Monaco to test the hypothesis that the degree of ^{234}Th:^{238}U disequilibrium in the overlying waters may be a reasonable indicator of particle and ultimately carbon flux that are traditionally measured using sediment traps. Sediment trap data indicated that fluxes measured by traps on three separate moorings were in quite good agreement. Furthermore, predicted ^{234}Th fluxes based on ^{234}Th deficiency measurements in the overlying waters were similar to actual particulate ^{234}Th fluxes measured with the traps. Likewise, carbon fluxes were derived using experimentally-determined C/^{234}Th ratios in the sinking particles.

Key words: Particle flux, carbon, radionuclides, sedimentation, particulates

Introduction

Sediment traps have been widely used over the past 30 years to study the downward flux of particles under in various marine environmental conditions. They are a unique tool for measuring particle flux in the water column and for collecting samples to estimate fluxes of a variety of elements and compounds [1]. Also, they permit recording fluxes over long periods of time to observe seasonal and annual changes in sedimentation [2]. Their records have provided key data for the better understanding of ocean biogeochemical processes. It is widely accepted that traps deployed in calm environments or the deep ocean provide a reasonable estimate of *in-situ* sedimentation. The situation is not always the same when traps are deployed in high energy environments or shallow waters. Trap data obtained under the latter conditions may be affected by hydrodynamic bias [3].

Since the activity of ^{234}Th in sea water is primarily controlled by production from its soluble parent ^{238}U and losses through radioactive decay plus sorptive removal on sinking particles, the accuracy of trap measurement in shallow waters can be verified by studying the ^{234}Th:^{238}U disequilibria in the overlying water column. From the ^{234}Th deficiency in sea water one can predict the ^{234}Th flux down to the depth of radionuclide disequilibrium [4]. Given this and a ^{234}Th measurement in the traps, one has an independent check whether the trap is collecting ^{234}Th-bearing particles in a predictable fashion. In a similar way, carbon fluxes can be predicted by using experimentally determined C/^{234}Th ratios.

Field test and results

During a spring bloom, a field intercomparison of the three Technicap models of sediment traps (Fig.1a) was carried out off Monaco. During one month the traps were deployed at 170 m depth on three independent moorings over a bottom 370 m deep. Currents were also recorded during the entire period of the experiment. In order to relate the measured fluxes to changes in the environment, using Niskin bottles the water column was sampled weekly for basic physico-chemical parameters such as temperature, salinity, fluorescence, chlorophyll *a* and particulate organic carbon. In addition, particulate and dissolved ^{234}Th were measured in the water column using *in-situ* large volume pumps (Fig.1b) in order to compare ^{234}Th trap-measured fluxes with fluxes predicted based on ^{234}Th-deficiency, and to estimate carbon fluxes from the observed ^{234}Th:^{238}U disequilibria.

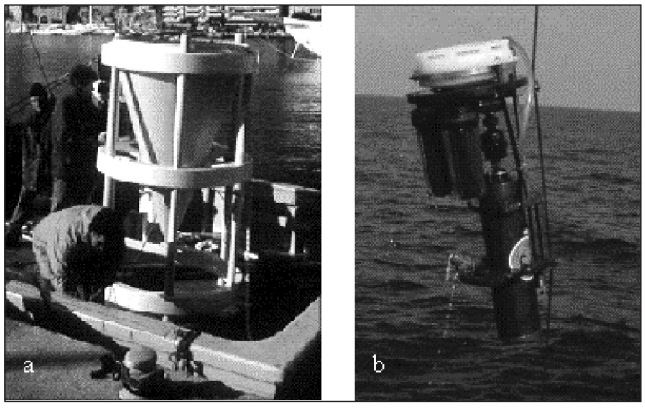

Figure 1. Sampling devices: a) conical sediment trap with a 1 m^2 surface collection area; b) large volume in-situ pump.

Fluxes measured by the three sediment traps were in good agreement during most of the sampling period. Only during short periods of high sedimentation did the measured fluxes present a high variability between traps but without any consistent differences for any given model. Similar trends were observed for carbon fluxes and, to a lesser extent, for pigment fluxes. Thorium data, although preliminary, indicate that ^{234}Th trap-measured fluxes and predicted ^{234}Th fluxes based on ^{234}Th-deficiency were relatively similar and, thus, suggest that the collection of particles by the traps was representative of the actual *in-situ* fluxes off Monaco during the experiment.

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TRACE ELEMENTS, HEAVY METALS AND PB ISOTOPIC RATIOS IN MARINE SEDIMENTS OF THE SOUTH MEDITERRANEAN SEA (MOROCCO).

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Abstract.

A sediment core collected in the South Mediterranean Sea was analyzed for trace metals and selected radionuclides. The resulting data was evaluated and the interpretation reported herein. High-resolution (5 to 10 mm) sediment core sections were analyzed for ^{210}Pb, ^{137}Cs, ^{239,240}Pu geochronology. Using a CRS model, ^{210}Pb gives a sediment accumulation rate (AR) of 0.11 g cm^2 y^{-1} and a sedimentation rate (SR) of 0.112 cm y^{-1}. These values are in good agreement with those calculated using ^{137}Cs and ^{239,240}Pu (0.149 g cm^2 y^{-1}) as well as comparable values measured in the Mediterranean Sea under similar hydrological conditions. Heavy metals can be separated into two groups: one that demonstrated an enhancement from a geogenic background (e.g. Pb, Mn, U, Cu, Co, Sb, Zn and As), the second group (Ni, Cd, Cr, Tl, Fe, Mo and V) shows no clear changes along the sediment core. At the beginning of the century, Pb input flux was in the range of 1mg cm^2 y^{-1}, increased to 3 μg cm^2 y^{-1}later on in the 1900's, and thereafter was rather constant until 1960, increasing to 3.5 μg cm^2 y^{-1} until mid 80's and then increased again towards 1997. The isotopic ratio follows the same trends as the lead flux with one exception at around 1960. Apparently a more radiogenic (natural) source of Pb entered the system. However towards recent years the flux of Pb may be attributed to an urban source (Moroccan alkyl lead additive type) rather than a radiogenic one.

Introduction

Assessment of Pb and heavy metals in general anthropogenic or geogenic have been the subject of several environmental studies in the last decade, especially in the northern hemisphere and the northern countries of the Mediterranean sea (1.2.3.4). Industrial manufacturing has produced these metals in the past in substantial quantities. Recently, due to improvement in emission control, their input has globally decreased since 1975 (5). However, the historical inputs of these metals are still a primary problem for fragile ecosystems and coastal areas, particularly in economically-challenge countries.

As part of a regional program RAF7004, we have attempted to combine the use of Pb isotopes with metal concentrations to describe the historical (^{210}Pb, ^{137}Cs, ^{239,240}Pu chronologies) concentration of heavy metals in the South Mediterranean Sea. The findings from a sediment core collected off the Moroccan Coast are reported herein.

Material and Methods

In 1999 a sediment core was collected using a Ocean Instrument Box Corer of 50x50x80 cm. The sediment was sampled off the Moroccan Mediterranean shelf at 900-m water depth. ^{137}Cs was measured in the whole sediment sample using a HpGe detector. ^{239,240}Pu was measured by alpha spectroscopy using ^{242}Pu as a chemical yield determinant. ^{210}Pb analysis was done by measuring its granddaughter ^{210}Po (considered in secular equilibrium with ^{210}Pb) by alpha spectrometry. ^{209}Po was used as a chemical yield determinant. Supported ^{210}Pb was estimated by directly measuring ^{226}Ra (gamma spectrometry) on some sections throughout the core. Heavy metals and Pb isotopic composition were determined by ICPMS following a complete digestion of a 150-mg sediment aliquot. Samples were prepared in batches of 8 to 10, which included up to 4 samples in duplicate, a reagent blank, and a representative standard reference material; SD-2/TM.

Result and Discussion.

The excess concentration of Co, Cu, As, Sb, Zn, Mn, U and Pb increased towards the surface. In contrast Cr, Cd, V, NI, Tl, Fe and Mo, in this particular core, did not show a trend, rather their excess concentration was scattered. On the other hand, Cd, Ni, V, and Cr showed some subsurface maxima at around 20 cm. In the case of Ni there is apparently a second peak at five cm. To date we do not have a good hypothesis to explain this. The CRS was used to reconstruct the depositional history of the sediment core. The average sediment accumulation rate calculated in this fashion was 0.11 g cm^{-2} y^{-1} (0.124 cm y^{-1}) which is not different than the values obtained using the activity profiles of ^{239,240}Pu and ^{137}Cs. The latter gives an accumulation rate of 0.13 g cm^{-2} y^{-1} (0.149 cm y^{-1}).

The excess flux of Pb and the ^{208}Pb/^{207}Pb isotopic ratio vs time is shown in Figure 1. In pre-anthropogenic time (1800) a less radiogenic isotopic signature (coal burning, Eurasian aerosol) follows the increment of Pb flux. Until the 1950s the isotopic signature nicely mirrors the changes in the flux of lead. Between 1970-1984 the ratio was rather constant decreasing towards mid 90s and this may be the result of worldwide practices in the use of unleaded products. However, the increase during the last few years is also followed by a less radiogenic signature and perhaps is the result of a more anthropogenic lead input to the study area.

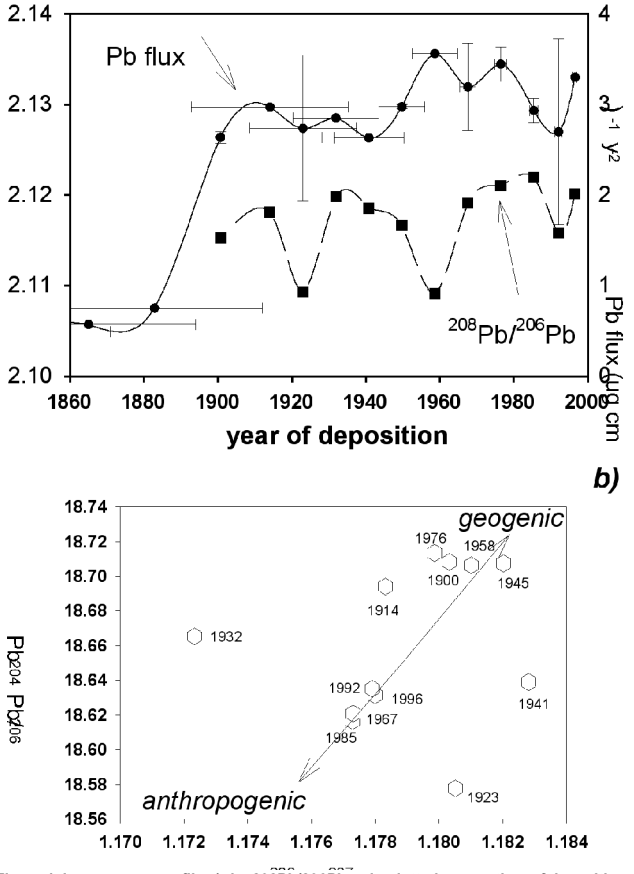

Figure 1. Isotope core profile a) the 208Pb/206Pb ratio plotted versus time of deposition. Also superimposed is the excess Pb fluxes vs. time of deposition. b) 206Pb/204Pb versus 206Pb/207Pb ratios. In the early 1900s, the input of Pb may have resulted from atmospheric deposition. However, in recent years, the 206Pb/207Pb ratio is within the range of the Moroccan Alkyl additive (1.16-1.18). Non-atmospherical input can also be responsible for the input of Pb in 1976.

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DISTRIBUTION OF NATURAL RADIONUCLIDES IN ABU-QIR BAY,EGYPT.

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Abstract

Consideration of natural radionuclides belonging to ^{238}U and to ^{234}Th decay chains in sands and bottom sediments at various locations over Abu-Qir bay have been determined using low background computerized high resolution gamma ray spectrometer. Mean grain sizes of the investigated sediments have been determined. A distribution map for each radionuclide distribution was presented for the study area as well as that for the distribution of mean grain size.

Keywords: Radioactivity, Sediments, Mean grain size.

Introduction

The natural radionuclides in the environment are classified into cosmogenic and primordial types. Cosmogenic radionuclides such as ^{3}H, ^{14}C, ^{22}Na and ^{24}Na do not contribute significantly to the external gamma radiation dose at ground levels. Primordial radionuclides such as ^{40}K, ^{87}Rb and the elements of the three radioactive series headed ^{235}U, $2^{38}U$ and ^{232}Th have been investigated in different environments (1). As a matter of fact, the radionuclides present in the ^{235}U decay series contribute very little to environmental radioactivity (1). ^{3}H has natural and man made sources in the environment; the nuclides were studied previously in the area under investigation (2). The natural radionuclides ^{238}U, ^{232}Th and ^{40}K have been determined in Alexandria beach sediments (3). These nuclides also were measured in soil of Nile Delta and middle Egypt (4). Radiation dose assessment has been carried out by Naim *et al*. (5), and a regional study of black sands radioactivity along the beach north of the Egyptian Delta was undertaken by El-Khatib and Abou-El-Kheir (6).

In the present work, radionuclides were determined in sediments over the area under investigation from Abu-Qir bay to the Rashid coast. This area is famous for its black sand deposits and a considerable volume of industrial pollutants discharged into the bay through El-Tabia pumping station, from Rakta paper factory and from Abu-Qir fertilizers company at El-Tarh. Also, drainage water from cultivated areas of El-Behera district open into the bay through the El-Amia drain.

The aim of this work was to determine the levels of radioactive isotopes that exist in Abu-Qir bay, as well as their distribution throughout the bay and to assess radioactivity levels in the surrounding marine environment.

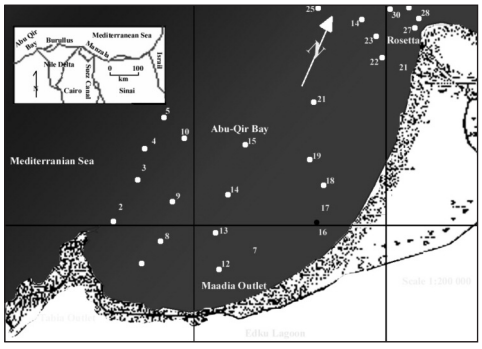

Fig. 1. Location of sites in the study area

Experimental work

Sediment samples were collected from various locations in Abu-Qir bay (Figure 1). Samples were homogenized, heated and dried using a vacuum drier at 100 °C in the lab, then cleaned from gravel and large shell fragments. Complete grain size analysis was carried out and the mean grain size was calculated. Each sample was packed in a 1000 cm^3 Marinelli beaker, weighed and analyzed for radioactivity. Samples were measured using a computerized pre-calibrated high-resolution gamma ray spectrometer. This detection system was based on a coaxial HPGe detector (Model CS20-A31C-Aptec) with 108 cm^3 sensitive volume and 5.4 cm diameter. The detector has a photo-peak relative efficiency of 24.5 % for 1332 keV gamma transition of ^{60}Co. The system was calibrated for efficiency using ^{152}Eu standard source. Radioelements were assigned to their energy photopeaks according to IAEA, 1989.

Results and discussion

The detected radionuclides are classified into three categories according to their origin. These are: ^{234}Th, ^{226}Ra, ^{214}Pb and ^{214}Bi, which belong to the ^{238}U decay chain and ^{228}Ac, ^{212}Pb, ^{208}Tl and ^{212}Bi, belonging to the ^{232}Th decay chain. It was observed that the levels of ^{234}Th ranged from 4.58 Bq/kg to 231.94 Bq/kg with an average of 53.32 Bq/kg; the levels of ^{226}Ra ranged from 11.01 Bq/kg to 499.18 Bq/kg with an average of 89.84 Bq/kg. The distribution of ^{238}U and ^{232}Th series radionuclides is shown in Figs. 2 and 3, reflecting those radionuclides belonging to both ^{232}Th and ^{238}U series which displayed high levels at the Rashid promontory.

Conclusions

The results from the study discussed have shown the areas of natural decay series, e.g. those originated from ^{238}U and ^{234}Th decay chains as well as ^{40}K. The maximum levels of radionuclides are observed near the Rashid coast. Furthermore, the grain size of the sediments plays an important role in controlling the distribution and concentration of radionuclides in this area.

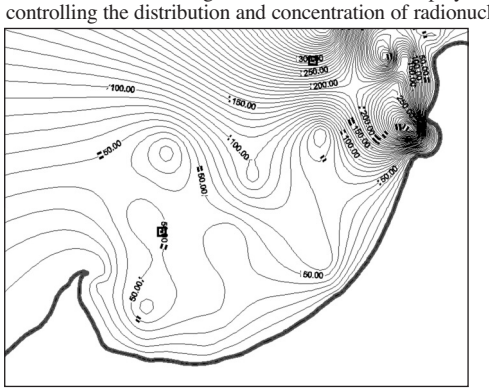

Fig. 2. Distribution map for ^{226}Ra at Abu-Qir bay

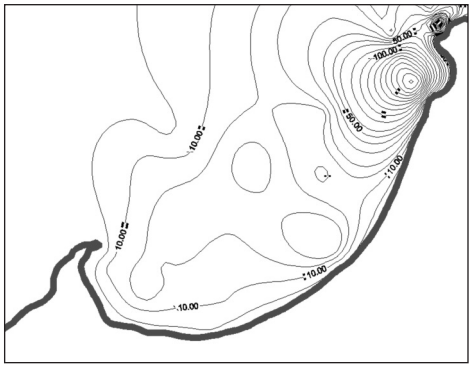

Fig. 3. Distribution map for ^{214}Pb at Abu-Qir bay.

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SPECIATION OF DISSOLVED TRACE METALS IN THE MARINE ENVIRONMENT BY PSEUDOPOLAROGRAPHY

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Abstract

The speciation of dissolved trace metals has been studied in model solutions and in natural water samples using a pseudopolarographic method, with a static mercury drop electrode (SMDE) and a thin mercury film glassy carbon disk electrode (TMFGCDE). The stability constants of the labile lead(II) complexes with chloride ions were determined from the shift of the half-wave potential of automatically measured pseudopolarograms. In the solution of constant ionic strength of 4 M ((4-X) M $NaClO_4$ + X M NaCl) and a concentration of lead(II) ions of $5x10^{-8}$ M) at pH = 2. It has been established that copper in seawater exists mainly in the form of strong inert complexes (>95%).

Keywords: chemical speciation, trace elements

Introduction

Pseudopolarography (repetitive anodic stripping voltammetric measurements with changing accumulation potential) is a relatively new electroanalytical approach for species the analyzing of dissolved trace metals at low metal concentration in natural and polluted water (<10^{-8} M) [1-8]. The anodic peak current-accumulation potential curves are polarographically-shaped and named pseudopolarograms[1,3] and it is very useful for the determination of both labile and inert metal stability constants[1-4,6-8]. The electrochemical characteristic of labile complexes is a shift of the half-wave potential of the complexed species towards negative values as compared to the "free" metal. The reduction half-wave potential of inert metal complexes is well separated from the reduction potential of free and labile metal complexes and is shifted towards more negative value. This shift depends on the stability constants of the inert metal complex. The DeFord-Hume method for the determination of the consecutive stability constants of labile metal complexes was based on the shift of the polarographic (cathodic) half-wave potential with changing ligand concentration at relatively high metal concentrations (>10^{-5} M). It is also applicable for the irreversible processes [9]. As the half-wave potential of the pseudopolarogram is dependent on the half-wave potential of the accumulation cathodic process, it is possible to use this method, following the same procedure, for the determination of stability constants of labile metal complexes at very low metal concentrations [1-3].

Materials and methods

An EcoChemie μAUTOLAB potentiostat was used. The working electrodes were PAR 303A SMDE and a home-made thin mercury film glassy carbon disk electrode (TMFGCDE). The auxiliary electrode was platinum wire and the reference electrode was Ag|AgCl|NaCl(sat). The chemicals used were either of "suprapur" grade, concentrated HNO_3, or of "analytical-reagent" grade: NaCl, $Pb(NO_3)_2$, $Cu(NO_3)_2$, $HgCl_2$, EDTA, NaOH, H_3BO_3 (all MERCK, Darmstadt) and T-X-100 (Rohm and Haas). Sea water sample was taken from Krka river estuary (Sibenik) and stored at 4°C before analysis. Milli-Q water was used in all experiments.

Results and discussion

Figure 1 shows the determination of the consecutive stability constants of the lead-chloro complexes using pseudopolarography. The entire procedure (the addition of chloride ions and pseudopolarographic measurements) was automatically managed. In the solution of ionic strength 4 M ((4-*X*) M $NaClO_4$ + *X* M NaCl) and $5x10^{-8}$ M lead(II) by pH = 2, the apparent stability constants are determined as: logβ1 = 0.61±0.05, logβ2 = 1.77±0.02, logβ3 = 2.18±0.02, logβ4 = 1.85±0.02.

The pseudopolarographic determination of dissolved copper species in seawater samples exemplifies the possibilities of this speciation analysis of trace metals in natural systems. In the analyzed natural seawater sample (Figure 2) pseudopolarographic measurements show that copper(II) occurs mainly in the form of inert complexes (>95%).

Pseudopolarographic determination of the labile copper and inert complex (CuEDTA) in model solution (0.55 M NaCl, pH = 8.1) shows two well separated waves both using SMDE and TMFGCDE. First of them at the potential of about –0.35 V corresponds to the reversible copper reduction and a more negative wave (about -1.0 V) to the reduction of the inert CuEDTA complex. In chloride solutions copper is reduced as copper(I). The successful separation of two waves (labile copper and CuEDTA complex) using SMDE are obtained by addition of 1 mg T-X-100 /L. Triton (T-X-100) adsorbed on the mercury drop surface shift the reduction potential of CuEDTA complex to more negative values. Using TMFGCDE with thinner mercury film separation of two waves (labile copper and CuEDTA complex) is achieved without addition of Triton. Pseudopolarography is the first and essential step for the metal complexing capacity determination using anodic stripping voltammetry at the actual metal concentration level in pristine seawater. These measurements enable the determination of the convenient accumulation potential range where free/labile metal complexes are separately reduced from inert metal complexes [10].

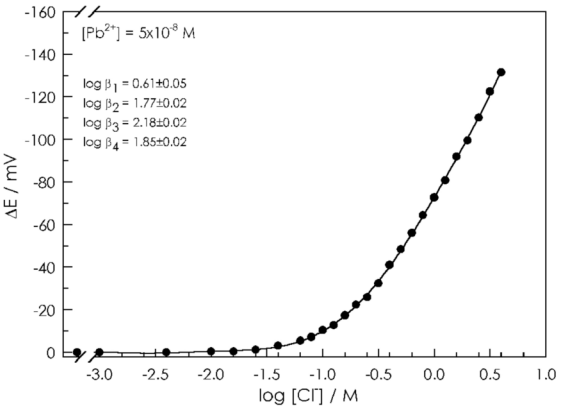

Figure 1. Shift of the half-wave potentials of the pseudopolarograms as a function of concentration of Cl- ions.

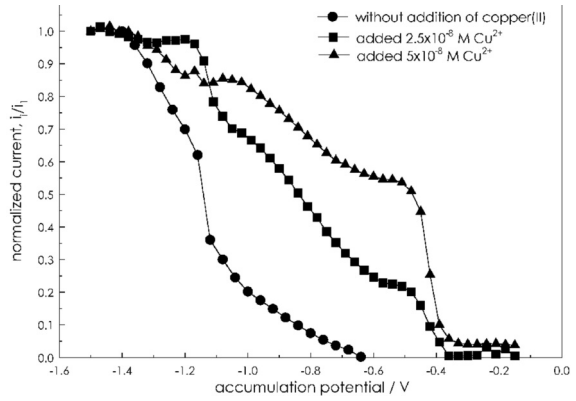

Figure 2. Pseudopolarogram of copper in seawater sample (S = 38 ‰, pH = 8,2)

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DISTRIBUTION OF DISSOLVED OXYGEN AND NUTRIENTS IN THE WATER COLUMN OF THE INNER SARONIKOS GULF (CENTRAL AEGEAN SEA) AFFECTED BY THE PSITTALIA SEWAGE OUTFALL

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Abstract
The chemical signal of the sewage effluents of Athens and Piraeus cities was detected at 40-55m during May–September 2000, whereas in October the signal was detected deeper, at approximately 60-65m. The dissolved oxygen values in the inner Saronikos gulf ranged between 2.98 ml/l and 5.85 ml/l. Low concentrations were found mainly at the depth of the sewage effluents (40-60m). The highest concentrations of ammonium and phosphate were measured near Psittalia, at 40-60m depth, whereas for nitrate and silicate an increase with distance from the sewage sea outfalls is recorded which is related to organic load mineralization. The sewage diffused mainly towards the south-southwest of Psittalia.

Keywords: Aegean Sea, sewage, dissolved oxygen.

Introduction

The wastes of the Athens metropolitan area, after a primary treatment in the Psittalia Sewage Treatment Plant, are discharged in the inner Saronikos Gulf at 63 m depth and thereafter follow the water circulation of the area. A number of studies undertaken within the framework of monitoring programs (e.g. MEDPOL Saronikos, 1987-2000; Monitoring of the Saronikos gulf ecosystem affected by the Psittalia sea outfalls 1998 - 1999), have recorded the concentrations and distribution of dissolved oxygen (DO) and nutrients in Saronikos gulf. This work, performed in the framework of the program: "Monitoring of the Saronikos Gulf ecosystem affected by the Psittalia sea outfalls (2000)", provides a brief summary of the results of a 6-month study concerning the impact of the Psittalia sewage on dissolved oxygen and nutrient distribution in the inner Saronikos gulf.

The objectives of this work were: (a) to record the concentrations of dissolved oxygen (DO) and nutrients in the inner Saronikos Gulf in a 6-month sampling period, (b) to investigate the way that the sewage diffuses in the inner Saronikos Gulf and (c) to assess the impact of sewage discharge on the oxygen and nutrients distribution.

Materials and Methods

Seawater samples from 11 sampling stations in the inner Saronikos Gulf were collected monthly. Additionally, in May 2000 and August 2000, a dense and more detailed grid of 25 stations was used (Fig.1). DO measurements were carried out on the oceanographic vessel "AEGEO" using the Winkler method [1]. Phosphate and ammonium were also measured on board with a Perkin –Elmer UV/VIS (Lambda 2S) Spectrophotometer using standard methods [2 & 3], whereas silicate, nitrate and nitrite were measured with a BRAN+LUEBBE autoanalyzer following standard methods [4 & 5].

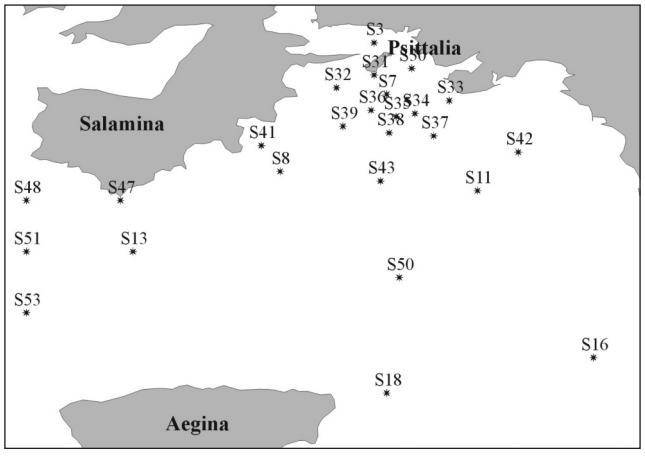

Fig. 1:Location of sampling stations in the inner Saronikos Gulf, in May and August 2000.

Results and discussion

The load of treated wastes during the sampling period "May 2000-October 2000" was trapped bellow 40m depth, due to the stratification of the water masses in the inner Saronikos Gulf during May to early December [6].

DO concentrations ranged between 2.98 and 5.85 ml/l. The lowest concentration was measured in September near the bottom (95m) of station S8, west of Psittalia (S7). The vertical distribution of DO at the stations located near Psittalia showed minimum values at the wastewater layer (40-60m) due to oxidation of the organic matter of the sewage effluents.

Nutrient concentrations ranged as follows: PO_4^{3-}: 0.01-2.26 μM (maximum value at station S31 near Psittalia, in August), NO_3^-: 0.03-7.04 μM (maximum value at the bottom layer of station S39, southwestern of Psittalia, in July), SiO_4^{2-}: 0.53-14.6 μM (maximum value at the bottom layer of station S8, southwestern of Psittalia, in September) and NH_4^+: 0.01-21.8 μM (maximum value at S30, near Psittalia, in May). The most intense and extended chemical signal of the sewage effluents was detected during May. Nitrate and silicate distribution showed an increase with distance (from Psittalia) and depth, which was related to the mineralization of the accumulated organic load. The sewage effluent, during the most of the sampling period, seems to diffuse mainly towards the south - southwest of Psittalia (Fig. 2 & 3) while in May it appears to move, almost equivalently, towards the southeast and southwest of Psittalia.

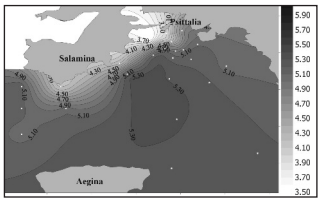

Fig. 2 : Horizontal distribution of DO (ml/l) at the depth of severage effluents, during August 2000.

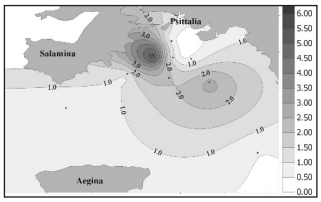

Fig. 3 : Horizontal distribution of ammonium (μM) at the depth of severage effluents, or 50 m, during June 2000.

Conclusions

During May to October 2000, low DO concentrations along with high ammonium and phosphate concentrations were measured within the layer of 40-60m (depending on the sampling period), mainly towards south-southwest of Psittalia due to the presence of the sewage effluent from the Treatment Plant. High concentrations of nitrate and silicate were measured at a greater distance (1.5-1.7 Km) due to the decomposition of the accumulated organic load. The sewage discharge seems to influence the DO and nutrient distribution and subsequently the water quality in the inner Saronikos Gulf.

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DISTRIBUTION OF MERCURY AND SELENIUM IN SELECTED ORGANS AND MUSCLE TISSUES OF TUNA FROM THE MIDDLE ADRIATIC

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Abstract

The mercury and selenium contents are determined in organs (liver and gills) and muscle tissues (light and dark muscle) of the tuna caught in the Middle Adriatic. Atomic absorption spectrophotometry with hydride generation was used to determine the concentrations of mercury and selenium in tuna. The method is accurate and precise which is confirmed by using a standard reference material. It was shown that the mercury concentration reaches maximum in liver, then in dark muscle, and finally in light muscle while it is lowest in gills. Furthermore, it was found that the selenium content reaches maximum in liver, then in dark muscle, and finally in gills, while it is lowest in light muscle.

Key words: AAS, Hg-Se distribution, Middle Adriatic, Thunnus thynnus L., tuna

Introduction

Based upon acute toxicity tests, mercury is important in bioaccumulation and sublethal effects in marine organisms. In its ecological cycle Hg is found in a part of the Earth's crust, its water and atmosphere layer, but when incorporated in living organisms mercury may perturb vital bio chemical processes. The fish that live in marine waters could obtain their mercury load directly from the seawater and through the food web. This accumulated mercury may increase with fish age, and one such example is the tuna, *Thunnus thynnus* L. Since the Mediterranean is considered to be an area of enhanced natural mercury input (the biggest world mercury mines are situated on the edges of this basin) (1), it is possible that tuna in the Adriatic contain significant mercury levels. Toxic effects of mercury are expressed in different ways according to the chemical form of Hg, the dose, and the route of exposure in various species of animals.

Selenium as a rare metalloid is both essential and toxic within a relatively narrow concentration range. A biological interest in selenium has significantly increased during the last four decades when its useful influence in living organisms was established (2,3). The fact that selenium is essential in the metabolic defence of an organism against oxide stress (4) was an important discovery.

Materials and methods

The tuna were obtained by professional fishermen in middle Adriatic area (around the Islands of Vis and Jabuka) in the summer of 1996. After biometric measurements (weight, length and age defining of fish) were made, two organs (liver and gills) and two comestible tissues (light and dark muscle) were taken for analysis. The samples were homogenized, placed in polyethylene pots and stored in refrigerator at –20°C.

The quantitative analysis was carried out by A.A.S. (Perkin Elmer 1100B) with hydride generation after organic matrix digestion with HNO_3/H_2O_2 for Hg and $HNO_3/H_2SO_4/HClO_4/HCl$ for Se. The accuracy of the analytical procedures was tested and controlled using NRCC TORT-1 (lobster hepatopancreas) and DORM-2 (dogfish muscle) certified reference material. A comparison of the obtained results with the reference values is shown in Table 1.

Table 1. Results of standard reference-material analysis.

Standard reference material	w(Hg)/mg kg^{-1}	w(Se)/mg kg^{-1}
TORT-1		
Certified value	0.33±0.06	6.88±0.47
Our value	0.33±0.02	6.81±0.49
DORM-2		
Certified value	4.64 ± 0.26	1.40 ± 0.09
Our value	4.32±0.29	1.41 ± 0.11

The obtained results showed very good compliance with the reference values.

Results

Measured average values of mercury and selenium concentrations in the selected organs and tissues are shown in Table 2.

Table 2. Average values (±SD) of Hg and Se concentrations (mg/kg wet weight) in the selected organs and tissues

	Liver	Gills	Light muscle	Dark muscle
w(Hg)/ mg kg-1 w.w.	3.08±1.55	0.50±0.14	1.28±0.48	1.87±0.73
w(Se)/ mg kg-1 w.w.	19.24±7.20	9.58±2.32	1.46±0.30	14.68±5.01

Conclusions

The results obtained lead to the following conclusions:

- It is determined that the mercury concentration reaches maximum in liver, then in dark muscle and finally in light muscle, while it is lowest in gills.
- According to the mass contents in comestible parts of tuna a great number of specimens was not appropriate for human consumption, because the obtained values were higher than MPL of 1 mgHg/kg wet weight (Maximum Permissible Levels for tuna in Croatia).
- It is determined that the selenium content reaches its maximum in liver, then in dark muscle, and finally in gills, while it is lowest in light muscle.

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RHEOLOGICAL PROPERTIES OF SEAWATER FROM SICILIAN COSTAL AREAS

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Abstract.
A clear positive variation of sea water rheological properties has been observed during phytoplankton blooms (1). Viscosity of filtered and unfiltered seawater samples taken from Sicilian coastal areas where formation of mucilage aggregates are likely to occur, has been measured at 4.00 °C. Monitoring of the development of such secretions is thus made possible by studying the increasing creep resistance of the samples.

Key-words: bathymetry, density, temperature, Adriatic Sea, Tyrrhenian Sea.

Introduction

Seawater rheological properties – It is known that formation of mucilage aggregates is primarily of biological origin and is certainly being initiated by marine meteorological conditions of high temperature and pressure coinciding with conditions of reduced hydrodynamics. However, the features needed to characterize the system from a physical-chemical point of view, have not been yet been studied. A sharp positive variation of sea water rheological properties has been observed during phytoplankton blooms and particularly in cases when effects emerging at the seawater surface occur (Adriatic Sea and North Sea).

Viscosity can be then included within the range of models which are employed to evaluate mucilage phenomena when it is conceived as a parameter to test creep resistance of fluid layers, caused by interaction between different polymer chains and their flexibility (2). If we also consider that sea water is classified as a "weak gel" full of agglomerates which can exceptionally turn into a "strong gel" characterized instead by agglomerates with increased creep resistance (1), it follows that viscosity should have a cyclic occurrence and thus, we should be able to foresee the likely formation of aggregates.

Materials and Methods.

Sampling and sample preservation – A few samples were taken in the Southern Tyrrhenian Sea in areas where phenomena attributed to mucilage aggregates have occurred in the past. Two transects have been chosen along the northern coast of Sicily, one at Isola delle Femmine and one at Capo d'Orlando. Monthly surveys and sampling were made from June 1999 at the stations with bathymetry C = 30 m, D = 40 m, E = 50 m: four samples have been taken for the station C (from the surface and at every 10 m depth) and a sample at –20 m for the D and E stations. We could thus analyse some results following horizontal guide-lines (coast – open sea): $C_2 - D_1 - E_1$ and vertical guide-lines (surface – sea-bottom): $C_0 - C_1 - C_2 - C_3$. (fig 1)

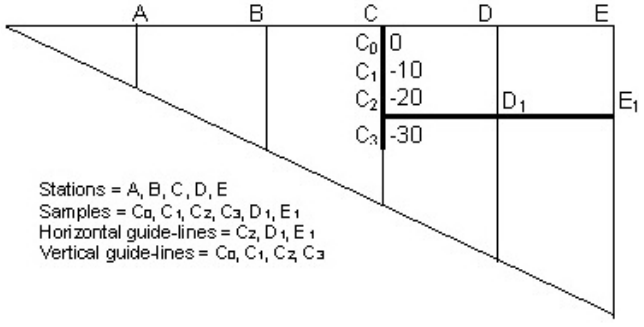

Figure 1. Transect indicating the stations.

Samples are taken and immediately stored at 4 °C in a portable refrigerator. Viscosity is measured at 4.00 ± 0.05 °C in unfiltered seawater (SW) and filtrate (filter GF/F, 7 μm (FSW)) samples. Due to the dimensions of some colloid substances in solution, it was decided to test viscosity of samples using 0.2 μm filters (F_2SW).

Filtering took place within one hour of sampling; samples were stored in a refrigerator at 4 °C and tested within no more than five days maintaining the same temperature.

Preservation and measurement at low temperature, without addition of chemical preservatives, allowed us to evaluate the physical-chemical properties of creep resistance which are caused only by the polymers in solution.

Measurement – Kinematic viscosity was measured at 4.00 ± 0.05 °C by an *Ubbelohde* capillar viscosimeter, Schott-Gerate Macro (0c) connected with AVS 350, an automatic viscosity-measuring instrument, by Schott-Gerate. Kinematic viscosity (ν) converts into absolute viscosity (η) in terms of $\eta = \nu$ d

where d represents the sample density (3,4). Sea water sample densities result from electrical conductivity readings taken at the same temperature. The accuracy of absolute viscosity was ± 0.001 cp. The ratio between the sample viscosity and the artificial sea water viscosity (ASW: NaCl, $MgSO_4$, $NaHCO_3$) provides the sample's relative viscosity which can be related to the rheological influence of those substances present as solute.

Results and Discussion.

The final outcome of more than one year of study seems to indicate that values obtained for the viscosity of unfiltered seawater show small differences depending on the sampling depths, although not as much as noted during the first three months. The viscosity of filtered seawater, on average, was always slightly lower than that of the unfiltered sample. Little difference was noted between viscosity determined by use of 0.2 μm filters and that using 0.7 μm filters. This is due to the fact that at the moment of sampling, measurements were not affected by substances which were more than 0.2 μm. No major differences were seen with respect to the horizontal guide-lines (coast – open sea): $C_2 - D_1 - E_1$ whilst more marked ones were noted using vertical guide-lines (surface – sea-bottom): $C_0 - C_1 - C_2 - C_3$.

Analysis of recorded values showed that the physical-chemical properties varied according to time (viscosity generally decreased from June 1999 until December 2000), bathymetry, and distance from the coast. Such data apply to both transects in our survey. Figures regarding kinematic and relative viscosity were related to marine meteorological conditions and weather at the time when the of samples were taken.

Therefore is important to continue the viscosity measurements in order to underscore the variations caused by polymers in solution, and in order to link rheological properties with biological and chemical parameters of the samples (i.e. nutrients, chlorophyl and phytoplankton biomass). In this way it will be possible to use viscosity as a predictive parameter of phenomena attributed to the formation of mucilage aggregates.

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COMPARISON OF PREWAR AND POSTWAR PCB AND DDT LEVELS IN FISH FROM THE ZADAR AND DUBROVNIK COASTAL AREAS ENCOMPASSED BY WARFARE DURING 1991/1995

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Abstract

The karstic area of Croatia warrants particular ecological attention because of its exceptional sensitivity to technology and hazardous wastes. The territory that was encompassed by warfare during 1991/1995 is in even greater jeopardy due to the unscrupulous destruction of natural resources, infrastructures, homes and enterprises. There are fears and concrete evidence that polychlorinated biphenyls were released into the environment during the warfare in Zadar and Dubrovnik areas. Results show significant higher levels of PCB in the fish samples collected after the war in comparison with the levels of these pollutants before the war in Dubrovnik and Zadar areas. On contrary, levels of DDT in fish are significantly lower in samples collected after the war in comparison with the levels of DDT in samples collected before the war.

Keywords: Adriatic Sea, monitoring, PCB, pollution

Introduction

After the war, the proposed priorities for investigation of the karstic area of Croatia jeopardized during the war are as follows:

Priority 1. Inspection of the terrain at polluted sites and control of the polychlorinated biphenyl pollution levels, with assessment of the subterranean pollution penetration based on existing hydrogeological data.

Priority 2. Monitoring the level of hazardous chlorinated hydrocarbons (mainly PCB) generated by warfare in the soil and water at the pumping sites of the Zadar and Sibenik waterworks and the sea around Zadar, Sibenik and Dubrovnik (1).

Taking into account the location of the destroyed Zadar and Dubrovnik electrical transformer stations, there is some speculation regarding the potential hazard from toxic organohalogenated compounds to the sea around the Zadar and Dubrovnik areas (2). The aim of this paper is to compare the prewar and postwar PCB compound levels in fish samples from the Zadar and Dubrovnik coastal areas that were impacted by warfare in 1991/1995. It should be emphasized that all the samples were analyzed by a single analytical group (mostly by the same analyst), using a uniform methodology that has been very successfully intercalibrated during eleven international intercalibration exercise (3).

Methodology

Muscle tissue and anhydrous Na_2SO_4 were concurrently homogenized and extracted with petroleum ether in a blender. The analytical method used for the analysis of fish extracts included filtration through a column of Na_2SO_4 anh., cleaning on an alumina column and separation of the PCBs from organochlorine insecticides on a miniature silica gel column. After concentration to 1 cm^{-3}, elutes were analyzed by EC gas chromatography. During all the analytical procedures, the Mirex standard was used as the internal standard (4).

Results and discussion

Pollutants mass fractions in the fish samples ranged from <0.5 to 353 (before the war) and from <0.1 to 35.8 (after the war) for $DDTs_{ww}$ and from <0.5 to 311 (before the war) and from 74 to 4004. 10^9 for $PCBs_{ww}$ after the war. The highest levels of PCBs and DDTs in fish samples were found in Zadar and Dubrovnik areas in comparison with other areas investigated in the Eastern coastal waters of the Middle Adriatic during 1997. The box-and-whisker plots show significant higher the mass fractions of PCBs in the fish samples collected after the war in comparison with the levels before the war in Dubrovnik and Zadar areas. Such differences are not observed for the DDTs levels. Trends of DDTs and PCBs levels in fish samples were investigated by using linear regression analysis of the mass fractions of DDTs and PCBs (natural logarithmic values) with the year of collection.

Correlation of DDTs levels in fishes from the Zadar and Dubrovnik area with the year of collection for 1974-1980 period shows significant negative correlation coefficient, ratios of PCBs/ DDTs show significant positive correlation coefficient, correlation coefficient for PCBs is positive but statistically nonsignificant.

Taking into statistical analysis data obtained after the war (1997), for DDTs correlation coefficient is negative but for PCBs is highly significantly positive. It means that only DDT and its metabolites show a statistically significant yearly trend of decrease in samples investigated, but the levels of PCBs significantly increase in fishes from the Zadar and Dubrovnik areas.

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THE COPPER COMPLEXING PROPERTIES OF MELANOIDINS AND MARINE HUMIC MATERIAL

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Abstract

Melanoidins, condensation products of sugar and amino acids may represent a key link in the transformation of polysaccharides to humic material in marine environment. Melanoidins prepared using a condensation time longer than two days exibit complexation properties towards copper ions that appear to depend on the basicity of the amino acid precursor. Melanoidins of molecular mass <10000 and >10000 exibit similar complexing properties. The copper complexing properties of humic material isolated from marine lagoon sediments were determined for a comparison.

Key words: electrochemistry, organic matter, metals

Introduction

Recently, melanoidins, sugar- amino acid condensation products, have gained attention due to their chemical similarities to natural humic substances. Although humic substances are often thought to be formed from lignin polymers, in marine environments carbohydrates are more abundant and are thus more likly precursors of humic acids (1). Although, melanoidins are commonly prepared in laboratories by prolonged heating (1) , they also may be formed under natural environmental conditions in soil as well as in sea water. For example, melanoidins have been identified in archeological plant remains from excavations in Egypt and thus must have been produced by reactions that occured in buried organic matter (2). In the present work we examined and correlated the copper complexing capacity values of twelve differently prepared melanoidins and two humic acids (HA).

Experimental

Voltammetric measurements were performed on aμ - Autolab (ECO-CHEMIE), connected to a Metrohm VA 663 stand. Complexing capacity was determined as described in detail previously(3, 4, 5). Fulvic acid (FA) was isolated from Cannet lagoon sediments (France) at the University of Perpignan (6)(Table1). Aldrich HA is a commercially available, well characterized humic material (Table1). Melanoidins were prepared at SUNY (USA) from glucose and amino acids (glutamic acid, lysine or valine) which were added in 1:1 ratio and heated at 100°C for 2, 4,16 or 32 days.The products of the reactions were soluble in water and were separated into two fractions :1) molecular mass <10000 Da, and 2) molecular mass >10000 Da. For lysine and valine, only a 16-d reaction time with glucose was used. Thus 12 different melanoidins were obtained (Table 2). The copper complexing capacity was determined for 10 mg/L solutions of each melanoidin, FA or HA in 0.55mol/L NaCl at pH 6 and pH 8.5.

	C	H	N	O	S	Acidity (meq./g)	Mol. mass distr. (Da)
FA (Canet)	38.7	5.38	2.25	51.64	1.97	5.82	>1000–20 000
HA (Aldrich)	50.17	5.43	0.88	41.00	3.26	-	1000-5000
glu-glut (7 days)	46.0	3.6	3.5	46.9	-	5.3	not determined
glu-val (7 days)	53.3	3.7	3.8	39.2	-	3.4	not determined
glu-lys (7 days)	54.4	7.4	8.0	30.2	-	1.3	not determined

Table 1. The elemental composition of humic acids and melanoidins (1)

Results and Discussion

The complexing capacity of the investigated melanoidins, HA and FA are presented in Table 2. Among the melanoidins higher complexing capacity values for copper ions are obtained for glu-lys, followed by glu-val and the lowest values are for glu-glut.Lysine contains more amino groups than glutamic acid or valine (1); basic amino acids (i.e., those containing more amino groups than carboxylic groups) preferentially condense with sugars to form nitrogen-rich polymers (1). These polymers are good complexing agents for copper ions. Glu-glut 1 and glu-glut 5 show no complexing capacity towards copper ions regardless of their large molecular masses, which shows that two days of heating is not enough to form structures capable of binding copper ions.

The complexing capacity for glu-glut 7 was determined at both pH 6 (shown in Table2) and at pH 8.5. The complexing capacity at pH 8.5 is much higher with: $L^T = 2.65 \times 10^{-7}$ mol/L and Kapp= 9.8×10^7 L/mol. This higher value is obtained at pH 8.5 because additional binding sites for copper ions are available as more groups are dissociated. There was no difference in complexing capacity between melanoidins with molecular masses <10000 Da and >10000 Da (Table 2). FA isolated from lagoon sediments has a complexing capacity in the same range as melanoidins while HA isolated from soil (containing more lignin type residues) has a complexing capacity four times higher than the highest one for melanoidins.

Melanoidins; HA; FA [10 mg/L]	Reaction time (days)	Mol. mass (Da)	L_T (mol Cu^{2+}/L)	K_{ML} (L/mol Cu^{2+})
glu-glut 1	2	<10 000	not detected	not detected
glu-glut 2	4	<10 000	$4.83 \lozenge 10^{-8}$	$1.4 \lozenge 10^7$
glu-glut 3	16	<10 000	$4.56 \lozenge 10^{-8}$	$2.4 \lozenge 10^8$
glu-glut 4	32	<10 000	$7.43 \lozenge 10^{-8}$	$7.2 \lozenge 10^7$
glu-glut 5	2	>10 000	not detected	not detected
glu-glut 6	4	>10 000	$2.03 \lozenge 10^{-8}$	not determined
glu-glut 7	16	>10 000	$8.01 \lozenge 10^{-8}$	$5.8 \lozenge 10^7$
glu-glut 8	32	>10 000	$6.86 \lozenge 10^{-8}$	not determined
glu-val 9	16	<10 000	$1.42 \lozenge 10^{-7}$	$3.3 \lozenge 10^7$
glu-val 10	16	>10 000	$1.98 \lozenge 10^{-7}$	$4.6 \lozenge 10^6$
glu-lys 11	16	<10 000	$9.92 \lozenge 10^{-8}$	$7.6 \lozenge 10^6$
glu-lys 12	16	>10 000	$2.14 \lozenge 10^{-7}$	$1.4 \lozenge 10^7$
FA	-	>1000-20000	$8.68 \lozenge 10^{-8}$	$5.8 \lozenge 10^7$
HA	-	1000-5000	$9.7 \lozenge 10^{-7}$	$2.9 \lozenge 10^6$

- glu = glucose; glut = glutamic acid; val = valine; lys = lysine

Table 2. The composition, molecular mass, time of reaction, complexing capacity and apparent stability constant determined at pH=6

Conclusion

Melanoidins complex copper ions, and the similarity in complexing properties with FA isolated from marine lagoon sediments is obvious.The extent of complexation depends on basicity of the amino acids used to make the melanoidin. A reaction time of two days was not enough to form structures capable of complexing copper ions.Complexing capacity values differed little between melanoidins with molecular mass <10000 Da and >10000 Da. As melanoidins have been found in nature (2), they may form under certain conditions (*e.g.*,UV- light) and may represent a link in transformation of labile organic matter (polysaccharides, amino acids) into more recalcitrant humic material in seawater.

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LA SURVEILLANCE *IN SITU* DE LA RADIOACTIVITE MARINE AU LARGE DE MONACO

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Résumé

Le système fixe de surveillance appelé NEMO (Nautique Environment Marine Observatoire), comprenant un spectromètre gamma, un courantomètre, des sondes de température et de salinité (densité) et dont les données ainsi recueillies sont transmises par satellite, a été déployé au large de Monaco. Des observations sur l'effet des retombées de radionucléides naturels (^{7}Be, ^{40}K, ^{214}Pb et ^{214}Bi) entraînés par la pluie de l'atmosphère à la surface de la mer sont présentées.

Mots-clés : radioactivité marine, radionucléides naturels, spectrométrie gamma subaquatique

Introduction

Installés sous l'eau, les spectromètres gamma peuvent être utilisés à court terme comme à long terme pour la surveillance de la radioactivité marine, mais aussi pour la surveillance des rivières et des lacs. Ce système pourra, dans des cas spécifiques, se substituer aux campagnes sporadiques d'échantillonnage et au travail laborieux d'analyse en laboratoire. Comparés aux systèmes traditionnels, les systèmes fixes de surveillance ont plusieurs avantages tels que (a) l'enregistrement en temps réel des résultats, (b) la mise en évidence de changements dans le temps, (c) les campagnes d'acquisition programmables dans le temps. Puisque les radionucléides déchargés dans l'environnement sont généralement accompagnés d'émetteurs gamma (par exemple, dans les déchets provenant d'usines de retraitement et de centrales nucléaires, et dans les déchets radioactifs déchargés en mer), un système de surveillance gamma sera un excellent outil pour la surveillance des radionucléides dans le milieu aquatique [1-4]. Un détecteur à scintillation à gros volume, de haute efficacité et d'une résolution raisonnable, serait un bon choix pour la surveillance des émetteurs gamma dans le milieu marin.

Methodes et matières

Deux types de spectromètres gamma submersibles ont été utilisés. Le premier détecteur utilisé lors d'une expérience en 1995 était de type NaI (Tl), d'un diamètre de 100 mm et de 150 mm en longueur, et équipé d'un modem permettant la transmission de données par cable. Le deuxième système utilisé récemment, le NEMO (Nautique Environment Marine Observatoire) est un système de surveillance encore plus sophistiqué comprenant un spectromètre gamma (detecteur NaI (Tl), 75 mm de diamètre et 75 mm en longueur) et muni d'un courantomètre, des sondes de température et de salinité (densité) avec transmission de données par satellite, et a été déployé près des côtes monégasques.

Résultats et discussions

La figure 1 montre un spectre gamma, obtenu pendant une semaine dans la baie de Monaco à une profondeur de 24 m. Le pic dominant dans le spectre est dû au ^{40}K. Le pic de ^{137}Cs (le radionucléide le plus recherché comme émetteur gamma) n'est pas facilement visible car il est masqué par le ^{214}Bi naturel. L'activité calculée pour ^{137}Cs est de 4 Bq/m^3 et de

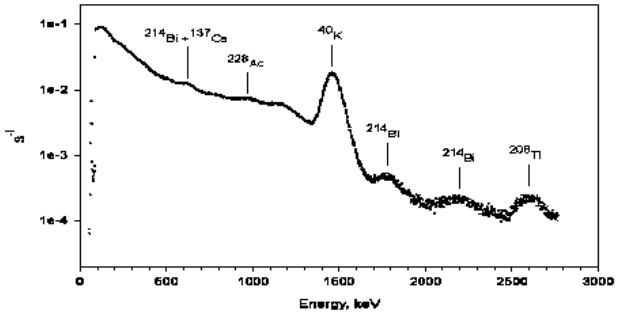

Fig 1. Spectre gamma d'eau de mer mesuré en novembre 1995 dans la baie de Monaco.

2 Bq/m^3 pour, respectivement, une semaine et un mois de comptage.

La figure 2 montre, à titre d'illustration, les possibilités offertes par l'observatoire NEMO pour l'étude des changements dans les concentrations des radionucléides cosmogéniques (^{7}Be), primordiales (^{40}K) et radiogéniques (^{214}Pb, ^{214}Bi : produits des désintégrations du ^{222}Rn dans la chaîne de désintégration de l' ^{238}U) dans l'eau de mer de surface. La figure démontre clairement l'effet des retombées de radionucléides entraînés par la pluie de l'atmosphère à la mer. Cet effet, l'un des processus prédominants dans des zones côtières, est responsable de la présence de radioactivité dans les eaux de surface

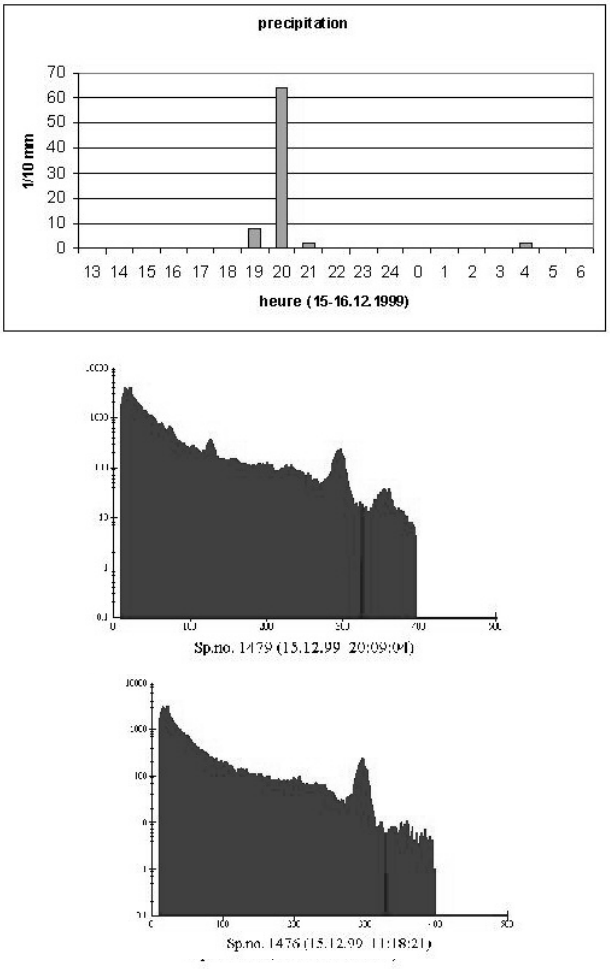

Fig 2. Précipitation (haut) et spectres gamma d'eau de mer (4 m profondeur) mesurés avant (milieu) et après (bas) pluie.

L'observatoire NEMO a été déployé en Mer d'Irlande pour la surveillance à long terme des concentrations de ^{137}Cs dans l'eau liées à l'étude de modèles de circulation d'eau et à la remise en suspension de ce radionucléide dans les sédiments du fond. Dans un avenir proche, l'observatoire NEMO sera muni de sondes pour l'analyse des nutriments et des hydrocarbures ainsi que d'un appareil d'échantillonnage programmé afin d'effectuer des prélèvements d'eau à intervalles réguliers sur de longues périodes de temps.

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LONG-TERM CHANGES OF NUTRIENT CONCENTRATIONS AND PHYTOPLANKTON BIOMASS IN THE NORTHERN ADRIATIC SEA

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Abstract
A significant reduction of the Po River flow in the season February-April and a marked increase in autumn occurred during the years 1993-2000, compared to previous periods. Reduction of the orthophosphate and ammonia concentrations, and of phytoplankton biomass were observed except in October when the freshwater discharge was often much greater than normal.

Key-words: Adriatic Sea, Biomass, Nitrogen , Phosphorous

Introduction

Both seasonal and long-term changes in the nutrient loads, primarily contributed by the Po River (75% of the total inputs), significantly affect the ecosystem of the shallow northern Adriatic Sea (1). Data series collected during the period 1993-2000 along an eutrophication gradient between the Po Delta and the opposite Istrian coast together with a previous 25-year data set (1969-1992) were used to investigate changes in the nutrient cycles and phytoplankton biomass (chlorophyll a) during the nineties.

Material and Methods

The data collected at stations SJ108, 12 Nm off the Po River delta (44° 45,4' N; 12° 45,0' E), and SJ107, 13 Nm off Rovinj, western Istria coast, Croatia (SJ107- 45° 2,8' N; 13° 19,0' E) were selected and presented in this paper. The water was collected with 5 L Niskin (salinity and nutrients) and 6 L VanDorn (chlorophyll a) samplers. 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).

Results and Discussion

The mean seasonal flow model of the Po River (calculated from daily averages) for the period 1993-2000 substantially differs from those for the periods 1917-1992, 1969-1980, and 1981-1992, particularly in the months February-April and October-November (Fig.1). While lower values were recorded in the first season of the most recent period, the flows were markedly higher during the autumn months. For example, in five years of the period 1993-2000 the mean flow for the season October-November was 1000-3000 m3 s-1 higher than the long-term average (1917-1992; 1772 m3 s-1). This analysis indicated that recently the hydrological regime over the Po River watershed has been substantially modified, influencing also the nutrient and phytoplankton biomass distributions in the marine environment.

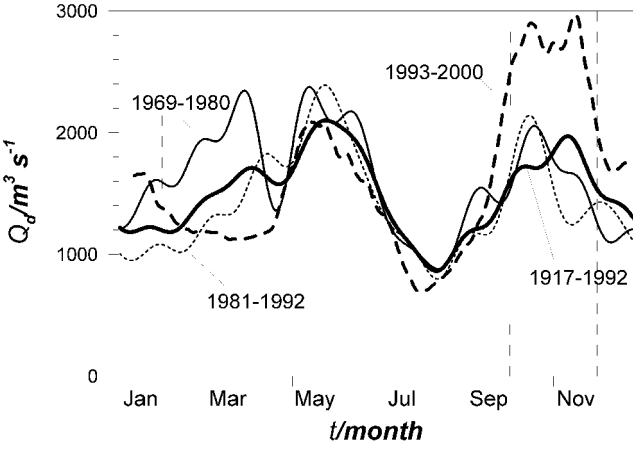

Figure 1. Average daily Po River flow (Qd) at Pontelagoscuro for four different periods.

Generally, the average surface salinity and Secchi disk depth in the period 1993-2000 did not differ significantly from the long-term averages (1969-2000) at both stations, if the October value is excepted. In fact, salinity was exceptionally lower (by 5) than the long-term averages, indicating that the freshwater impact on the area was often substantial in October during the period 1993-2000. Consequently, values for the nutrient surface concentrations, significantly higher than the averages, were measured in the area off the Po Delta (station SJ108; Fig. 2), but this was not the case for the more oligotrophic area off Rovinj. Nevertheless, the chlorophyll a level was markedly increased also in this area, indicating that the nutrient excess was incorporated in the biomass during the eastwards advection of the diluted waters.

In contrast, in the most of the months of the period 1993-2000 the nutrient concentrations were near the long-term averages (nitrate) or significantly lower (orthophosphate and ammonia; Fig.2). A decrease in phosphorous, probably resulting from reduction of polyphosphate contents in detergents, was observed since the mid 1980's (1) and it persisted through the last period. The reduction of the chlorophyll *a* concentration in the more eutrophic area (Fig. 2) can be ascribed to an enhanced phosphorous limitation. Consequently, the lower ammonia levels observed recently may be also related to a decrease of the organic matter remineralization rate.

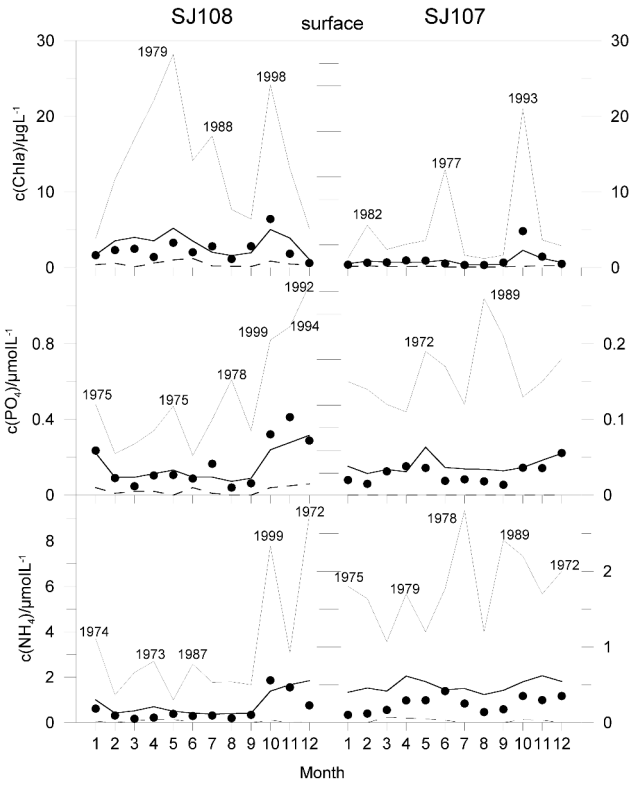

Figure 2. Monthly means, maxima, and minima for the period 1969-2000, and monthly means for the period 1993-2000 (C) of chlorophyll *a*, orthophosphate and ammonia concentrations at stations SJ108 and SJ107.

Exceptionally high freshwater discharges during the autumn have lesser consequences for the marine ecosystem than in spring when the nutrient utilization is much faster, and the water exchange between the northern and the rest of the Adriatic is reduced (1).

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PRODUCTION OF TRANSPARENT EXOPOLYMER PARTICLES (TEP) IN THE NORTHERN ADRIATIC SEA DURING 2000

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Abstract
The distribution, seasonal changes and properties of transparent exopolymer particles (TEP) were studied in two areas of the northern Adriatic with different degrees of eutrophication. Preliminary results suggested that TEP formation occurs mainly in the more eutrophic western part of the northern Adriatic while horizontal advection probably represents the principal mechanism of TEP accumulation in the more oligotrophic eastern part.

Key words: TEP, organic matter, phytoplankton, Adriatic Sea

Introduction

The transparent exopolymer particles (TEP) play an important role in the formation of marine snow (1) and probably also in the mucilage events (2) that have occurred frequently in the Adriatic since 1989 and were particularly intense in the northern part (3). It was hypothesized that mucilage events can develop when the concentration of microaggregates with enhanced stickness properties (including TEP) rise above a «critical» level (4). To verify those assumptions, the distributions, seasonal changes, and properties of TEP were studied in two areas of the northern Adriatic with different eutrophication degree.

Materials and methods

Samples were collected from March to December 2000 at stations SJ101, 12 Nm off the Po River delta, Italy (44° 59,9' N; 12° 49,8' E), and SJ107, 13 Nm off Rovinj, western Istrian coast, Croatia, (45° 2,8' N; 13° 19,0' E). The total TEP concentrations (xanthan equivalent) were measured by the alcian-blue spectrophotometric method (5). The particle abundances and total areas were determined with a light microscope on filters stained with alcian blue (1). Salinity was measured by a high precision laboratory salinometer, temperature with reversing thermometers, and the phytoplankton abundance was determined by the Uthermöl method from samples preserved with neutralized lugol. The results were compared using the Spearman's rank correlation test.

Results and discussion

The occurrence of TEP was extremely variable and, surprisingly, the mean values for the period March-December 2000 did not differ substantially between the investigated stations (Tab. 1), although the influence of nutrient rich freshwaters were much more marked at station SJ101. Increases in TEP concentration at this station during the spring and summer were due to phytoplankton blooms in surface layers with significantly lowered salinity (Fig. 1). In contrast, a much higher freshwater input during October did not induce a corresponding phytoplankton (and TEP) production, probably due to light limitation in turbid waters. Remarkably, at station SJ107 extremely high TEP concentrations (up to 2500μg xanth.equiv.L^{-1}) were measured in June in surface layers with low phytoplankton abundance, although their salinity was significantly reduced.

Table 1. Concentrations, abundances and total surface areas of TEP at stations SJ101 and SJ107.

	SJ107				SJ101			
	n	Mean	C.V.	Range	n	Mean	C.V.	Range
Concentration 'xanthan equiv. μgL^{-1})	55	309	127	4-2498	50	322	111	9-2000
Abundance ($N°*10^6L^{-1}$)	54	5.3	77	0.9-28	50	9.1	70	0.8-30
Total surface area (mm^2L^{-1})	54	717	98	78-3774	50	985	114	72-6255

Moreover, all TEP parameter values (total concentration, abundance, and surface area) were inversely correlated with salinities at both stations (statistical significance at least at $p<0.05$), but different results were obtained when comparisons with temperatures and diatoms' abundances were made. While significant positive correlations ($p<0.01$) were found at station SJ101, no evident relationships were noted at station SJ107.

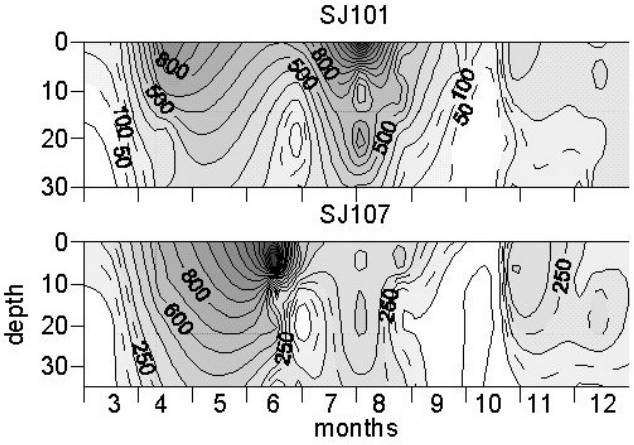

Figure 1. Temporal distribution of TEP (μgL^{-1}xanthan equiv.) at stations SJ101 and SJ107.

These results suggest that TEP production occurs mainly in the more eutrophic western part of the northern Adriatic. Horizontal advection would represent the principal mechanism of TEP accumulation in the more oligotrophic eastern areas, assuming that their residence times are longer than for their producers (phytoplankton).

Finally, unexpectedly weak correlations were observed when the total TEP concentrations were compared with the abundance and total surface area values. This may be related to contamination of samples by gel substances that can also react with the alcian blue. In fact, a mucilage event occurred in June and July 2000, with formation of aggregates up to several meters in length in the upper water column (CMR, unpub. data).

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ORGANIC MATTER DISTRIBUTION IN SURFICIAL SEDIMENTS FROM WESTERN ALBORAN SEA

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Abstract

In order to address the question of whether there is a pelagic-benthic coupling in the western Alboran Sea, we studied the distribution of organic matter, proteins, carbohydrates, chlorophyll and phaeopigments in the surface sediments of this area. The distribution of these variables was compared with the oceanographic features in the overlying water column. The results suggest the existence of a pelagic-benthic coupling in this zone.

Keywords: Alboran Sea, Sediments, Upwelling, Organic matter

Introduction

In the marine environment the coupling between pelagic and benthic systems is an issue to growing interest in recent years (1). Benthic activity in marine areas is dependent on phytoplankton production in the overlying water column. Observations in the western Alboran Sea indicate biological and geochemical structures in the water column that appear to be associated with the local circulation pattern (2). This pattern is influenced by both the inflowing Atlantic jet through the Strait of Gibraltar, which follows a wave-like path towards the east (3; 4), and local winds. The Atlantic jet creates a geostrophic front and leaves an area of divergence between the front and the continental shelf, promoting the upwelling of nutrient-rich deep Mediterranean water. This upwelling produces an increase in the primary productivity in this area (2). Moreover, the frequent local SW winds induce periodic upwelling events along the coast of Málaga (5), providing higher productivity in the coastal area. In this study we address the question of whether the enhancement in productivity associated with these oceanographic features has consequences for the benthic ecosystem underneath.

Material and methods

The sampling was carried out in January 2000, on board the R/V "Odon de Buen". Sediment samples were taken at 23 stations located along 6 different transects which ranged from 13 m to 540 m depth. Chlorophyll a (Chla), phaeopygments (Phaeo), organic matter (OM) and its biochemical composition: proteins (PRT) and soluble carbohydrates (sCHO) were determined in sediment samples. A CTD profile was carried out at each station.

Results

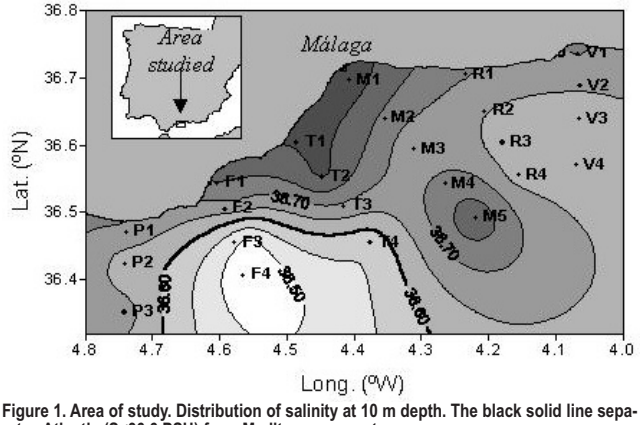

Figure 1. Area of study. Distribution of salinity at 10 m depth. The black solid line separates Atlantic (S<36.6 PSU) from Mediterranean waters.

The circulation pattern observed during the cruise showed the influence of the Atlantic front in the area under study (Fig.1).

The position of the front is indicated by the isohaline of 36.6 PSU. Higher salinities were observed near the coast due to upwelling of deep Mediterranean water. Moreover, the high values of salinity found at station M5 suggest a cyclonic circulation.

Overall, the organic matter (OM) content in sediments, and its constituents PRT and sCHO, showed higher values in the coastal stations of transects T and M, and in most of the offshore stations. (Figure 2). Those are the stations influenced by coastal upwelling and the front respectively. The organic matter distribution in the oceanic stations appeared to show the same wave-like pattern as that observed in the Atlantic jet. The OM content ranged from 0.9% at the station R1 (a coastal station out of the influence of the upwelling) to 6.2% at the station P3 (most-influenced by the front).

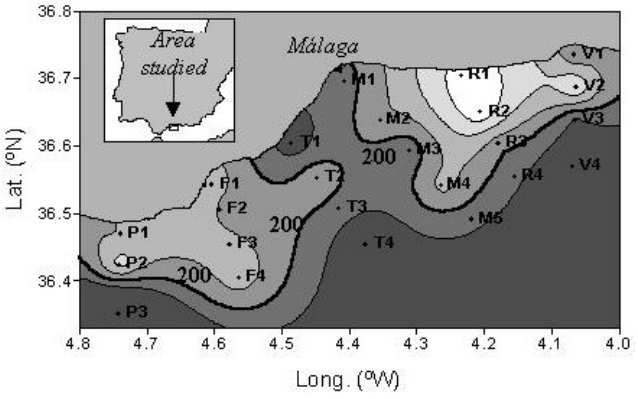

Figure 2. Distribution of proteins in surface sediments (µg/g). (Solid lines show the concentration of PRT=200 (µg/g).

sCHO concentrations ranged from 0 to 220 μg/g. sCHO showed a similar distribution to the OM although the maximum values were found slightly displaced towards the West. The sCHO maxima encountered in transect T may be explained not only by the presence of the coastal upwelling, but also by terrestrial imputs by the Guadalhorce river. The minimum was found at station R1.

PRT distribution in surface sediments showed a similar pattern to that observed for OM: high values in the zone influenced by the upwelling and in the oceanic stations affected by the front. The highest protein concentrations were observed at station P3 (>410 μg/g). There were also high concentrations of proteins in the deeper stations of the transect V (V3, V4) suggesting again the wave-like path of the Atlantc jet.

In generall, Chlorophyll a (Chla) concentrations in sediment were very low. The higher values were found in the coastal stations and in the westernmost oceanic station, P3. Station R3, also displayed high values. The distribution of phaeopigments (Phaeo) showed the maximum values in the coastal stations of transect T probably due to OM inputs from the river.

The high values observed for all the organic matter constituents studied at station P3, despite its notable depth (540 m), could be explained by the strong influence of the front. The enhancement of productivity associated with the front would be reflected in a larger vertical flux of phytodetritus to the sea floor at this station. The low values in OM, PRT and CHO in sediments of the eastern area (transect R, especially R1) reflect the oligotrophy of the overlying waters, which are out of the influence of the front. Despite the low values of OM constituents at R1, that station displayed a high Chla/Phaeo ratio. This high ratio may be due to benthic microalgae biomass, since R1 is only 13 m depth. The results of this preliminary study strongly suggest the presence of pelagic-benthic coupling in this area.

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SURVEILLANCE DE LA POLLUTION PAR L'UTILISATION DE BIOMARQUEURS BIOCHIMIQUES CHEZ LA MOULE EN MÉDITERRANÉE NORD-OCCIDENTALE

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Abstract

The water quality of the bays of Cannes and Nice was studied. For this purpose, biochemical biomarkers were measured in cultured mussels translocated in cages at different sites during spring and autumn. Results allowed classifying the stations as a function of their relative degree of pollution. Stations neighbouring the harbor of Nice and Cannes were characterized by high metal concentrations and high levels of biomarkers indicating an exposure to pollutants, whereas in the mussels placed in the Paillon estuary, the presence of pesticides was hypothesized. The mussels from the Lérins Island can be considered as essentially devoid of contamination.

Key words : Mollusca, Pollution, metals, enzymes

Introduction

Le concept de biosurveillance (biomonitoring), qui repose sur l'étude de la réponse biologique des êtres vivants aux polluants est fondé sur une batterie de tests toxicologiques et écologiques. Le principe de cette méthode est l'utilisation d'indicateurs biologiques de pollution, communément appelés biomarqueurs, qui révèlent l'exposition d'un individu à au moins une substance chimique à caractère polluant (1). Certaines molécules biologiques ont la particularité de réagir à la présence de toxiques dans le milieu; l'amplitude de la réponse étant souvent proportionnelle à la quantité de xénobiotiques présents. Les marqueurs biologiques constituent des indicateurs spécifiques et mesurables qui répondent de façon précoce et sensible à un dysfonctionnement et leur utilisation rend compte de la biodisponibilité des polluants et des effets qu'ils engendrent sur les organismes et les populations (2). A l'heure actuelle une approche multiparamétrique c'est-à-dire comportant la mesure de différents biomarqueurs, est utilisée. Les biomarqueurs les plus utilisés sont les enzymes dépendant du cytochrome P 450, induites par les hydrocarbures aromatiques polycycliques et qui assurent la phase I de détoxication de ces molécules, les enzymes de phase II, comme la glutathion S-transférase, qui prennent en charge les métabolites de phase I afin d'en faciliter l'excrétion et qui sont induites par des organochlorés. Les pesticides organophosphorés et carbamates inhibent l'enzyme acétylcholinestérase dont l'activité peut être considérée comme un biomarqueur de ces polluants. Les métaux lourds sont piégés dans les organismes sous forme d'une protéine de faible poids moléculaire, riche en soufre, appelée la métallothionéine. Le taux de métallothionéines peut être considéré dans certains cas comme biomarqueur d'exposition aux métaux. Des biomarqueurs moins spécifiques indiquent l'état physiologique d'un animal, tels que le taux de peroxydation lipidique exprimé par la concentration de malonedialdéhyde, ou l'activité antioxydante catalase. Dans une étude de biosurveillance de la qualité des eaux des baies de Nice et de Cannes, nous avons placé en mer pendant trois semaines, en octobre 1999, juin et octobre 2000, des cages contenant des moules provenant de l'aquaculture, ces animaux constituant une population génétiquement homogène et ayant donc des réponses moins variables. Les biomarqueurs activités enzymatiques glutathion S-transférase (GST), catalase (CAT), acétylcholinestérase (AChE) et taux de métallothionéines (MT) et de malonedialdéhyde (MDA) ont été mesurés sur les moules mises en cage ainsi que les concentrations en métaux cadmium, cuivre et zinc mais aussi en fer et manganèse (ces deux métaux étant traceurs de sédiments).

Matériels et méthodes

Les stations de mouillage des cages se situent au port de Nice et ses environs immédiats et dans l'estuaire du Paillon. Pour ce qui est de la baie de Cannes, les moules ont été placées dans le port de Cannes et au nord de l'île de Lérins Sainte-Marguerite. Le dosage de la GST s'effectue selon la méthode décrite dans Habig et coll. (3), celui de la catalase d'après Greenwald (4). La peroxydation lipidique est estimée par la formation de substances réactives à l'acide thiobarbiturique et quantifiée en taux de MaloneDiAldéhyde (MDA)(5). La détermination de l'acétylcholinestérase est réalisée avec le réactif d'Ellman (6) suivant les modifications de Galgani et Bocquené (7). Les métallothionéines ont été analysées par la méthode décrite dans Viarengo et coll. (8) et les métaux par spectrophotométrie d'absorption atomique.

Résultats et Discussion

Les résultats analysés statistiquement montrent que l'on peut clairement distinguer 3 stations ou groupes de stations : celles de la zone portuaire (stations 4, 5, 6, port de Nice et de Cannes) caractérisées par des activités GST et catalase élevées, un taux de MDA fort et une activité AChE modérée, une concentration en métaux plus élevée (notamment la concentration en cuivre dans le port de Cannes de 4 à 5 fois plus forte qu'aux autres stations) et un taux de métallothionéines relativement fort (particulièrement au port de Nice et à la station 5); cette zone serait donc soumise à l'exposition aux hydrocarbures aromatiques ou aux organochlorés et aux métaux lourds, celle de l'estuaire du Paillon (station 2) présentant une activité AChE faible qui tendrait à montrer chez les mollusques une exposition à des pesticides organophosphorés ou carbamates ou à des métaux, les moules en cage devant l'estuaire présentant des concentrations élevées en fer et manganèse; enfin une zone peu influencée par les pollutions : celle de l'île de Lérins. En effet, à cette station les moules ont des activités GST, catalase faibles, un taux de peroxydation lipidique faible et une activité acétylcholinestérase élevée. Cependant les taux en cadmium des moules placées devant celle île sont significativement (tests de Fisher) supérieurs à ceux des stations proches du port de Nice (Stations 4, 5 et 6) en revanche les taux en fer sont significativement inférieurs. Ce qui suggérerait donc une compétition entre les deux métaux et pourrait éventuellement expliquer que les moules de la station de référence aient des teneurs légèrement plus fortes en cadmium, mais très éloignées de ce qui est trouvé en zone polluée. En conclusion, le «caging» permet, non seulement, d'établir un gradient de pollution, d'étudier l'impact d'un rejet précis et d'évaluer les différences de qualité du milieu avec une précision de l'ordre d'une centaine de mètres, mais aussi, d'un point de vue statistique d'amoindrir les différences possibles liées au polymorphisme génétique par l'emploi d'animaux d'aquaculture.

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Le tableau ci-dessous donne les résultats obtenus pour l'expérience de mise en cage de moules d'octobre 1999.

	Estuaire Paillon	Station 4	Station 5	Station 6	Port de Nice	Port de Cannes	Ile de Lérins
		Stations proches du port de Nice					
Cd (ng/g)	798 + 32	533 + 66	656 + 158	743 + 97	802 + 87	837 + 108	1100 + 147
Cu (µg/g)	5,1 + 0,7	5,0 + 0,7	5,2 + 1,0	4,9 + 0,5	7,3 + 0,9	27,5 + 3,3	5,4 + 1,1
Zn (µg/g)	128 + 9	169 + 36	264 + 55	155 + 19	264 + 29	243 + 55	174 + 33
Fe (µg/g)	301 + 94	143 + 20	134 + 21	122 + 17	228 + 29	129 + 20	74 + 4
Mn (µg/g)	13,9 + 4,1	7,8 + 0,5	6,8 + 0,7	8,4 + 1,3	6,6 + 0,7	4,5 + 0,9	7,5 + 1,2
MT (µg/g)	172 + 7	204 + 13	243 + 2	187 + 2	230 + 4	205 + 4	182 + 2
GST nmol/min/mg prot.	98,0 + 7,1	130,9+12,9	98,1 + 7,4	145,0+17,9	131,2+13,7	135,6+11,3	88,6 +12,5
CAT µmol/min/mg prot.	25,8 + 3,5	34,7 + 4,3	23,2 + 2,7	31,0 + 3,8	49,4 + 7,5	23,9 + 2,1	11,9 + 3,2
MDA nmol/mg prot.	3,7 + 0,5	5,0 + 1,3	3,6 + 1,0	5,2 + 0,6	7,3 + 1,4	1,7 + 0,3	0,9 + 0,1
AChE nmol/min/mg prot.	5,6 + 0.5	9,1 + 0.5	6,7 + 0,5	7,6 + 0,9	8,5 + 1,2	7,1 + 0,7	13,1 + 0,7

ETAT DE POLLUTION PAR LES MÉTAUX LOURDS DANS LE PORT DE DJEN-DJEN ET LE PORT DE JIJEL (ALGÉRIE)

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Résumé

Les indices de contamination des métaux lourds analysés (Hg, Cu, Zn, Mn et Fe) dans les sédiments superficiels indiquent que le port de Jijel est légèrement pollué par le Cu et le Zn, mais il constitue une zone à risque concernant le mercure. La répartition des teneurs des métaux (Hg, Cu et Zn) montre une décroissance à partir des stations qui subissent l'action directe des rejets vers la passe d'entrée principale où l'éloignement des sources de pollution entraîne une baisse de concentration. Alors que dans le nouveau port de Jijel (Djen-Djen) les indices de contamination indiquent qu' il n'est pollué que par le mercure.

Mots clés: pollution, mercure, métaux traces, géochimie.

Introduction

Les métaux lourds ont une grande importance en raison de leur diversité et de leur impact sur l'écosystème marin. La toxicité de ces éléments métalliques impose une surveillance continue et la nécessité de contrôler leur introduction dans l'environnement. Les résultats reportés ici dans les sédiments superficiels du port de Jijel sont complémentaires aux études antérieures (1) et du nouveau port de Jijel (Djen-Djen) qui est situé à 10 Km à l'Est de la ville de Jijel et récemment son activité connaît une croissance notable. Afin de connaître l'état de pollution, il est nécessaire de procéder par comparaison avec les études antérieures et d'évaluer le degré de pollution en déterminant l'indice de contamination (2).

Matériel et méthodes

Les sédiments ont été prélevé à l'aide d'une benne de type "Van-Veen". Ce système de prélèvement permet d'effectuer un échantillonnage des sédiments superficiels dans la zone portuaire de Jijel. L'analyse granulométrique de la fraction fine (<63 μm) a été faite par la méthode classique (pipette d'Andréason) permettant de déterminer la nature du sédiment. La fraction inférieure à 63 μm du sédiment lyophilisé (0,5g) a subi une attaque par l'acide nitrique (HNO_3). Après minéralisation, les métaux lourds (Fe, Mn, Cu, Zn et Hg) dans les sédiments superficiels ont été analysés par un spectrophotomètre d'absorption atomique (Perkin-Elmer) avec flamme air-acéthylène. Un test d'intercalibration sur un échantillon standard (SDM/2TM) de l'AIEA a été réalisé.

Résultats et discussion

Cuivre, zinc et mercure

L'enrichissement relatif en métaux cuivre et zinc dans les sédiments sableux à l'extérieur du port de Djen-Djen par rapport au reste des autres stations est relié au rejet de la centrale électrique (Tableau 1). Leur indice de contamination indique que l'état de pollution par ces deux métaux lourds n'est pas inquiétante. Egalement dans le port de Jijel les teneurs en cuivre et en zinc sont variables et les valeurs élevées sont rencontrées dans les sédiments sablo-argileux qui sont répartis près des rejets, mais il est légèrement pollué en ces deux métaux. Leur répartition semble être identique correspondant parfaitement à la nature du sédiment dont la teneur en argile et ou en matière organique jouerait un rôle déterminant (3). Par ailleurs des études (4) montrent que le cuivre et le zinc sont associés au faciès sableux exposé directement aux rejets et l'association du cuivre avec la matière organique est marquée quelque soit son origine (5).

En ce qui concerne le mercure, l'indice de contamination indique que le port de Djen-Djen est légèrement pollué, mais demeure inquiétante si l'activité deviendra importante. En effet les valeurs les plus élevées qui ne semblent avoir aucun lien avec les rejets domestiques et industriels, sont à relier à l'activité portuaire. Quant au port de Jijel, l'indice de contamination indique que le seuil critique serait atteint et de ce fait ce port constituerait une zone à risque en particulier au niveau des stations qui subissent l'action directe des rejets. Les résultats obtenues par une étude similaire (1) confortent nos résultats, mais les concentrations demeurent inférieures à celles observées dans cette étude. Ceci montre qu'on assiste à une croissance continue de pollution en mercure et en d'autres métaux (Cu et Zn) rejetés dans le milieu par l'intermédiaire des rejets domestiques et industriels.

Fer et manganèse

Dans le port de Djen-Djen, les teneurs en fer et en manganèse sont variables et les valeurs élevées sont observées dans les sédiments sableux situés à l'extérieur du port près du rejet de la centrale électrique (Tableau 1). Ces teneurs élevées ne présentent pas une pollution notable et semblent être liées aux conditions hydrodynamiques et physico-chimiques (6 et 8).

En effet la turbulence provoquée par le rejet et l'existence d'une agitation intense (fortes houles) permettent une bonne oxygénation favorisant la précipitation des oxydes de Fe et de Mn et augmentent les collisions, donc l'agrégation des particules organiques et minérales (6 et 7). Les substances humiques qui forment une grande partie de la matière organique à l'état colloïdale constituent le support le plus favorable aux phénomènes d'adsorption, de complexation et de précipitation (9, 10 et 11).

Inversement dans le port de Jijel les faibles teneurs sont observées dans le sédiment, soumit à l'influence des eaux apportées par les rejets, malgré qu'il est constitué d'argile qui est considérée comme étant le substrat sur lequel le fer et le manganèse s'adsorbent le plus (3). En conséquence, les oxydes du fer et du manganèse qui sont très sensibles aux variations de pH, de l'oxygène et donc du potentiel d'oxydoréduction (10), se trouvent remobiliser et passent en solution.

Tableau 1: Concentrations des métaux Cu, Hg, Zn, Mn en µg/g et Fe en mg/g dans les sédiments superficiels et variation de leur indice de contamination (IC) à l'extérieure et à l'intérieure du port de Djen-Djen et dans le port de Jijel.

nature	Cu	Hg	Zn	Mn	Fe
silt argileux (int.Djen-Djen)	18.74 - 26.69	0.10 - 0.36	94.23 - 121.63	325.34 - 437.13	11.22 - 20.30
sable et silt (int.Djen-Djen)	12.98 - 36.11	0.09 - 1.15	78.86 - 106.15	335.37 - 394.13	12.26 - 16.47
sable (ext.Djen-Djen)	34.54 - 48.67	0.27 - 1.29	120 - 128.57	461.49 - 510.22	19.59 - 21.30
sable argileux (Jijel)	85.22 - 100.87	0.32 - 2.53	253.00 - 267.64	203.29 - 348.34	10.00 - 14.64
argile (Jijel)	40.00	0.24	174.43	325.26	15.19
silt (Jijel)	29.57 - 38.26	0.33 - 0.34	147.14 - 166.45	348.34 - 376.91	15.70 - 16.34
IC (Jijel)	1.1 - 3.9	1.2 - 12.7	1.6 - 3.1	0.5 -1	0.5 - 0.8
IC (int. Djen-Djen)	0.5 - 1.4	0.5 - 5.8	0.8 - 1.4	0.8 - 1.1	0.6 - 1
IC (ext Djen-Djen)	1.3 - 1.9	1.3 - 6.5	1.3 - 1.5	1.1 - 1.3	1 - 1.1

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METAL PARTITIONING IN PIRAEUS PORT SEDIMENTS

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Abstract

The metal partitioning among the geochemical phases of sediment samples from the Piraeus port was studied. It shows a total metal enrichment close to the ship repair and maintenance site of the port. Copper and Zn show significant bioavailability. Significant proportions of Pb, Fe and Zn are bound to ferromanganese oxides. Lead, Fe, Zn and especially Cu are highly associated with the organic and sulphide fraction. The major percentages of Pb, Fe and Zn are found to the residual fraction as they are bound in the lattice structure of aluminosilicate minerals.

Keywords : sediment, metals, zinc, lead.

Introduction

Piraeus port is considered as the third most frequent passenger port in the world and the leading container hub in the Eastern Mediterranean. Its main port areas are a central passenger port, a container terminal, a commercial port, and a ship repair and maintenance site. Previous studies of Piraeus port have shown high values of dissolved metals (Fe, Zn, Pb, Cu, Ni, Mn) indicating the relatively poor seawater quality in the area studied [1].

In the present paper metal partitioning among the various geochemical phases of the sediments is examined by sequential chemical extraction which, although a time consuming technique, can provide detailed information concerning the source, mode of occurrence, biological and physicochemical availability, mobilization and uptake of metals in sediments [2].

Methodology

Twenty-five surface sediment samples from various locations of the Piraeus port (Fig.1) were collected during three annual cruises (1997,1998, 1999). The total metal content (Pb, Fe, Cu, Zn) was measured after treatment of the samples by a mixture of concentrated HNO3, HClO4, HF at high temperature [3]. The partitioning of the metals was examined following the Tessier *et al* (1979) procedure [4] with some modifications [5]. Pb, Fe, Cu and Zn were examined within five fractions, the following: exchangeable (E), (1M NH_4OAc, pH 8.2) ; carbonate associated (C), (1M NaOAc, pH 5) ; reducible (Red), (0.04M $NH_2OH.HCl$, pH 2) ; organic matter-sulphide bound (Ox+Sul), (HNO_3, 30% H_2O_2, NH_4OAc) and residual (Res).

All metal concentrations were measured by Atomic Absorption Spectrophotometry. The relative standard deviation of the measurements, which was obtained from the analysis of five discrete subsamples of selected samples was <5%.

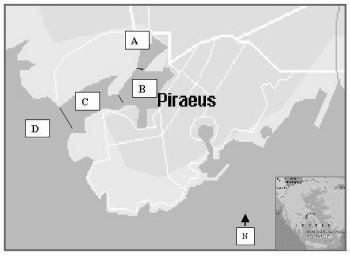

Figure 1 : The Piraeus port with the studied areas.Results and Discussion

From the results of Table 1 the following conclusions are drawn:

❮ The total metal content shows an enrichment in area C that can be attributed to the presence of the ship repair and maintenance site of the port.
❮ Cu and Zn show significant percentages in the exchangeable fraction, indicating that they can be easily released.
❮ All metals show very small percentages present in the carbonate bound fraction, which represents sedimentary carbonates, mainly calcium carbonate.
❮ Pb, Fe and Zn show significant percentages in the reducible fraction, which represents metals bound to ferromanganese oxides.
❮ Pb, Fe, Zn and especially Cu show significant percentages in the organic/sulphide fraction indicating their association with the organic matter and/or sulphide minerals.
❮ The major percentages of Pb, Fe and Zn and a significant percentage of Cu are found to the residual fraction as they are bound in the lattice structure of aluminosilicate minerals.
❮ In area D, some extreme values (Fe >200,000 μg/g, Zn >6,000 μg/g) , not included in the Table 1, were found in restricted areas in the vicinity of industrialized sites (cement and fertilizer manufacturing).

Table 1. Metal content in total sediment and percentages in fractions.

Area A	Pb	Fe	Cu	Zn
Total (µg/g)	56-374	12619-18055	87-270	720-925
E (%)	<1	<1	12-33	6-20
C (%)	0-7	<1	1-4	0-4
Red (%)	18-44	9-15	1-4	12-22
Ox+Sul (%)	5-20	17-24	38-58	3-10
Res (%)	35-70	64-74	24-44	45-74
Area B				
Total (µg/g)	217-464	14175-20541	173-305	700-1090
E (%)	0-1	<1	17-25	9-16
C (%)	1-3	<1	1-3	1-4
Red (%)	13-48	9-15	0-3	10-20
Ox+Sul (%)	4-17	17-34	43-59	4-10
Res (%)	33-81	56-70	19-34	53-75
Area C				
Total (µg/g)	449-749	24869-64429	291-867	1059-2403
E (%)	0-1	<1	15-23	10-14
C (%)	1-5	<1	1-5	2-4
Red (%)	24-39	8-12	0-3	13-20
Ox+Sul (%)	11-20	8-26	49-65	6-10
Res (%)	39-63	62-84	15-25	56-66
Area d				
Total (µg/g)	279-390	11600-20250	160-408	1200-1605
E (%)	<1	0-1	15-25	6-18
C (%)	1-3	<1	1-2	1-4
Red (%)	18-42	14-18	0-3	11-31
Ox+Sul (%)	9-42	19-40	50-72	5-14
Res %	25-72	46-64	12-22	39-73

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PHYTOCHELATIN SYNTHESIS BY MARINE MACROALGAE LIVING UNDER NATURAL HEAVY METAL CONCENTRATIONS IN THESSALONIKI BAY, NORTHERN GREECE

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Abstract

Thioles are sulfuric analogous of alcohols and include phytochelatins (PT) with cystein and glutathione (GSH) being the most common peptides in plants. When metals (Hg, Pb, Cu) are present, thioles form chelating complexes. Photo-autotrophs are the main entrance for heavy metals in the trophic chain with humans and animals as the final receivers. Phytochelatins are polypeptides, different from the metallothioneis (MT) of mammals, and their synthesis is linked to the presence of metals. Biosynthesis of MT is connected to the metabolism of glutathione, and only limited information exists about their role in macroalgae. An innovative HPLC method for measuring micromoles of the peptides is presented in this study.

Key words: algae; metals; analytical methods; Greece

Introduction

The reduced form of glutathione, GSH, is a tripeptide (γ-glu-cys-gly) that exists interchangeably with the oxidized form, GSSG. In plants, the physiological importance may be divided in two categories: sulphur metabolism and defence. GSH is the predominant non-protein thiol (1) and it regulates sulphur uptake at root level in the plant. It is also the precursor of the phytochelatins, which are essential in sequestering heavy metals (2). Heavy metal toxicity poses major environmental and health problems. Cadmium, for example, is a non-essential heavy metal, which is toxic to cells at very low concentrations. Cadmium ions displace Ca++ or Zn++ in proteins and may cause oxidative stress (3). Furthermore the concentration of essential, but at high concentrations toxic, metals such as Cu++, Zn++, Fe++ is strongly controlled. We present data on phytochelatin concentrations in natural samples of dominant macroalgae species from Thessaloniki Bay, a body of water under the impact of increasing pollution levels.

Methods - materials

Algae specimens of the dominant species in the Thermaicos Gulf were collected on a monthly basis from inshore of a heavily industrialized area. Reduced, oxidized, and free glutathione and cystein were determined in algal tissue with post column derivatization with monobromobimane and liquid chromatography. The chromatography system was composed of a Hewlett-Packard Series 1100, fluorescence detector Hewlett-Packard 1046A and Hewlett-Packard CHEM Station for LC Version A.04.02 (1996). Chromatography columns for inverse phase chromatography were packed with 3_m Hypersil ODS at 9000 p.s.i. Heavy metal concentrations in the algal samples were measured with AAS (6).

Results and discussion

Seasonal variation of the oxidized, reduced and total cystein in Chlorophyceae showed an inverse pattern. The concentration of the reduced form was only high during spring 1994.

Reduced and total glutathione exhibited a similar fluctuation and the highest concentrations coincided with that of cystein. The oxidized forms showed the opposite temporal trend.

Environmental conditions caused much higher synthesis of glutathione than cystein in Chlorophyceae where metals accumulated to a greater degree than in Rhodophyceae (7). Further statistical analysis (multi-factor linear correlation) showed that 90% of the concentration variation of all forms of glutathione was due to the combined presence of Cr, Pb, Cd and Zn. Synthesis of glutathione was even better attributed to the synchronous effect of Cu, Pb, Cd and Zn and copper ions were suspected for causing extended production for the peptide (8).

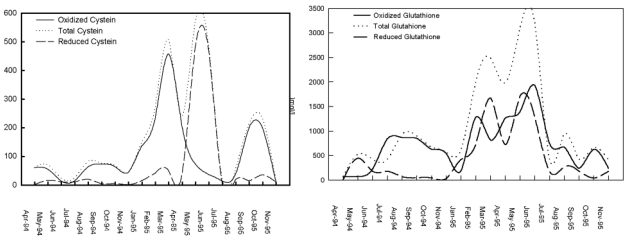

Fig. 1: Oxidized, reduced and total cystein and glutathione concentration (µmol/l) over time in the dominant Chlorophyceae.

Table 1: Uptake of Pb, Zn, Cu, Cr and Cd and glutathione and cystein biosynthesis in Chlorophyceae and Rhodophyceae.

Rhodophycea				Chlorophyceae			
	mean value (µg/g dry wt)	min-max	SD		mean value (µg/g dry wt)	min-max	SD
Pb	3.29	1-18.33	3.62	Pb	3.6	1.5-5.9	1.42
Zn	3.10	0.7-7.03	1.73	Zn	6.36	2.7-10.9	3.04
Cu	0.49	0.15-1	0.22	Cd	55.17	2-18	50
Cr	552.72	53.33-1966	531.92	Cr	477.2	10-1766	547.3
Cd	65.9	4-705	149.2	Cu	683.7	0.324-1	0.3
	(µg/l)				(µg/l)		
Oxy-Cys	103.74	13.1-456.76	111,8		4.5	1,7-5.64	1,03
_xy-Glu	710.4	68.9-1928.5	497.5		50.18	29.7-71.1	4,6
Tot-Cys	5.3	23.1-566.4	175.8		5.3	1.7-6.3	1.248
Tot-Glu	1094	70-3213	961.3		54.1	32.6-75.8	15.96
Red-Cys	64.4	0.1-473	144.2		1.25	0.3-2.01	0.47
Red-Glu	441.2	1.6-1706.1	544.8		3.82	1.4-5.98	1.4

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NIVEAUX, SOURCES ET ORIGINES DES HYDROCARBURES DANS LE SÉDIMENT SUPERFICIEL DU GOLFE D'ARZEW (ALGÉRIE)

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Résumé
L'analyse des hydrocarbures présents dans les sédiments superficiels du golfe d'Arzew a permis d'évaluer les niveaux des contaminants et de caractériser les sources et les origines de ces derniers. La source exubérante est pétrolière ; elle traduit principalement les influences littorales de l'importante zone pétrochimique implantée dans le secteur Ouest du golfe où débouchent un oléoduc et un gazoduc. Une source biogène récente allochtone et autochtone est également mise en évidence.

Mots clés : Hydrocarbures, Sédiments, Contamination, Algérie.

Introduction

Le golfe d'Arzew, de par ses deux ports pétroliers et son importante zone pétrochimique, est l'objet de rejets chroniques chargés d'hydrocarbures. Ces polluants se concentrent particulièrement dans le sédiment superficiel. Ce dernier est la matrice sélectionnée pour évaluer le niveau de contamination de ce golfe.

Matériels et méthodes

Le golfe d'Arzew (Fig. 1), soumis aux influences côtières et océaniques, a été échantillonné au mois d'août 1997, en 8 points sélectionnés selon la texture du sédiment et les sources potentielles de pollution. Les hydrocarbures sont extraits du sédiment lyophilisé, sur dispositif soxhlet, par un mélange hexane-dichlorométhane. Le rendement de l'extraction et estimé par l'addition d'étalons internes (dihydroanthracène et nC32). Les extraits sont purifiés et fractionnés par chromatographie sur colonne ouverte (gel de silice et alumine), selon le protocole IOC [1]; l'analyse des fractions recueillies est réalisée par chromatographie en phase gazeuse, colonne capillaire et détecteur FID. Pour chaque série d'extraction, un blanc de procédure et un échantillon de référence certifié (IAEA 383) sont analysés; les résultats sont exprimés en μg/g de poids sec.

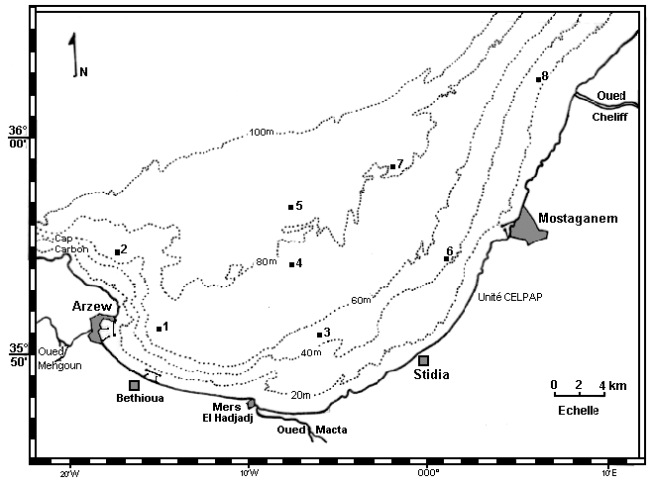

Figure 1.: le golfe d'Arzew : localisation des stations de prélèvement.

Résultats et discussion

Les concentrations totales d'hydrocarbures non aromatiques (HNA) varient de 5,31 à 737 μg/g de poids sec (Fig. 2). Les plus grandes teneurs, signe d'une forte pollution pétrolière [2], sont relevées à des fonds supérieurs à 60 mètres (stations 2, 5 et 7). Les chromatogrammes de la fraction aliphatique présentent une distribution bimodale ; le premier mode est centré vers n-C18 – n-C25 et le second vers n-C29 – n-C33 (Fig. 3). Les n-alcanes impairs prédominent dans la majorité des stations, traduisant ainsi des apports de cires cuticulaires des végétaux [3]. L'approche multidiagnostique établie par le calcul des CPI (Carbon Preference Index), la présence des doublets n-C17-pristane et n-C18-phytane et de l'UCM (Unresolved Complex Mixture) sur la majorité des chromatogrammes, permettent la mise en évidence d'une source anthropique pétrolière, résultat probable de l'implantation de l'importante zone pétrochimique et de l'activité pétrolière présente dans le golfe.

Une Source biogène récente allochtone, marquée par des rapports n-C29/n-C17 supérieurs à 1, et la prédominance dans certaines stations des composés impairs, est également mise en relief. Les influences phytoplanctoniques et algales autochtones sont également présentes. Ces influences d'origines et de sources différentes agissent de concert et de manière inégale sur les sédiments du golfe d'Arzew, de telle sorte qu'une station donnée est soumise à une contamination pétrolière récente et est, suite à cette pollution, caractérisée par une forte activité bactérienne et/ou par une production primaire non nulle, enrichissant le milieu en alcanes biogènes récents. A cela s'ajoutent les apports terrestres d'hydrocarbures autres que pétroliers (végétaux, feux de forêts,...).

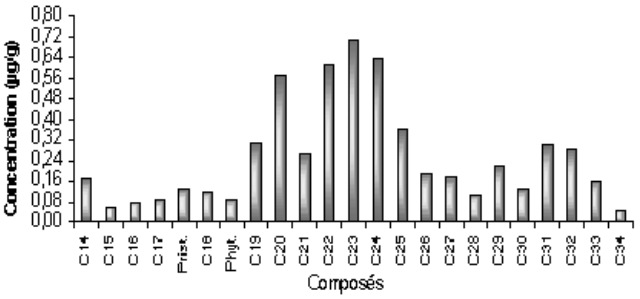

Figure 2. distribution des n-alcanes et des isoprénoides à la station 5.

Les teneurs en hydrocarbures polyaromatiques (HPA) totaux évoluent de 4,79 μg/g à la station 4, à 122 μg/g, à la station 7. Cette dernière, malgré sa situation au large de la côte Est du golfe, semble être un lieu d'accumulation des rejets pétroliers issus des industries côtières d'Arzew. Les stations situées près de la côte (1, 2, 3, 6 et 8) présentent toutefois des concentrations élevées. Les composés polyaromatiques identifiés sont au nombre de seize, partagés entre composés méthylés (méthyl-1 naphtalène, éthyl-1 naphtalène, triméthyl-2,3,6 naphtalène, méthyl-2 phénanthrène, méthyl-1 phénanthrène, diméthyl-3,6 phénanthrène et méthyl-1 pyrène) et parents (naphtalène, acénaphtylène, acénaphtène, phénanthrène, anthracène, fluoranthène, pyrène, chrysène et pérylène). Ces derniers prédominent dans l'ensemble du golfe, excepté aux stations 3 et 6 où les HPA alkylés à 4 et 5 noyaux condensés caractérisent les apports pyrolytiques [2]. L'importance du monométhyl phénanthrène au regard du composé parent et du di-méthyl phénanthrène dans toutes les stations du golfe, confirme la forte influence des rejets pétroliers dans la zone. L'analyse multi-diagnostique suggère que le golfe d'Arzew est sous l'influence conjuguée des rejets directs d'origine pétrolière et indirects d'origine pyrolytique (torchères).

Enfin, le calcul des MOPI (Marine Oil Pollution Index) [4] permet d'affirmer que les sédiments du golfe d'Arzew sont soumis à des influences pétrogéniques fortes à modérées.

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GEOCHEMISTRY OF PARTICULATE MATTER IN THE OTRANTO STRAIT AND THE IONIAN SEA

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Abstract

The geochemistry of major and trace elements in particulate matter (PM) from the Otranto Strait and the Ionian Sea has been studied in the framework of INTERREG-II project. Chemical elements form three groups related to detrital aluminosilicates, biogenic activity, oxyhydroxides and organic matter. Elemental distribution patterns largely follow the PM concentration that was found elevated in shelf surface waters as well as over the Greek continental slope and the Otranto Strait seafloor. PM originating in the rivers flowing in the Ionian Sea is transported toward the Adriatic Sea through the eastern part of Otranto Strait.

Keywords: geochemistry, particulates, Otranto Strait, Ionian Sea, Eastern Mediterranean

Introduction

The aim of the present communication is to provide information about the levels of major and trace elements in particulate matter (PM) of the Otranto Strait and the Ionian Sea, and moreover to evaluate elemental transport processes from the continental shelves to the Ionian Basin. Apart from a recent study on the distribution patterns of major elements in the Adriatic Sea and the Otranto Strait [1], the geochemistry of PM in the Ionian Sea had not been studied in the past. This work is part of the INTERREG-II project and presents preliminary data on the geochemistry of twenty major and trace elements determined in PM.

The Otranto Strait links the Adriatic Sea and Ionian Sea; it is about 75 km wide and maximum depth is ~780 m (Fig. 1a). The Ionian Sea can be identified as the region between Sicily and western Greece; maximum depth in the area under investigation is about 2000 m. Samples were collected along two transects: the first was located in the Strait of Otranto, and the second at the south of Kerkyra (Corfu) and Paxoi Islands in the Ionian Sea (Fig. 1a).

Methods

Combined CTD/Light transmission casts were made at 11 stations during the first INTERREG-II cruise (14-27 February 2000) on board R/V Aegaeo. Water samples were collected and filtered through membrane filters (for details see [2]) that were used for the determination of particulate matter concentration (PMC). Total elemental composition (Mg, Al, Si, P, S, Cl, K, Ca, Ti, Ba, V, Cr, Mn, Fe, Ni, Cu, Zn, As, Sr, and Pb) of the PM was determined by X-ray spectrometry at the laboratories of PMEL/NOAA [3]. Particulate organic carbon (POC) and nitrogen (PON) were analyzed by combustion methods in a CHN elemental analyzer [4].

Resulsts

On the Otranto Strait transect higher PMCs are observed: (i) in the upper 200 m of the water column, the higher PMCs (0.13-0.19 mg/L) originating in the Greek continental shelf and decreasing westwards; (ii) in mid-waters (400-600 m; PMC: 0.17-0.25 mg/L), where PM is probably detached from the steep slope; and (iii) in a zone 100-200 m thick, over the seafloor at water depths between 600 and 1000 m, which is most likely the result of surface sediment resuspension (PMC: 0.15-0.22 mg/L). Chemical element interrelations were studied with respect to their spatial distribution patterns, the correlation coefficient matrix and factor analysis scores. The majority of the elements determined (Mg, Al, Si, P, K, Ca, Ti, V, Cr, Mn, Fe, As, and Pb) follow the distribution patterns of the PMC. These elements are the constituents of terrigenous aluminosilicates, represented by Al (Fig. 1b). Sr and partly Ca are biogenous constituents and show relatively elevated concentrations in the upper waters where biological activity takes place (Fig. 1c). Similar patterns are observed for Ni, but its behavior remains unclear. Cu, Zn and Fe concentrations are higher in the particles resuspended from the Greek continental slope and probably represent a metal oxyhydroxides phase. Particulate organic carbon (POC) varied between 0.71 and 3.83 μmol/L and along with S and a part of the metals, forms an organic-related phase.

On the Ionian Sea transect surface waters (0-200 m) show higher PM concentrations (PMC: 0.2-0.3 mg/L). The geochemistry of all elements follows this prevailing pattern indicating the detrital origin of the particles (Fig. 1d). Elemental concentrations decreased constantly with depth, whereas resuspension over the slope was not identified. Element interrelations were similar to the Otranto Strait phases: lithogenic, biogenous, oxyhydroxides and organic. POC varied between 0.59 and 3.32 μmol/L, and was grouped with S and some metals.

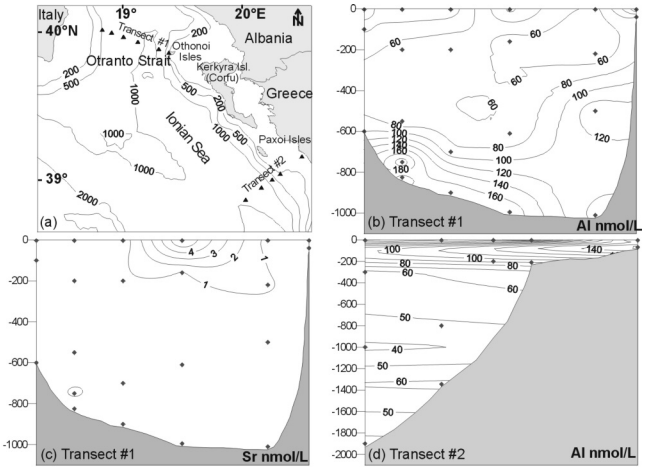

Figure 1 a : Location map, sampling stations and general bathymetry; b : distribution of particulate Al (nmol/L) at thz Otranto Strait; c : distribution of particulate Sr (nmol/L) at the Otranto Strait; and d : distribution of particulate Al nmol/L) at the trasect south of Kerkyra Isl.

Discussion and conclusions

Particulate matter originating in the western Greek mainland occupies the surface waters of the continental shelf and supplies the Ionian Sea with detrital aluminosilicates represented by Al (Fig. 1d). This material, following the general cyclonic circulation [5] is transported to the north, along the coastline, and enters the Adriatic Sea through the Strait of Otranto. PM is also entrained in the water column from sediment resuspension occurring over the eastern slope and seafloor of the Otranto Strait. However, elevated elemental concentrations in the latter area may be related to the presence of deep Adriatic water [5], which is rich in Al [1]. Significant outflow of PM from the Italian shelf has been reported [1], but was not detected, possibly due to the distance of the stations from the Italian coast.

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THE EFFECT OF DIFFUSION ON THE CONTENT OF RADIOCARBON IN PORE WATER OF DEEP MEDITERRANEAN SEDIMENTS

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Abstract

We present here field evidence from the deep SE Mediterranean sediments for significant ^{14}C excess in total dissolved inorganic carbon (DIC) of pore water down to depths of more than 2 meter. It is concluded that this enrichment is caused by diffusion of $^{14}CDIC$ across the water-sediment interface. The $^{14}CDIC$ flux distorts the ^{14}C ages of pore water, and may also severely interfere with age determination of small oceanic water masses. In addition, the ^{14}C excess can serve as a tool to identify the extant and duration of authigenic carbonate precipitation. We suggest a simple algorithm to correct for the effect of diffusion on the ^{14}C ages of pore water.

Keywords: ^{14}C; DIC ages; ^{14}C diffusion; Pore water; Deep SE Mediterranean.

Introduction

The activity of ^{14}C in the dissolved inorganic carbon in water ($^{14}CDIC$) is frequently used as a dating tool for groundwater (1), oceanic water masses (2) and marine pore water (3). It was recognized that 14CDIC activity is dependent not only on the decay of ^{14}C but also on diagenetic and transport processes (1,4-5). The effect of transport processes (diffusion, advection) was demonstrated only in theoretical studies (4-5).

Our study used field measurements to quantify the effect of the major biogeochemical processes, diffusion, advection and decay on the $^{14}CDIC$ activity in water. This was achieved by measurements of major ions and stable and radioactive carbon isotopes in SE Mediterranean deep-sea sediment and pore water. This area serves as an ideal natural laboratory to investigate ^{14}C processes due to its sole well-defined seawater end-member, relatively homogeneous sediment, steady state conditions and lack of significant advection.

Methods and Materials

Three cores, 25, 40 and 230 cm long were collected in June and September 1996, and in April 1999 at ca. 1500 m water depth in the SE Mediterranean. The cores were immediately sectioned and centrifuged under argon atmosphere to avoid contamination with atmospheric CO_2. Pore water was sampled for DIC, total alkalinity (A_T), $\delta^{13}C$ of DIC ($\delta^{13}C_{DIC}$), $^{14}C_{DIC}$ and major ion (Cl^-, Br^-, SO_4^{2-}, Na^+, Mg^{2+}, Ca^{2+}) analyses. Sediments were analyzed for stable and radioactive carbon isotopes in inorganic (SIC) and organic (SOC) fractions ($\delta^{13}C_{SIC}$, $\delta^{13}C_{SOC}$, $^{14}C_{SIC}$, $^{14}C_{SOC}$,) and also in foraminifera skeletons ($^{14}C_{SKT}$). Sediments from the long core were also sampled every 5 or less cm for $\delta^{18}O$ high-resolution chronostratigraphy.

Results and Discussion

The main results of this study are that the $^{14}C_{SOC}$, $^{14}C_{SIC}$ and $^{14}C_{SKT}$ apparent ages at each depth were similar to each other and to the independent «$\delta^{18}O_{GR}$ ages» and therefore represent the real age of the layer. The sediment ages varied from recent (top of the cores) to ca. 30 ky b.p. (bottom of the long core), covering most of the dynamic range of the ^{14}C method (ca. 5 half lives) (Fig. 1). These ages were markedly older than the apparent ages of the pore water DIC, calculated directly from the radioactive age equation (Fig. 1).

Major ions and stable carbon isotope profiles proved that this marked apparent rejuvenation of the pore water was caused by a downward diffusive flux of ~90 atoms of $^{14}C_{DIC} \cdot m^{-2} \cdot s^{-1}$ from the overlying bottom water into the sediment. A simple algorithm is suggested to correct for the effect of diffusion (6). The $^{14}C_{DIC}$ flux is opposite in direction to the DIC flux out of the sediment.

It is suggested here that the $^{14}C_{DIC}$ flux may severely interefere with age determination of small submarine «brine lakes» formed in the deep Mediterranean. In addition, the ^{14}C excess should show up in authigenic carbonate phases precipitating within the sediment and hence, may serve as a tool to identify the extent and duration of authigenic carbonate precipitation.

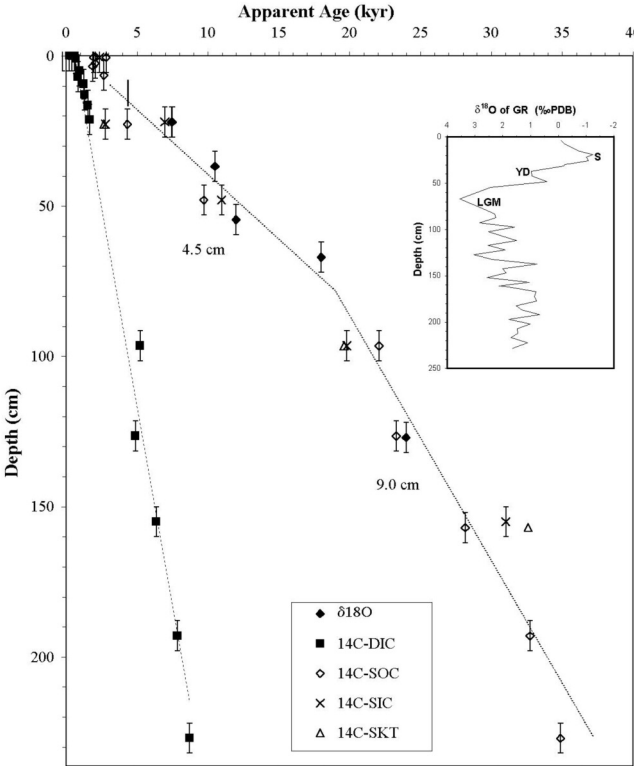

Fig. 1: Radiocarbon and $\delta^{18}O$ apparent ages as a function of depth in the long core.

$\delta^{18}O$ ages are based on the global events found in $\delta^{18}O$ depth profile of the planktonic Foraminifera Globigerinoides ruber (insert in the upper right). The identified horizons in this profile are marked as S – S1 sapropel, YD - Younger Dryas, LGM - Last Glacial Maximum. ^{14}C apparent ages were calculated for the DIC in pore water, for the inorganic and the organic sediment (SIC and SOC respectively), and for the carbonate skeletons (SKT). The ^{14}C sediment's ages of SIC, SOC and SKT and the $\delta^{18}O$ ages are similar to each other at each depth. Their profile shows a constancy down to ~5 cm due to bioturbation. A sedimentation rate of 4.5 cm kyr^{-1} (the slope of the best fit line) was calculated for the 5 to 75 cm depth interval and 9.0 cm kyr^{-1} below it.

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THE RED MULLET *MULLUS BARBATUS* (LINNAEUS 1758) AS AN INDICATOR FOR HEAVY METAL POLLUTION IN IZMIR BAY (TURKIYE)

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Abstract

Monitoring of cadmium, lead, zinc, copper and iron in different tissues of red mullet (*Mullus barbatus* L.1758) was conducted in Izmir Bay during a one year period. The levels of trace elements for *M. barbatus* were between; 0.50-1.10 μgCd/g fresh weight, 3.83-11.44 μgPb/g fresh weight, 0.49-1.05 μgCu/g fresh weight, 19.00-34.89 μgZn/g fresh weight, 90.85-170.11. μgFe/g fresh weight *in gills,* 0.94-1.66 μg Cd/g fresh weight, 2.40-9.43. μgPb/g fresh weight, 1.10-3.20 μgCu/g fresh weight, 42.00-62.25 μgZn/g fresh weight 44.00-114.71 μgFe/g fresh weight in livers, 0.14-0.53 μgCd/g fresh weight, 0.80-2.55. μgPb/g fresh weight, 0.11-0.48 μgCu/g fresh weight, 6.59-10.99 μgZn/g fresh weight 2.12-10.83 μgFe/g fresh weight in muscle tissues.At the end of this study, the edible parts of demersal fish *M. barbatus* which still contain relatively low concentrations, lie just between the safe range given by WHO.

Key Words: Heavy metals, Mullus barbatus, Izmir Bay,

Introduction

The resultant concentrations of metals in biota arise from a series of complex interactions between several processes. In any particular organism, tissue metal concentrations reflect the amount of metal taken up into the organism (1). Especially, investigations of metals in fish are an important aspect of environmental pollution control. Contaminant accumulation in various fish tissues is used as a measure of contaminant exposure and effects. The accumulation of heavy metals in fish depends on several factors, namely trophic concentrations and age/size which comprise the nature and activity of organisms. Physicochemical variables determine its bioavailability by controlling the speciation, binding, release, distribution and biogeochemical pathways of heavy metals in the environment (2). The subject of this study was to screen the trace metal concentrations (Cd, Pb, Zn,Cu, Fe) in different tissues of the demersal fish *M. barbatus* caught in Izmir Bay during a one year period.

Sampling area

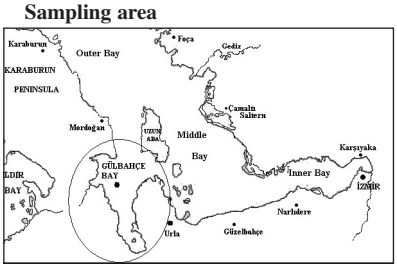

Fig.1. Map of sampling locations.

Izmir Bay (Aegean Sea, Turkiye) receives pollutants from direct urban effluents, industrial zones and the sewage of 3.000.000 inhabitants of Izmir City. Since 1999 only 30-40% of these wastes had been treated in the sewage plant. Effluents from land-based activities are also discharged into Izmir Bay through 11 rivers and 128 channels. The bay is divided into the Inner, Middle and Outer Bay from the standpoint of topographical and hydrographical characteristics. Fish were caught in Gülbahce Bay which is located in middle part of Izmir Bay (Fig.1).

Methodology

During the period November 1999- October 2000, *M. barbatus* specimens were caught in Izmir Bay by trawl from the Gülbahce region of Izmir Bay. All fish samples were placed in plastic bags and stored below –20°C until analysis. Dorsal muscle, liver and gill were taken from specimens of similar size. Single homogenized tissues were also taken for analyses. These samples were prepared according to international standard methods (3). The composite samples were weighed and digested with conc. HNO_3: $HClO_4$ (5:1) under reflux and filtered. Metal samples were analyzed by atomic absorption spectrophotometer using a PYE Unicam SP 9 (AAS). Metals were determined by direct aspiration using air-acetylene flame. Intercalibration fish muscle homogenate samples (IAEA-407/TM from Monaco Laboratory) were used as a quality control sample for the analytical methodology.

Results and discussion

Some demersal fish species (especially *M. barbatus, M. surmuletus* and *Upeneus moluccensis*) are known to accumulate high levels of trace metals in their different tissues, and these species are commonly used in biomonitoring studies.(4) Bioaccumulation in demersal marine fish species adequately reflects the changing levels in the environment for trace metals. The degree of their accumulation depends on their metabolic activity, growth, biochemical composition and reproductive and feeding condition (5,6). The levels of trace elements in demersal fish *M. barbatus*, sampled from Izmir Bay have changed slightly; 0.50-1.10 μg Cd/g fresh weight, 3.83-11.44 μg Pb/g fresh weight, 0.49-1.05. μg Cu/g fresh weight, 19.00-34.89 μg Zn/g fresh weight , 90.85-170.11. μg Fe/g fresh weight *in gills*, 0.94-1.66 μg Cd/g fresh weight, 2.40-9.43 μg Pb/g fresh weight, 1.10-3.20 μg Cu/g fresh weight, 42.00-62.25 μg Zn/g fresh weight. 44.00-114.71 μg Fe/g fresh weight *in livers*, 0.14-0.53 μg Cd/g fresh weight, 0.80-2.55 μg Pb/g fresh weight, 0.11-0.48 μg Cu/g fresh weight, 6.59-10.99 μg Zn/g fresh weight 2.12-10.83 μg Fe/g fresh weight in muscle tissues. The average concentrations and accumulation ratio of heavy metals determined in different tissues of *M. barbatus* are shown in Figs 2, 3. All values being expressed on a μg g-1 fresh weight basis. Previous trace metal levels in muscle of *M. barbatus* are given in Table I from different regions of Izmir Bay. The following order was found between the different tissues in accumulating trace metals; Liver>Gill>Muscle for Zn, Cu and Cd, Gill>Liver>Muscle for Fe and Pb and in general the order of heavy metal concentrations in liver and muscle was Fe>Zn>Pb>Cu≥Cd , and in the gill the order was different Zn>Fe>Pb>Cu≥Cd.

Table I. Previous trace metal levels in muscle of Mullus barbatus from different regions of Izmir Bay. (μg g-1 fresh weight) - **This study*

Location/Metals	Cd	Pb	Cu	Zn	Fe	Year	Ref.
Gulbahce Bay	0.10	1.18	0.95	5.98	5.80	1984	8
Cesme offshore	0.006	0.14	-	-	-	1998	9
Gulbahce Bay	0.25	1.67	0.25	8.71	6.42	2000	*

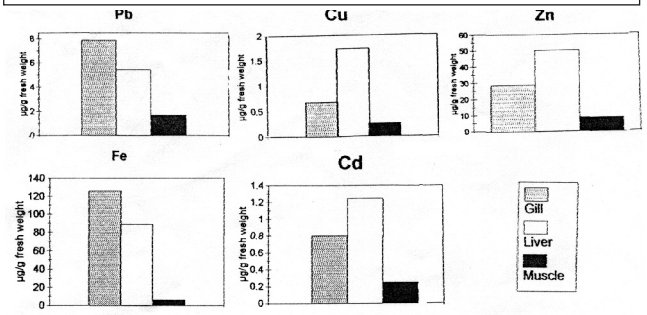

Fig. 2. Average concentrations of heavy metals in different tissues of *M. barbatus* (μg g-1 fresh weight).

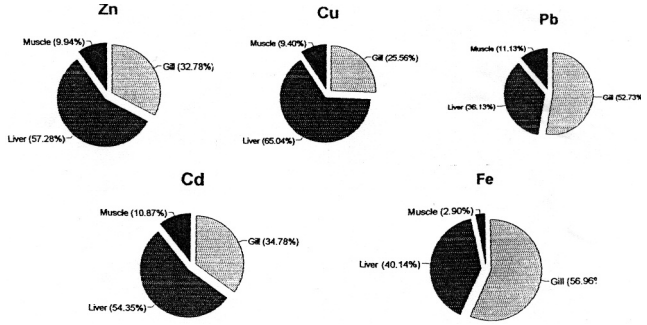

Fig. 3 . Accumulation ratio of Heavy metals in different tissues of *M. barbatus*.

Conclusions

In conclusion, this study indicates that significant long-term changes of heavy metal concentrations in *M. barbatus* in Izmir Bay parallel to the observed increase of Izmir Bay pollution. Since the mid 1980's heavy metal concentrations in sea water have increased remarkably in inner part of Izmir Bay. This is very important because heavy metal pollution of inner part of Izmir Bay represents a serious problem. Although the edible parts of demersal fish *M. barbatus* (L 1758.) which still contain relatively low concentrations, lie just between the safe range given by WHO (0.2 mg/kg wet weight for Cd, 2.0 mg/kg wet weight for Pb, 20.0 mg/kg wet weight for Cu, 50.0 mg/kg wet weight for Zn) (7), it would be prudent to continue monitoring trace metals in demersal fish species which are eaten by humans.

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SEASONAL VARIABILITY OF PARTICULATE AND DISSOLVED CARBOHYDRATES IN THE NORTHERN ADRIATIC

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Abstract

Particulate (PTCHO) and dissolved (DTCHO) carbohydrates were measured using the MBTH method along a transect in the central part of the northern Adriatic in order to determine their seasonal variability with a special emphasize on the relationship with phytoplankton dynamics. Distribution of PTCHO was well-correlated with chlorophyll *a*, showing maxima during spring and autumn phytoplankton blooms. In contrast, DTCHO showed maximum levels during summer stratification, indicating a significant accumulation of carbon-rich organic matter during that season.

Key words: organic matter, Adriatic Sea, phytoplankton, particulates

Introduction

During the last two decades episodes of hypertropic formation of organic macroaggregates in the northern Adriatic seemed to occur at a much higher frequency than it was in the past (1). Since carbohydrates represent the major constituents of the northern Adriatic mucilage, study of their seasonal variability and the contribution to the overall carbon cycle in the basin is one of the important prerequisites for understanding this phenomenon. There have been recently several studies looking into the distribution of carbohydrates in the northern Adriatic (2, 3, 4), however, none of the studies provided a full insight into the seasonal variability of particulate and dissolved carbohydrates over the whole annual cycle.

Methods and Materials

Study area and sampling: Samples for the carbohydrate and pigment analyses were collected in the middle part of the northern Adriatic at several stations along the Po River mouth-Rovinj transect, which is generally accepted as representative of eutrophication gradients the northern Adriatic. Sampling was performed in the period from February 1998 to December 1998 from the research vessel *Vila Velebita* at 5-6 depths (0, 5, 10, 20, 30 m and near bottom) using 5 l Niskin bottles.

Determination of carbohydrates: Seawater samples (150 ml) were filtered on board onto 47 mm GF/F filters. The filtrate, containing dissolved CHO, was poisoned with $HgCl_2$ (final concentration 20 mg/l) and stored in the dark at 4°C until analysis. The filters, containing particulate CHO, were transported in liquid nitrogen and finally stored at –80°C until analysis. Dissolved and particulate carbohydrates were determined spectrophotometrically using the MBTH method, following the procedure by Johnson and Sieburth (5) and including an HCl hydrolysis step (100°C, 3.5 h, 1.7 mol/l HCl). Samples were analysed in duplicate and quantification was performed using glucose as a standard. All concentrations are expressed in glucose carbon equivalents, multiplying the weight glucose equivalents by 0.4, since glucose is 40% carbon by weight. Chlorophylls and carotenoids were determined using a reversed-phase HPLC method (6).

Results and discussion

The Northern Adriatic is a very dynamic system characterized by conspicous spatial gradients of hydrographic properties and trophic conditions, especially in its western part, which is under the strong influence of freshwater discharges from the north Italian rivers. The distribution of carbohydrates is therefore very complex and shows rather pronounced temporal variability. Figure 1 illustrates the seasonal variability of PTCHO, DTCHO and chl a in the two characteristic layers of the station SJ 108, which is situated about 12 nautical miles from the Po River mouth. The concentration of PTCHO in the upper layer varied in the range from 23-276 μgC/l with maxima occuring in October and May/June. These two peaks coincided with maxima of the phytoplankton crop after typical spring and autumn freshets of the Po River. A smaller maximum of PTCHO in the bottom layer observed in mid summer can be interpreted as a consequence of phytobiomass thriving on regenerated nutrients. The distribution of DTCHO showed no correlation with chlorophyll *a*. In fact, the highest levels of DTCHO in the upper layer were observed during summer stratification (316-539 μgC/l) while the phytoplankton crop remained low. The reason for this observation is most probably an enhanced release of carbon-rich organic matter by summer phytoplankton in nitrogen-depleted conditions. This process seems to be effective only in the upper layer of the stratified water column, while the concentration of DTCHO in the bottom layer remains rather low (98-207 μgC/l) and relatively constant throughout the year.

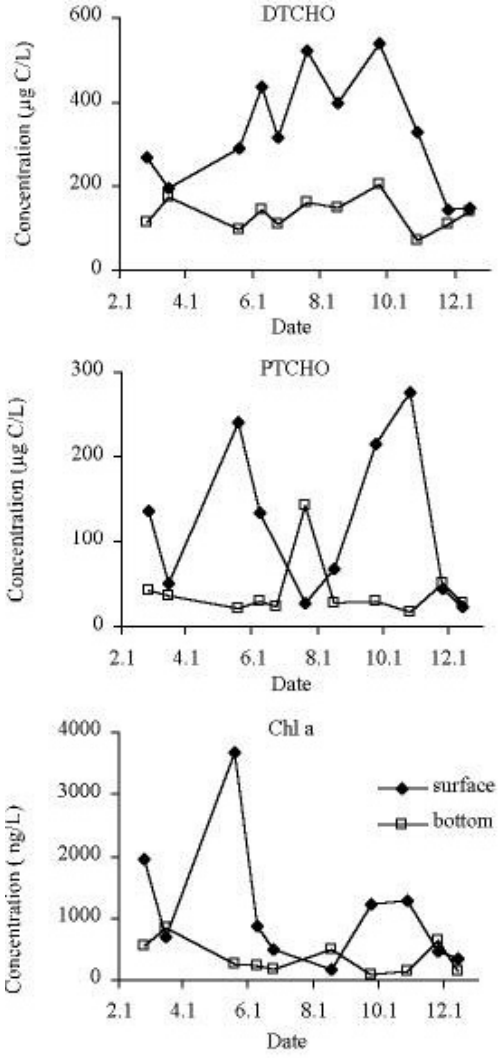

Fig. 1 Seasonal distribution of particulate and dissolved carbohydrates and chlorophyll *a* in the surface (0 m) and bottom (30 m) layer of the station SJ108.

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VERTICAL PARTICLE FLUX IN A BRACKISH WATER LAGOON, KÜÇÜKÇEKMECE LAKE, IN NORTHWESTERN TURKEY

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Abstract

Vertical particle fluxes are relatively high in this brackish water region. In the upper 10 m the daily flux varied between 5.7 - 21.3; 3.4 – 4.5 and 0.7 – 2.9 g m^{-2} d^{-1} for total mass, organic matter and carbonate, respectively. The highest particle flux was recorded during April and June. Concentrations of Zn and ^{210}Po in sinking particles were found to be 10764 μg g^{-1} d.w. and 1746 Bq kg^{-1} w.w. for particles > 1μm.

Key-words: particle flux, metal, polonium, brackish water

Introduction

Küçükçekmece Lake, a lagoon containing brackish water, is located on the western outskirts of Istanbul . The geographical position of the lake is 41°00' N – 28°43' E and it has a 15 km^2 surface area with a maximum depth of 20 m. Some physical and chemical parameters, measured at different stations in the lake, indicated that Küçükçekmece Lake is eutrophic (1). Furthermore, some papers have been published previously concerning heavy metal and radioactivity levels in biota and sediment samples from the lake (2,3). The collection of sedimenting material in aquatic environments using different types of sediment traps is a method frequently employed by many scientists for different purposes (4-6). It is well known that studies of vertical particle flux have adequately explained the differences with regard to the quantity and quality of the particulate matter exported from the upper layers as well as seasonal and inter-annual differences (6). A literature review of various types of sediment traps and brief survey of applicable sedimentological concepts have been previously published by Blomqvist and Hakanson (7).

Our objectives in this study were (a) to measure mass, organic matter and carbonate fluxes, (b) variability of flux during different seasons under brackish water conditions and (c) to determine some metal and ^{210}Po concentrations in the sedimenting particulate material.

Materials and methods

Vertical flux of particulate mater was determined using a Hydro-Bios model (Saarso), cylindrical trap with 14 cm diameter and 56 cm height. The trap had a conical bottom which ended in a 280 ml sample jar. We have regularly monitored particle fluxes at one station (12 m depth) in the lake from September 1998 to July 1999. The depth of deployment was 10 m and the duration of the deployment was 24 h for each collection. Upon arrival at the laboratory, sediment trap samples were separated from larger organisms by sieving through 1500 μm and 600 μm mesh sizes, and then the wet sample was split into 1/4 aliquots using a rotary splitter. Three 1/4 aliquots were filtered through precombusted and preweighed 47 mm Whatman polycarbonate filters of 1 μm and 0.2 μm pore size. After that the filters were rinsed with 250 ml prefiltered distilled water. The filters were than dried at 60°C for 24 h and weighed. The mass, organic matter and carbonate fluxes were determined using the methods of Puskaric *et al*. (4). Determinations of metal and ^{210}Po concentrations in the particulate matter were similar to that previously described (8-9).

Results and discussion

The highest sedimentation fluxes of mass, organic matter and carbonate were recorded in April and June (Fig.1). Our results indicated that these high fluxes were related to phytoplankton and zooplankton abundances. The Secchi disc depth and suspended matter values in the surface water of the lake were found to be 0.3 and 0.5 m and 18 and 21 mg l^{-1} in April and July, respectively (1). In contrast, the highest Secchi disc and the lowest suspended matter values were noted in October and December. In the lake's surface waters, BOD5 ranged from 0.86 to 9.10 mg l^{-1} with the higher values observed in April and July (1). This observation also indicates a rapid degradation of biogenic materials. Examining the results in detail, it can be seen that the smallest mass flux represented ~40 %, of the total particulate material with the exception of the January samples. This suggests that natural planktonic bacteria also play a significant role in the mass flux. Furthermore, the organic matter flux was much greater than carbonate flux in this brackish water environment. The metal concentrations in sediment trap water and particulate materials are shown in Table 1. The sediment trap material (> 1μm) contained a higher concentration of Cr, Sc, Zn and Co than in the other fractions examined. The Cr, Fe, Zn and Co levels in sediment trap material (>1 μm) are higher when compared with the deep sediment samples of Küçükçekmece lake (2-3). The highest ^{210}Po natural activity in sedimenting particles from the brackis lake was recorded during May 1998 (1746 Bq kg^{-1} in the > 1 μm fraction) (Table 1). Our preliminary results on vertical particle fluxes show that it is necessary to have more ancillary data (e.g., nitrogen flux, lithogenic flux, fecal pellet flux, chlorophyll a equivalent flux) in order to better understand the transfer and transport processes affecting chemical pollutants and natural radionuclides in this unique brackish lake which is heavily influenced by man's activities.

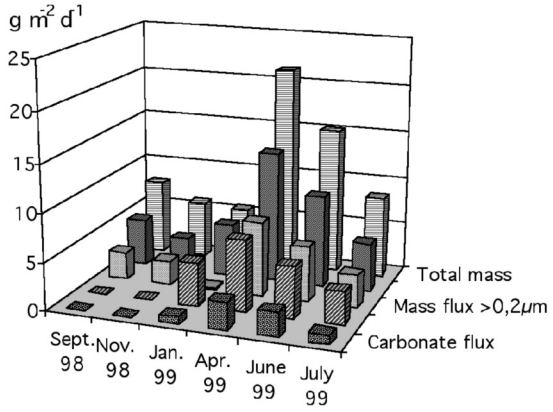

Fig. 1. Vertical particle flux in a brackish lagoon measured over 24h with a sediment trap.

Table 1. Metal and 210Po concentrations

Metals µg g-1 d. w. June 1998	Sediment trap water	Sediment material >1µm	Sediment material > 0.2 µm
Br	1208±245	938±290	284±177
Th	0.38±0.18	7.43±1.15	3.67±1.41
Cr	15.6±2.5	123.4±22.1	47.4±23.7
Sc	0.41±0.03	7.73±0.43	1.09±0.12
Fe	2013±139	30019±862	4002±845
Zn	3345±220	10764±519	1868±114
Co	1.09±0.16	16.43±1.11	5.61±1.13
Radionuclide			
^{210}Po Bq kg^{-1} w. w.			
January 1998	-	587±17	-
May 1998	-	1746±83	983±115
June 1998	-	405±29	491±54
July 1998	-	134±12	

Acknowledgement. Thanks are due to IAEA for supporting part of this study under its Technical Co-operation project for the Küçükçekmece Lake Region (TUR/2/012) and Technical Co-operation project (RER/2/003) for instrumental asistance . We also thank I.Akkurt for his valuable assistance.

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MEASUREMENT OF ELEMENT CONCENTRATIONS IN MARINE NANOPLANKTON CELLS USING AN X- RAY FLUORESCENCE MICROPROBE

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Abstract:
A novel technique is described for the quantification and localization of trace elements in marine nanoplankton that utilizes brilliant synchrotron x-rays to excite fluorescence. Thirteen individual cells, including ciliates, diatoms, and autotrophic flagellates collected off the coast of New York were analyzed for K, Ca, Fe, Cu, and Zn. There was considerable variability in trace metal concentrations both within and among taxa from a single site. This technique for studying the distribution of elements within single cells may provide a unique understanding of metal-biota interactions.

key words: synchrotron; metals; plankton

Introduction

The development of "clean" techniques has led to a sharp increase in studies on the geochemistry of trace metals and their roles as limiting nutrients for oceanic primary production. These studies require the use of bulk size-fractionation techniques to isolate organisms or particles from their surrounding liquid medium for analysis. Typically, whole water is collected and filtered either serially or in parallel through 0.2, 2.0 and 20 μm membrane filters to divide the particles into the corresponding biological size classes of pico-, nano-, and microplankton (1). The filters are then rinsed and analyzed for metal content. This approach can only provide information about the metal contents of the trapped particles in aggregate. In situations where there is a mixed assemblage of microbial organisms (as is usually the case in natural waters), this "bulk chemistry" technique cannot distinguish metal concentrations in different organisms of the same size or between living and abiotic particles. Additionally, heterogeneity among cells of the same species is not assessed, as all of the particles in a certain size class are grouped together for analysis.

Materials and methods

We have attempted to overcome the limitation of bulk- chemistry metal analysis through the use of a high-brilliance synchrotron x-ray fluorescence microprobe at the Advanced Photon Source (APS) at Argonne National Laboratory. This instrument uses highly-focused x-rays to induce fluorescence in metal atoms within individual plankton cells (2). Natural plankton samples are mounted on EM grids, and individual cells of interest are identified either through light or epifluorescence microscopy. The grids are then mounted in the x-ray microprobe and the same cells identified and characterized by light microscopy are targeted and scanned with the x-ray beam. The optics of the x-ray beam can be adjusted to increase photon flux (increasing sensitivity) or to reduce the area of the beam (increasing resolution). At each pixel in the two dimensional scan, the elements present in the sample are excited by the incident x-ray beam and emit fluorescent photons at characteristic energies, producing a fluorescence spectra for each pixel detected by germanium lithium detectors. The fluorescence intensity is quantified and converted to metal concentration through the use of standards. The technique is similar to energy-dispersive x-ray fluorescence used to quantify elements in macrophyte algae (3). Without the brilliant x-rays provided by the synchrotron, however, this technique lacks the sensitivity to measure metals in single-celled plankton samples. New third-generation synchrotrons such as the APS provide the necessary x-ray intensity. Additionally, advances in x-ray optics have reduced the size of the incident x-ray beam, increasing the resolution of the instrument to 0.2 μm (or 0.04 μm^2). The microprobe has the sensitivity to quantify and map Si, Ca, K, Fe, Cu, and Zn (and potentially Cr, Mn, Ni, As, and Se) in individual planktonic particles. The high resolution allows us to quantify element concentrations in different particles and to map the distribution of metals within single particles. We have used this novel technique to quantify elemental concentrations in several different classes of nanoplankton collected off the coast of Southampton, NY. In order to present the results as cellular concentrations, cellular metal contents were normalized to biomass by assuming a squashed ellipsoidal cell shape in combination with published estimates of C:volume ratio for each type of cell (4-6) and assuming C:dry weight conversions of 3 for ciliates and flagellates and 4 for diatoms. We examined two oligotrichous Strombidium-like ciliates 15 μm in diameter, 6 large Thalassiosira-like centric diatoms (25 μm diameter), and 5 small autotrophic flagellates (6 μm diameter).

Results and discussion

The measured concentrations of K, Ca, Fe, Cu, and Zn in ciliates, diatoms and flagellates are shown in Table 1. We included K and Ca in our results as possible indicators of cellular biomass. These are the first reported results, to our knowledge, of metal concentrations in individual phytoplankton and protozoa cells. All of the samples were collected from the same site and the ciliate and diatom cells appear to be of the same genus, respectively. Although these results are based on a small sample size, they suggest that there is considerable variation in the metal concentrations of similar cells from the same location as well as between the different cell types. The diatoms show the highest metal concentrations of all the cells, and the flagellates have significantly lower concentrations than the two groups of larger cells. The concentrations of Fe, Cu, and Zn in the ciliates and flagellates are within the range of values reported for plankton from bulk chemical measurements taken during a diatom bloom off Monterey, CA (7), but the diatoms in the present study have Fe and Cu concentrations that are 135% and 231% higher, respectively. Our results might be expected to be higher since the other study included all plankton-sized particles, including detritus that may have had lower metal concentrations.

Table 1. Concentrations of five metals in marine ciliates (n = 2 cells examined), diatoms (n = 6 cells), and flagellqates (n = 5 cells). Mean values (µg g-1 dry wt) and standard deviations (SD) are given.

Element	Ciliates (n=3)	SD	Diatoms (n=6)	SD	Flagellates (n=5)	SD
K	16,781	20,857	35,759	21,533	1,546	934
Ca	8,264	2,772	19,772	16,527	2,397	1,413
Fe	424	117	809	575	87	40
Cu	337	140	693	183	88	111
Zn	106	0	295	134	37	22

This technique also shows promise as a tool for studying the internal distribution of metals within individual plankton cells. Fig. 1 shows the distributions of 6 elements in one of the diatom cells. The elemental concentrations vary spatially: Si is primarily found in the exterior test of the cell; Cl, Ca, and Zn are more common in the organic biomass of the cell, as shown by their density in the two frustules of the cell; Fe appears to be highly localized in the upper frustule.

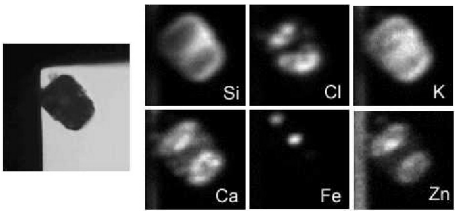

Fig. 1: The first image (right) is a light micrograph of a diatom. The other six images show the distribution of Si, Cl, K, Ca, Fe, and Zn within the same cell, based on x-ray fluorescence.

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TEMPORAL AND GEOGRAPHIC VARIABILITY OF PARTICULATE METAL CONCENTRATIONS IN BRINES USED IN CRYSTALLIZATION PROCESSES FOR SALT PRODUCTION

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Abstract

Suspended particulate matter seperated during two different seasons from brine ponds of a saltworks system were analysed for Fe, Pb, Cd, Cr, Cu and Zn. It was found that during both seasons the metal concentrations were markedly high in the first ponds of the system while they decreased with decreasing distance from the crystallizers. However, the waters entering the crystallizers contained significant amounts of particulate metals. This phenomenon should be investigated further in relation to the crystallization processes and the quality of the produced salt.

Keywords : particulate metals, lagoons, eastern Mediterranean, brines.

Introduction

The Mesolongi saltworks are located on the eastern coastal zone of the inner part of the Mesolongi lagoon (1, 2, 3). The extreme environmental conditions occuring in the Etolikon lagoon, in the vicinity of the saltworks due to its physiography, combined with the input of large quantities of metals in the lagoon derived from agrochemicals and other anthropogenic sources lead to an increase of metal concentrations in the waters of the area (4).

The aim of this work was to investigate the geographic and temporal variability of particulate metal concentrations in the brine ponds through which the water passes prior to its use in the crystallizers for the production of salt. It is considered that this investigation is of great importance because it can lead to conclusions related to the quality of waters and brines used which affect the quality of the salt produced.

Methods and materials

It is noteworthy that station PS1 which is the main pumping station for the water input to the saltworks aquatic system is characterized by low concentrations of SPM. The geographic distribution of SPM shows that stations at the northern part of the aquatic system, nearer to the crystallizers, are generally characterized by higher concentrations of SPM relative to the stations in the southern part of the system.

In order to determine the geographic variability of the quality of waters used in the crystallization process for the production of salt, SPM samples obtained along the brine ponds were analyzed for Fe, Pb, Cu, Cd, Cr and Zn. For the separation of SPM, waters/brines were filtered using a vaccuum pump and millipore filtering system with membrane filters of 0.45 μm pore size. The SPM material was then leached with hot 50% HCl for 3 hours and analyzed using a Perkin Elmer 2100 atomic absorption spectrophotometer. The precision was checked with replicates and the accuracy with standard samples, and were found to be below ±5% and ±2%, respectively.

Results and discussions

Geographic variability of particulate metal concentrations in spring 1995.

Iron, Copper, Lead

Iron varied in SPM between 53 μg/g and 2476 μg/g (Table 1) with its highest value found at station PS III. At this station Fe was markedly enriched relative to all other stations. At station PS IV Fe was slightly increased relative to station PS II. At station PS VI/15 the Fe concentration was very low. Generally Fe in SPM decreased in the following order :

PS III > PS IV > PS II > PS VI/15A > PS VI/15 (the number of stations increase with decreasing distance from the crystallizers).

The concentrations of Cu varied between 2 μg/g and 24 μg/g. The highest concentrations of Cu were observed at station PS III with equally high values found at stations PS II. Lower values were observed at stations PS IV, PSVI/15 and PSVI/15A.

It should be stressed that Pb exhibited marked enrichments in SPM, varying between 32 μg/g and 354 μg/g. As in the case of Fe and Cu, Pb displayed its maximum concentration at station PSIII with evaluated values at station PSII and lower values at PSIV, PS VI/15 and PS VI/15A, respectively.

Cadmium, Chromium and Zinc

The distributions of Cd and Cr differ from those of the other metals since both metals show very low values at stations PS III. However, both metals exhibited high values at station PS II. Low values of Zn were observed only at stations PS VI/15A and PSVI/15.

Table 1. Seasonal variability of particulate metal concentrations in the brine ponds.

Season	Fe µg/g	Pb µg/g	Cu µg/g	Cd µg/g	Cr µg/g	Zn µg/g	SPM gr/l
Spring	53-2476	32-354	2-24	0-4	0-74	0-8	0.0015-0.724
Summer	66-3467	32-942	10-67	0-13	0-67	0-173	0.032-0.960

Temporal variability of particulate metal concentrations

A comparison between the particulate metal levels found in early spring and those observed in late summer 1995 showed that the later were markedly higher. However, their geographic variability in the later samples was similar to the former with the highest Fe, Cu, Pb, Cd and Zn values found at station SP III.

A comparison between the metal concentrations obtained prior to pumping with those obtained after transfering the water to the next basin (i.e. stations SPIII, SPV) showed that the waters in the basin prior to pumping have higher concentrations of particulate metals (i.e. Fe, Pb, Cd).

Geochemical Behaviour of Metals

In order to determine the geochemical behaviour of the metals studied, the correlation coefficients among their concentrations were calculated. On the basis of this analysis the following grouping of metals was observed.

i) Fe, Pb, Cu; ii) Cd, Zn.

It is implied that Pb and Cu may be associated with the Fe oxide fraction of SPM, while Cd and Zn may be contained in a different SPM fraction. Although organic carbon was not determined in the SPM, Zn and Cd may be bound to the organic fraction of SPM since they have been found to be associated with organic carbon of the sediments from other regions.

Conclusions

The present data show significant enrichments as well as geographic and temporal variability in the particulate metal levels in the brines prior to their use in crystallizers for the production of salt. Significantly higher metal concentrations were observed in summer compared to spring.

The particulate metal concentrations during both sampling periods are generally very high in the first ponds and they decrease with decreasing distance of the basins from the crystallizers. This phenomenon is very pronounced in the case of Pb. However, particulate metal concentrations remain high in the waters entering the crystallizers. This phenomenon needs further investigation as it relates to the quality of the produced salt.

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CACO3 PRECIPITATION FROM ARTIFICIAL SEA WATER THE INFLUENCE OF ORGANIC AND INORGANIC ADDITIVES

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Abstract
The influence of montmorillonite and fulvic acid on the precipitation of calcium carbonate from artificial sea water (ASW) is investigated. Precipitation from pure ASW results in formation of aragonite. Calcium montmorillonite, which was found to be a promotor of the precipitation of calcite from the system containing only constituent ions, does not cause the same effect on the precipitation from ASW. In this case aragonite is formed. Fulvic acid inhibits the precipitation, causing a delay in the precipitation process. When montmorillonite is added together with fulvic acid, no delay in the precipitation is observed.

Keywords: calcium carbonate, precipitation, montmorillonite, fulvic acid

Introduction

Spontaneous precipitation of calcium carbonates may result in formation of one of the three polymorphs: vaterite, aragonite or calcite depending on the initial concentration of constituent ions, temperature and impurities. Vaterite usually precipitates from a solution containing only constituent ions (1), precipitation from artificial seawater (ASW) always results in formation of aragonite (2), calcium montmorillonite is found to be a suitable substrate for the precipitation of calcite (3), while organic impurities inhibit the process (4). The influence of montmorillonite and fulvic acid on $CaCO_3$ precipitation from ASW is investigated in this work. The main purpose was to find out if montmorillonite could promote the precipitation process and formation of calcite from ASW and in the presence of organic matter.

Experimental

Artificial sea water was prepared as $5 \cdot 10^{-1}$ mol dm^{-3} NaCl, $5 \cdot 10^{-2}$ mol dm^{-3} $MgSO^4$, 10^{-2} mol dm^{-3} CaCl2, $2 \cdot 10^{-3}$ mol dm^{-3} $NaHCO_3$ and $2 \cdot 10^{-4}$ mol dm^{-3} Na_2CO_3. Montmorillonite (g = 0.4 g l^{-1}) and/or fulvic acid (c = 4 ppm) were added after the ASW was prepared. Finally, 10^{-1} mol dm^{-3} NaOH was used to increase the pH to initiate the precipitation. The propagation of reaction was followed by measuring the pH of the solution. Composition of the precipitate was determined by using a FT-IR spectroscopy.

Results and discussion

The curves shown in Figure 1 represent the precipitation from the reference system (only ASW), from the ASW containing fulvic acid, and from the ASW with fulvic acid and montmorillonite. Precipitation of $CaCO_3$ from ASW started after approx. 40 minutes and resulted in formation of aragonite. Addition of fulvic acid significantly delayed the process – precipitation started after 150 minutes, and the resulting precipitate was again aragonite. This experiment confirmed the inhibiting effect of organic substances on the precipitation process.

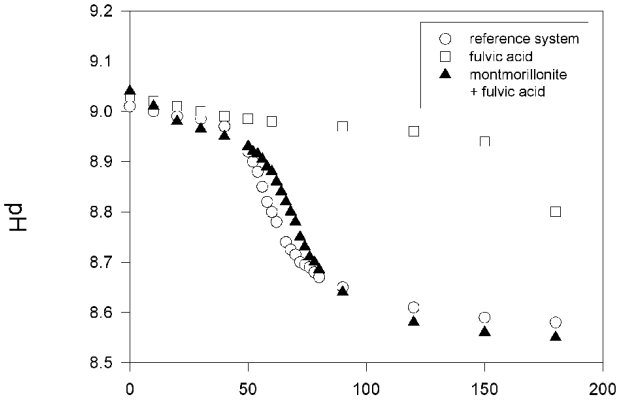

Figure 1. Variations of pH with time for the reference system (only ASW), system with fulvic acid added, and system with fulvic acid and montmorillonite.

The addition of montmorillonite did not have a significant effect on the $CaCO_3$ precipitation from ASW. As opposed to the precipitation from the system containing only constituent ions where the resulting precipitate was calcite (2), precipitation from ASW resulted in aragonite formation. Ionic species present in ASW (Mg^{2+} especially) obviously have a much stronger influence on the formation of a certain polymorph than montmorillonite.

However, the role of solid substrate in the precipitation process is not so insignificant. When montmorillonite was added in the system together with fulvic acid, there was no delay in the process. The precipitation started after about 40 minutes – the same as with the reference system.

These experiments are the first in a series of investigations of the calcium carbonate precipitation from complex systems. Further experiments will be performed from the natural sea water with some other dissolved and undissolved additives included.

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SEASONAL VARIABILITY OF DISSOLVED TRACE ELEMENTS AT TWO STATIONS OF THE AEGEAN SEA

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Abstract

Dissolved trace elements (Cd, Co, Cu, Fe, Ni, Mn, Pb) were measured on a seasonal basis at two Stations (MNB1, MSB1) in the North and South Aegean Sea, respectively. From the results obtained it appeared that the differences in the hydrology and input sources of the two sub-areas (North and South Aegean) are reflected in the distribution of trace elements. The seasonal variations observed were more pronounced for Mn and Cd, and are related to the strength of the input sources rather than to biological processes.

Keywords: Trace elements, surface waters, Aegean Sea, Eastern Mediterranean

Introduction

The North Aegean Sea represents a Mediterranean regime with both coastal and pelagic characteristics. The area receives fresh and brackish water inputs from three major rivers (Evros, Nestos, Strymon) situated along the northern Greek coastline and from the Black Sea and the Sea of Marmara through the Dardanelles Straits. It has been well documented that the surface layer of the North Aegean is largely affected by the presence of the above mentioned inputs (1). On the contrary, the South Aegean is unaffected by coastal runoff or the Black Sea outflow, and it is considered as a more typical pelagic area of the Mediterranean. The scope of this presentation is to show whether the above mentioned differences in the hydrology and input sources of the two sub-areas (North and South Aegean) are depicted in the distribution of trace elements.

Methods and Materials

For this purpose we present dissolved trace metal (Cd, Co, Cu, Fe, Ni, Mn, Pb) concentrations for two locations in the Aegean Sea on a seasonal basis. The location 40.16,00N 25.12,00E (MNB1) in the North Aegean was sampled five times in the period from March 97 to April 98 (3/97, 5/97, 9/97, 2/98, 4/98) and the location 35.44,70N 25.06,00E (MSB2) in the South Aegean was sampled three times (3/97, 9/97, 4/98) during the same period. The above Stations were chosen because they depict the prevailing trends in these two sub-areas. During sampling and analysis precaution was taken against contamination and "clean techniques" were applied. The analytical method used is presented elsewhere (2). Trace element concentrations were determined by graphite furnace AAS, a Perkin Elmer 4100, HGA 600. The accuracy of the method was tested against a certified reference seawater sample (NASS-4). Salinity data were taken from the CTD profiles.

Results and Discussion

Mean Cd concentrations at Station MNB1 exhibit maximum values of 0.128 nM and 0.109 nM during spring and summer, respectively, which fall to 0.047 nM during winter. This seasonal pattern, although less pronounced, is followed at Station MSB1 too, with mean Cd concentration 0.103 nM in spring and 0.071 nM in winter and summer. Copper showed similar concentration levels in both areas during all seasons with values fluctuating around 2.00 nM. Mean Ni concentrations were slightly higher at Station MNB1 (5.40 nM in winter, 6.94 in spring and 5.25 nM in summer) than at Station MSB1 (3.58 nM in winter, 4.93 nM in spring, 5.25 nM in summer) and no clear seasonal pattern could be established for this element. Manganese shows increased concentrations at Station MNB1 compared to those of Station MSB1. In particular mean Mn concentration at MNB1 during winter and spring is 2.36 nM and 2.02 nM respectively and peaks to 3.68 nM during summer. At Station MSB1 mean Mn concentrations are low, 1.18 nM in winter and 1.00 nM in spring, but peak to 2.35 nM in summer. So in both areas there is a clear trend with increasing Mn concentrations during the summer months. Cobalt was measured only in the North Aegean Station (MNB1) during summer and spring and showed mean concentration values of ~0.190 nM. Lead and iron were measured at both stations only during summer (9/97) and spring (4/98). Lead showed similar concentration values in both areas ~0.2 nM. Increased Fe mean concentrations (~4.00 nM) were recorded at Station MNB1, whereas Station MSB1 showed somewhat lower Fe levels. The above-mentioned results are referring to the whole watercolumn as shown in Figs. 1 and 2.

In Figures 1 and 2, the vertical distribution of trace elements at the two sampling locations is presented along with the salinity data. From Figure 1 it is apparent that the low salinity surface layer of Station MNB1 is enhanced in trace elements. It seems that the increased fresh and brackish water inputs in the North Aegean carry significant amounts of trace elements, which result in elevated trace element levels in the surface layer. This is very clearly depicted in the case of Mn, where the very low salinity values of September '98 correspond to maximum Mn concentrations. It is obvious that the above-described feature weakens any nutrient-like behaviour expected from elements such as Cd, Cu and Ni and strengthens the scavenging character of elements such as Mn, Fe, Co and Pb. The scavenging character is also clearly depicted in Figure 2 for Station MSB1 in the South Aegean. In contrast to the North Aegean situation, in the South Aegean there is neither surface enhancement nor surface depletion for elements Cd, Cu, and Ni and it seems that any nutrient-like behaviour present is very weak and not clearly detected from the present data set. It should be noted here, that this feature is common in the Western Mediterranean Sea too (3), and has been attributed to the proximity of land sources and the oligotrophic character of the Mediterranean Sea.

Figure 1: Vertical profiles of salinity and trace elements in the North Aegean Sea

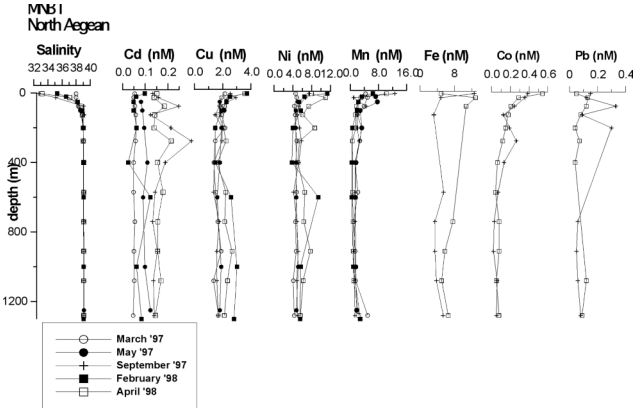
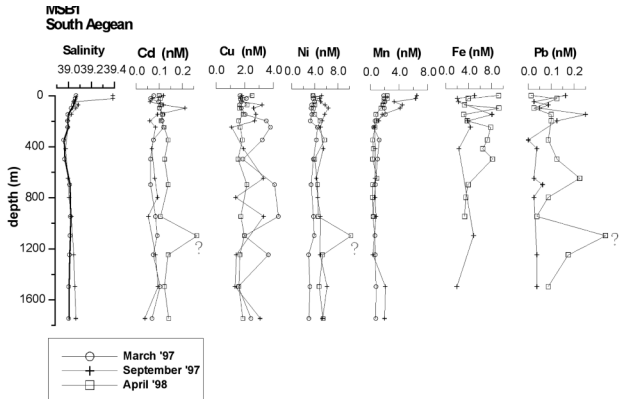


Figure 2: Vertical profiles of salinity and trace elements in the South Aegean Sea



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GEOCHEMICAL ASPECTS OF THE S. AEGEAN SEA SURFACE SEDIMENTS

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Abstract

Surface sediment samples from the South Aegean Sea were analysed for organic carbon and calcium carbonate content and for total Fe, Al, Ti, Mn, Pb, Cu, Zn, Ni and Cr in the <63μm grain size fraction. Analysis of the data revealed that most of the elements analysed do not have terrigenous origin since they are not correlated with Ti; elements like Pb, Zn, Mn and Fe show relatively strong correlation with organic carbon whereas only Zn and Pb follow the finer fraction of the sediments. The concentration ranges of the elements analysed are found to be similar to those reported for other unaffected Greek marine regions.

Keywords: Geochemistry, trace elements, sediments, Aegean Sea, Eastern Mediterranean

Introduction

The present study is part of an on-going monitoring project that aims at providing an assessment of the state of pollution in the Aegean and the Ionian Sea. This part is going to add information on the geochemistry of the surface sediments of the South Aegean Sea. Sediments are important carriers of trace elements and also they are potential sources of contaminants in the hydrological cycle. The contaminants are not necessarily associated with permanently on the sediment, but they may be part of biogeochemical cycles [1]. Metals reach the seabed associated with allochthonous (terrigenous) or autochthonous (biogenic) particles. As a result, sediment analysis plays an important role in environmental investigations especially in those cases in which a short-term or past pollution event is not or only insufficiently traceable from water analysis since they are the final reservoir of metals in the marine environment. The study area comprises part of the Cyclades Plateau and the central and western part of the Cretan Sea. It is poorly investigated as far as its geochemistry is concerned. Hence, comparisons can be made with other nearby areas.

Methods and materials

Sediment samples were collected, during the July 2000 oceanographic cruise of the R/V *Aegaeon*. For the collection of the surface sediment samples (0-3cm) a Smith-McIntyre type grab sampler was used. Wet sieving was employed for the separation of the <63μm grain size fraction. The chemical analyses were conducted on the <63μm grain size fraction of the sediments since metals from anthropogenic sources are mostly concentrated on the fine sediment particles [1]. For the major and trace metal analysis, the X-ray Fluorescence technique was used. The <63μm dried sediment fraction was ground to a fine powder in a twin mill agate mortar (Retsch MM-200). Five grams of powder were well mixed with 0,5 g of wax (Hoechst Wax-C). The mixture was pressed in a 31mm aluminum cup (20 tn, 20 sec) inside a Herzog HTP-40 hydraulic press. The elements were measured in the powder pellets with a Wavelength Dispersive X-Ray Fluorescence system (Phillips PW-2400). The XR-F system was calibrated using reference samples from the U.S. Geological Survey and the National Research Council of Canada [2].

Results and discussion

The concentration ranges of the elements Fe, Al, Ti, Mn, Pb, Cu, Zn, Ni and Cr are reported in Table 1. For comparison purposes, metal concentration ranges from some other unaffected Greek areas are also included in the same table. The five stations sampled cover a rather wide marine area of the South Aegean Sea. The water depths ranged from 120 m to 1120 m, with the shallower stations within the Cyclades plateau and the deeper stations within the Cretan Sea. The difference between the station depths is directly reflected in the granulometric characteristics of the surface sediments. Thus, the shallower station is characterized by the lowest percentage of silt and clay (18,3%), whereas the percentage of the <63μm grain size fraction is increased with the water depth. Accordingly, the surface sediments of the shallow station in Cyclades plateau exhibited the lowest organic carbon content (0,38%) and the highest carbonate content (74%). The more or less similar distribution with the organic carbon is reflected by the heavy metal concentrations except for Cr. Iron, Al, Mn, Cu and Ni concentrations did not show any significant variation between the deeper stations, while they were significantly lower in the shallow station due probably to the elevated proportion of sand (>80%). According to the table Fe, Pb, Cu and Zn levels are of the same magnitude in the South and the North Aegean Sea. Chromium in this study presented a very narrow concentration range, while the maximum value is relatively low. However, great care should be exercised in making such comparisons because the extraction techniques used for the metal determinations are different.

Table 1: Heavy metal concentrations in sediments (ppm, except Fe in %) from the South Aegean Sea and other unaffected Greek marine areas.

Area	Fe	Pb	Cu	Zn	Ni	Cr	Mn	Method
South Aegean Sea (this work)	**1,92-2,81**	**20-43**	**11-43**	**50-81**	**53-106**	**68-78**	**442-1652**	**Total**
North Aegean Sea [3]	0,8-2,6	5-57	4-49	24-125	11-105	20-278	65-740	2N HCl
North Aegean Sea [4]	-	23-57	19-49	54-125	57-104	92-137	-	total
East Aegean Sea [3]	1,4-3,3	11-22	4-29	25-55	39-291	52-157	280-2640	c.HNO_3
Ionian Sea [3]	0,66-3,43	2-28	0-43	7-94	8-192	12-257	212-3820	2N HCl
South Evoikos Gulf[3]	0,60-1,50	12-27	3-15	25-44	25-144	37-97	165-555	2N HCl
Lakonikos Gulf [3]	0,67-1,66	6-45	7-30	22-52	14-40	26-58	121-2214	2N HCl
Pagassitikos Gulf [3]	1,3-2,7	19-30	9-25	38-72	32-228	50-186	290-2790	2N HCl
Elefsis Bay [3]	0,8-1,1	25-32	28-33	55-68	80-95	50-65	280-325	2N HCl

In the North Aegean Sea Ti concentrations in sediments varied between 3216 and 4640 ppm [4], while in the South Aegean area Ti ranged from 2520 to 2700 ppm. The elevated concentrations of Ti in the North Aegean sediments are attributed to the existence of some significant riverine sources that supply the marine environment with large amounts of terrigenous particles. In contrast, in the South Aegean Sea the main sources of suspended particle supply are atmospheric transport and biological processes within the water column. In order to determine the sources of the sediments in the area under investigation, the covariation of the elements with Ti (lithogenic sources), organic carbon (biogenic particles) and Al (aluminosilicates) was tested by plotting the metal concentrations against Ti, organic carbon and Al, respectively. According to the XY plots of the elements against Ti, only Al seems to have a relatively stronger linear correlation with lithogenic particles whereas all the other metals do not seem to be of lithogenic origin. Since terrestrial transport does not seem to be the main source of the sediments in the South Aegean Sea, the covariation of the metals with organic carbon, representing particles of biogenic origin, was tested. Elements like Pb, Zn, Mn and Fe showed a rather strong correlation with organic carbon, implying that heavy metals reach the bottom sediments possibly bound to particles produced by biological processes. Furthermore, from the XY plots of the elements against Al, only Pb, Zn, and to a lesser extent Mn and Ni seem to be partly associated with the finer sediment fraction where aluminosilicates are the prevailing sedimentary phase. From inter-element correlation plots, Cr distribution was not found to be correlated with any of the other metals, Cu was correlated only with Ni, and Zn was strongly correlated with Pb. Two representative plots are shown in the Figure 1.

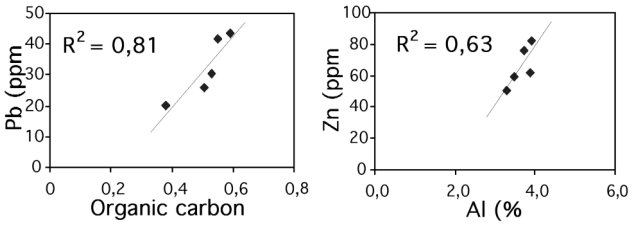

Fig. 1: Lead (ppm) *versus* org. C. (%) and Zn (ppm) *versus* Al (%) in South Aegean Sea

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PHOSPHORUS VERSUS NITROGEN LIMITATION IN THE MIDDLE ADRIATIC SEA

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Abstract

This paper reports on a nearly 30 years seasonal survey to determine which nutrient limits primary productivity in the middle Adriatic Sea. Containing 1884 data points, the depth and temporal variation of the N/P ratio ranged from 2 to 305 with mean values ranging from 28 to 41. The reason for the high N/P ratio in the middle Adriatic Sea can be ascribed to phosphorus poor fresh water runoff and to more rapid utilisation of phosphorus by phytoplankton compared with nitrogen. In general, we assume that the large excess of N over P related to phytoplankton demand which results in phosphorus being, the limiting factor in middle Adriatic Sea.

Keywords: Nutrients, phosphorus and nitrogen, Adriatic Sea.

Introduction

As is well known, N and P are the basic elements of primary production which transport and cycling is an essential feature in the marine ecosystem. Although nitrate (NO_3-N) is generally considered to limit organic productivity in most of the world's oceans, previous studies have suggested the Adriatic Sea may be an exception. To determine which element (N or P) limits phytoplankton production in the middle Adriatic Sea, we present data of PO_4-P , NO_3-N and dissolved inorganic nitrogen, DIN, (NO_3+NO_2+NH_4), and offer a plausible explanation of the processes that my be important in controlling the observed limitation.

The Adriatic Sea is one of the most oligotrophic marine systems, and thus most of the nutrient inputs from Po River (over 75%, 1) and other smaller rivers, which are taken up close to the estuary and little reaches the open sea. Both inorganic N-salts and P-salts are depleted in the Adriatic Sea compared to the adjacent Mediterranean and other world seas. Several studies carried out in the Adriatic basin have shown that phosphorus is probably the principal limiting nutrient (1 - 3).

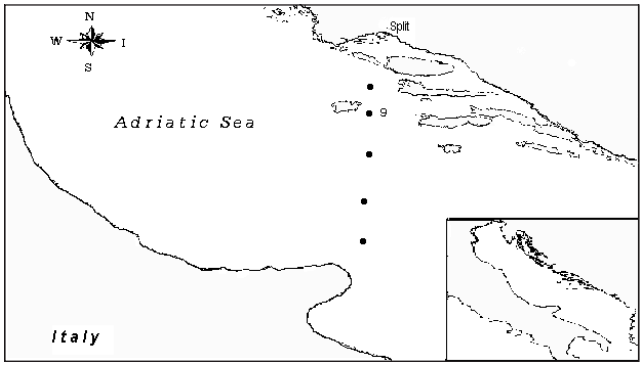

Figure 1. The study area with station, Stoncica-9, in the middle Adriatic.

Material and Methods

Research was carried out at one station in middle Adriatic Sea, (Soncica-9) which is located on the Split-Gargano transect (Fig. 1). Data used in this paper span the period from 1970 to 1999 and were collected regularly on a monthly basis. The maximum station depth was 100 m. Cruises were performed monthly and samplings were carried out at standard oceanographic depths (0,5,10,20,30,50,75 and 100m). Basic hydrographic parameters, e.g. temperature, salinity, pH and oxygen content were determined on board immediately after sampling, while the nutrients were measured in the chemical laboratory in IOF-Split. Standard oceanographic methods were used. (4).

Results and Discussion

Various natural factors affecting the productivity of this area have been studied. Changes of hydrographic parameters were noted, i.e. water exchange between the Ionian and Adriatic Sea, as well as the climatic factors and influence of water from the northern Adriatic. Study of nutrient salt levels, changes in the annual cycle of plankton communities (5, 6) and concentrations of some physiological groups of heterotrophic bacteria have also been studied (7). An understanding of the mechanisms which control the nutrient relationship as well as competition for nutrients have been considered as one of the major mechanisms determining species dominance, and both the temporal and spatial succession in the phytoplankton community (3).

In this paper we report nearly 30 years of seasonal data, in order to determine which nutrient limited productivity in water of middle Adriatic Sea. In surface water layers (0 - 30 m) supersaturated with oxygen, values of DIN concentration range from 0.2 - 6.21 μM with a the mean of 1.68±1.07 μM. Corresponding orthophosphate concentrations were 0.0 - 0.77 with a mean of 0.076±0.055 μM. In mid-depth and near-bottom waters (50 - 100 m) undersaturated with oxygen, inorganic nitrogen ranged from 0.31 - 13.0 μM with a mean concentration of 1.95±1.8 μM DIN. The concentrations of inorganic phosphorus did not vary much with depth, and values over time ranged from 0.0 - 0.72, with a mean of 0.074±0.06 μM.

Table 1. Ranges (R) and mean values (ξ) of relationship among dissolved inorganic nitrogen and orthophosphate (N / P), with standard deviation (sd) and number of analysed data (n) in two water layers at the station Stoncica-9 in the middle Adriatic Sea.

Season	Layers		N / P	Layers		N / P
Winter	0-30 m	R ξ±sd n	2.0-183 **35.4±26** 285	50-100 m	R ξ±sd n	5.6-305 **41.2±42.5** 178
Spring	0-30 m	R ξ±sd n	2.3-305 **36±35** 288	50-100 m	R ξ±sd n	2.5-201 **33.8±30** 180
Summer	0-30 m	R ξ±sd n	1.5-116 **27.8±18.4** 335	50-100 m	R ξ±sd n	2.7-101 **30.4±17.2** 206
Autumn	0-30 m	R ξ±sd n	2.1-179 **28.5±22** 224	50-100 m	R ξ±sd n	1.8-151 **36.7±26.6** 148

Based on the 1884 data points, the depth and temporal variation of the N/P ratio ranged from 2 to 305 with mean values ranging from 28 to 41 (Table 1). Statistical analyses show that during the investigated period, roughly 11% of the values lay below 16:1, and 2% below 5:1. If one accepts the concept of Redfield's ratio being indicative of nutrient limitation (8), than the limiting factor would have been nitrogen in less than 40 cases, and phosphorus in 1650 cases based on all data. The difference is the cases where either phosphorus or nitrogen would have been limiting. Krom *et al*. (9) found an unusually high nutrient ratio in the eastern Mediterranean and attributed this to the removal of P from water column by inorganic processes, i.e. adsorption on to Fe-oxyhydroxides. The reason for the high N/P ratio in the middle Adriatic Sea can be ascribed to phosphorus-poor fresh water runoff and to the more rapid utilization of phosphorus by phytoplankton compared to nitrogen. The N *vs*. P relationship was similar during all seasons and in both water layers. There were no any significant differences with respect to depth. In general, we assume that the large excess of N over P is related to phytoplankton demand which maintains phosphorus as the limiting factor in the middle Adriatic Sea.

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IMPACT DES EFFLUENTS ANTHROPIQUES SUR LES TENEURS EN MÉTAUX LOURDS DANS LES SÉDIMENTS DE LA LAGUNE DE OUALIDIA (MAROC)

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Résumé

les sédiments actuels de la lagune de Oualidia connaissent un enrichissement très modéré en plomb, zinc, cuivre, mercure, et chrome. Cet enrichissement provient essentiellement des effluents d'origine anthropique liés à des contraintes socio-économiques de plus en plus importantes imposées à cet écosystème lagunaire ..

Mots clés: lagoon – pollution – Western Mediterranean

Introduction

La lagune de Oualidia est située sur le littoral Atlantique marocain (9°02' W et de 32°44 N) (Fig.1). Le climat qui y règne est de type méditerranéen sous influence océanique et le milieu lagunaire est de type mesotidal (1). Actuellement la lagune de Oualidia est soumise à une action anthropique de plus en plus croissante (ostréiculture, tourisme, urbanisation, …). L'objectif de cet étude est de dresser un bilan concernant la pollution métallique et de déterminer le degré de contamination des sédiments.

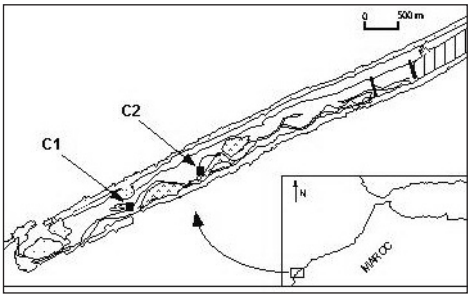

Figure 1 :Situation géographique de lalagune de Oualidia et localisation des carottes 1 (C1) et 2 (C2).

Matériel et méthode

Deux carottes ont été prélevées dans la lagune en face des parcs d'ostréiculture et des rejets d'eaux usées (fig. 1). Le dosage du plomb, du zinc, du cuivre, du mercure, du chrome et du cadmium a été réalisé sur la fraction fine (< 63μm) après une attaque partielle par des acides forts. Cette approche a permis de déterminer les teneurs en métaux lourds dans les sédiments et de faire la distinction entre les teneurs supposées naturelles (2)(bruit de fond géochimique) et la quantité des métaux d'origine anthropique. A partir des teneurs mesurées à 100 cm et 120 cm de profondeur nous avons calculé le degré de contamination (Cd) des dépôts selon la formule de Hakanson (3) définie pour les sédiments lacustres. Ce coefficient se base sur les six éléments métalliques dosés. Le facteur de contamination calculé correspond au rapport des concentrations mesurées à la surface sur les concentrations mesurées au fond de la carotte. Le degré de contamination du sédiment (Cd) est la somme de tous les facteurs de contamination. Le carbone organique a été dosé par la méthode de Walkl – Blak (4)

Résultats et discussion.

Les profils verticaux du cadmium et du chrome , dans une moindre mesure, sont irréguliers sans aucune variation notable vers le sommet (fig. 2). Par contre pour le plomb, le zinc, le cuivre et le mercure, il existe une variation très significative caractérisée par un enrichissement récent vers le sommet. Ces teneurs montrent, de toute évidence, l'impact des activités anthropiques sur la lagune. les profils du carbone organique dans les carottes donnent des profils irréguliers avec des valeurs élevées. Le degré de contamination pour la lagune est de 9.25 et 10.11 pour les deux stations d'études ce qui correspond à une contamination très modérée selon l'échelle établie par d'Hakanson (3). Ces deux sites ont un degré de contamination très modérée et ils semblent être moins affectées en micropolluants métalliques que d'autres écosystèmes similaires en Méditerranée comme la lagune de Venise en Italie (5) et l'Etang de Thau en France (Cd = 18) (6).

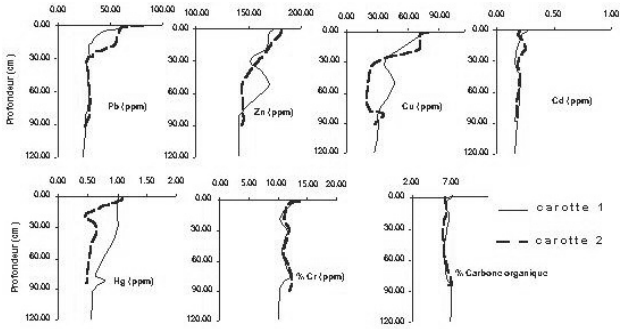

Figure 2 : Profils des teneurs en Pb, Zn, Cu, Cd, Hg, Cr et carbone organique des carottes C1 et c2.

Le facteur de contamination actuel et la comparaison avec les résultats obtenus par Bidet et Carruesco (3) et Carruesco (1) pour la même lagune montre que cet écosystème commence à enregistrer l'impact de la pollution anthropique ce qui exige une surveillance accrue de cet environnement. Il faudrait donc être attentif au seuil d'équilibre au-delà duquel les perturbations subies par l'écosystème risquent de devenir irréversibles .

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Comité

Microbiologie et biotechnologies marines

Président : David Gutnick

BIOMONITORING OF TOXIC , CARCINOGENIC POLLUTANTS BY MOLECULAR AND BIOCHEMICAL RESPONSES OF FISH CYTOCHROME P4501A1 (CYP1A1) ALONG THE IZMIR BAY ON THE MEDITERRANEAN SEA

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Abstract

In this report we present biomonitoring of toxic carcinogenic organic compounds by using induction of CYP1A1 mRNA, protein and 7-ethoxyresorufin O-deethylase (EROD) activity as biomarkers in liver of leaping mullet (*Lisa saliens*) caught along the Izmir Bay. Pasaport containing the highest concentrations of petroleum hydrocarbons (12.45μg/L) and the other sites (sites 2,3,4,and 11) showed significantly increased EROD activity and CYP1A1 protein level as compared to the values from uncontaminated (<1μg/L) reference site, Foca. These conclusions were further confirmed with the results of fish liver CYP1A1 mRNA level measurements.

Key words: Pollution, Biomonitoring, Enzymes, CYP1A1, PCB, PAHs, Carcinogens.

Introduction

With the recent advances in molecular biology and biochemistry, responses of fish and other organisms to pollutants are used for the ecological impact assessment of these compounds in the aquatic environment to detect both the early and long term effects and to examine also their possible genotoxicity. The best characterized and used biochemical marker so far is the induction of CYP1A in fish liver (1,2). Organic pollutants such as dioxins, dibenzofurans, polyaromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), specifically induce liver CYP1A in fish and in other vertebrates. CYP1A mostly converts certain classes of PAH procarcinogens and other organic chemicals to their carcinogenic metabolites by forming epoxides or other oxygenated compounds. Thus, induction of CYP1A is used to measure both exposure and resulting toxic, carcinogenic effects of these types of organic pollutants.

Izmir Bay is located on the Aegean Sea of the Mediterranean, west of Turkey. Domestic and industrial wastes, urban, agricultural run off, discharges from ships, sediments and contaminated waters of rivers heavily pollute the Bay (3). Although, the contamination of Bay with the heavy metals has been monitored since 1960s, both the degree and specific sites of pollution by the organic carcinogenic compounds and the biological effects of monitoring in the Bay have remained unexplored until recently (4).

We have carried out biomonitoring studies by using CYP1A1 dependent enzyme activity induction in leaping mullet (*Lisa saliens*) and in common sole (*Selea vulgaris*) liver measuring 7-ethoxyresorufin O-deethylase (EROD) activity, CYP1A1 protein amount by western blotting on the several sites in Izmir Bay since 1995. In the most recent studies, the degree of the increased liver CYP1A1 mRNA level of leaping mullet was added to our monitoring studies. In this communication, biomonitoring of toxic carcinogenic organic compounds by using these three parameters, that is, induction of CYP1A1 mRNA, protein and EROD activity in fish liver will be presented. Sequence analysis of cDNA cloned from liver of leaping mullet collected from site 1, Pasaport demonstrated that it is CYP1A1 (Sen *et al*., unpublished. GenBank Accession Number AF072899).

Sampling sites and fish :

The collection sites, all were in Izmir Bay, are given in Fig.1. Leaping mullets, each weighing 300-400 g, were caught by fish net.

Methods

Preparation of microsomes, determination of protein and EROD activity were described elsewhere in detail(4). Cytochrome P4501A1 protein levels were determined by Western blot analysis using polyclonal antibodies (anti-mullet CYP1A1) produced in our laboratory against purified leaping mullet CYP1A1 as described before (4).

Total cellular RNA was isolated from the liver tissue of leaping mullets collected from different stations essentially as described before (6). Following the electrophoresis and transfer of RNA samples, Northern blot hybridization was accomplished by using the synthetic new 33-mer oligonucleotide probe designed for this purpose, 5'-dCTC ATC CAG CTT CCT GCT CTC GCA GTG ATC AAT-3'. Details of the procedure are given elsewhere in detail (6).The results are subjected to Student's t-test for the statistical analysis.

Results and Discussion

The results of .biomonitoring studies carried out in January 1999 are given in Fig. 1. EROD activities of leaping mullet from site 1 (Pasaport) in the inner Bay showed highly elevated enzyme activities (1028 ± 287 pmol/min/mg, n=4) which were 93 times higher than the value at reference site 2 (site 8 on the Fig. 1). Leaping mullets caught from site site 6 and site 11 showed moderately elevated EROD activities that were 105± 26 (n=4) and 310± 21 (n=4) pmol/min/mg protein, respectively. In our first monitoring studies carried out in 1995 and 1996 using leaping mullet liver CYP1A1 enzyme activity, EROD, similar results were obtained

The leaping mullet from the highly urbanized and industrial section of the Bay, Pasaport (site1) showed highly elevated enzyme activities (1293± 292 pmol/min/mg protein, n=208), which were about 62 times higher than the value at the reference site 1, (site 10 in Fig. 1). (25 ± 9 pmol/min/mg protein, n=4).Leaping mullet caught along a pollutant gradient at three other sites, Karsiyaka (site 2), Inciralti (site 3), and Tuzla (site 4), also had highly elevated EROD activities, as can be

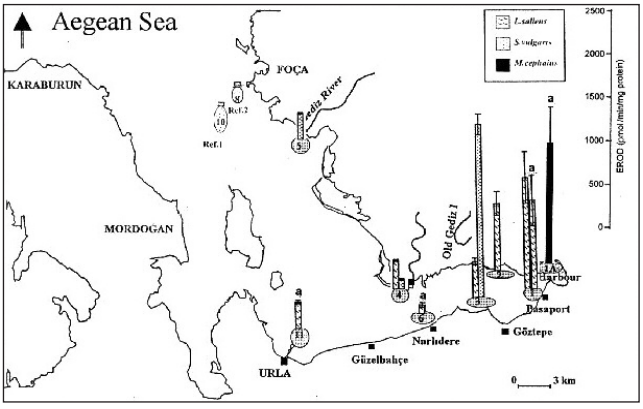

Figure 1. EROD activities of liver microsomes of common sole (*Solea vulgaris*), leaping mullet *(Liza saliens*) and gray mullet (*Mugil caphalus*) captured in Izmir Bay at ten different sampling sites.
The activity bars with "a" represent the field studies carried out in 1999. The others are carried out in 1995 and 1996. Compiled from the references 4, 5 and 6.

seen in Fig. 1 (4).

In both biomonitoring studies (1996 *vs*. 1999), leaping mullet sampled from site1, Pasaport containing the highest concentrations of petroleum hydrocarbons (12.45 μg/L) showed the highest liver EROD activity. In addition, these livers had highest CYP1A1 protein levels as determined by Western blotting. Next to site1, mullet captured from site 2 and site 3 also had very high EROD activities and a good correlation was obtained between the EROD activity and CYP1A1 protein content measured immunochemically as shown in Fig. 2A.

Thus, these molecular and biochemical indices, highly induced EROD activities, CYP1A1mRNA and protein levels in the liver of leaping mullet caught from sites 1,2,3 and 4 suggests that these sites are highly contaminated with carcinogenic PAHs and / or PCBs and possibly other toxic compounds.

The results obtained from CYP1A1 protein and EROD activity were further supported by CYP1A1 mRNA studies of leaping mullet. As seen in Fig. 2B, RNA isolated from the liver of mullet collected from the most polluted site revealed considerably strong hybridization signal whereas only a weak hybridization signal was detected with liver RNA of fish caught from reference point, site10

This results also suggest that CYP1A1 gene expression is transcriptionally induced by chemical pollutants in the contaminated sites. Thus,

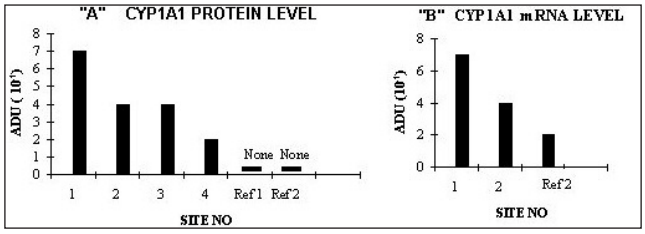

Figure 2. CYP1A1 protein ("A") and CYP1A1 mRNA ("B") levels in liver microsomes of leaping mullet caught from the several sites in Izmir Bay. *Numbers below the bars correspond to the collection sites given in the map in Figure 1. The bar graph "A" illustrates arbitrary densitometric units (ADU) obtained from Western blots of liver microsomes. Quantitation of CYP1A1 mRNA bands from Northern blots were obtained by using scanning densitometer and also expressed as ADU and given in graph "B". Ref1 and Ref2 are sampling sites 10 and 8, respectively., in Fig.1.*

these molecular and biochemical indices, i.e., highly induced EROD activities, CYP1A1mRNA and protein levels in the liver of leaping mullet caught from sites 1,2,3,4 and 11 suggests that these sites are highly contaminated with carcinogenic PAHs and/or PCBs and possibly other toxic compounds. These sites are prone to the alarming pathological changes at the population and community levels.

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Introduction

Au cours de ce travail, nous avons pu voir que la survie de *P. aeruginosa* est assez longue comparée à celle des eubactéries. L'adaptation de ce germe aux conditions marines se fait par modification des caractères morphologiques (réduction de la taille, diversification de la formes des bactéries) et modification des caractères culturaux : apparition des colonies rugueuses ou lisses à pigment jaune localisé au niveau des colonies ainsi que des colonies oranges et noires.

Matériel et méthodes

Préparation inoculation et incubation de la souche étudiée :

La souche de référence de *Pseudomonas aeruginosa* ATCC 27853 est incubée pendant 6 à 12 ans dans l'eau de mer plus du sédiment marin. Elle est cultivée à 37 °C pendant 24 heures sur une gélose nutritive. Elle est par la suite récupérée dans de l'eau physiologique et inoculée dans un flacon Erlen meyer renfermant 200 ml d'eau de mer stérile.

Milieux de culture utilisés:

Gélose nutritive (GN), Bouillon nutritive (BN),Gélose nutritive préparée à l'eau de mer (GNEM), Mueller hinton (MH), King A préparée à l'eau de mer (KAEM). L'étude des caractères biochimiques est faite sur des galeries Api 20 NE.

Résultats

1) Modification des caractères culturaux de P . aeruginosa au cours de son incubation en eau de mer.

P. aeruginosa incubé six ans dans de l'eau de mer additionné de sédiment marin et incubé trois jours dans du BN donne :

- des colonies blanches avec centre jaunâtre sur GN qui gardent leur aspect sur KAEM, des grandes colonies jaunes et blanches et d'autres naines.

- des colonies de taille variable entre 1 et 2 mm de couleur blanche avec un anneau transparent au milieu qui, par alternance de repiquages sur BN, GN et MH donnent des colonies oranges, blanches et d'autres jaunes rugueuses. Ces dernières donnent à la suite de plusieurs repiquages sur GN et KAEM des colonies blanches rugueuses qui deviennent jaunes après 48 heures de leur apparition sur ce dernier milieu et des colonies blanches sur GNEM.

P. aeruginosa incubé dix ans dans de l'eau de mer additionnée de sédiment marin ne donne pas de colonies après incubation de trois jours dans du BN et 24 heures sur GN mais c'est après environ une quinzaine de jours que les colonies naines poussent. Incubé trois mois dans du BN *P. aeruginosa* donne des formes très diversifiées avec des pigments orange et jaune. Les colonies orangées, au début transparentes donnent par vieillissement sur GN (2mois) des colonies noires bombées, desséchées incrustées dans la gélose. Dans un milieu liquide, elles donnent des amas indissociables. Une fois ensemencées, ces dernières donnent par repiquage sur GN des colonies transparentes puis orangés de tailles plus ou moins grande. Ces mêmes colonies ne donnent pas les mêmes profils biochimiques sur Api 20NE mais elles présentes la même résistance aux antibiotiques.

2) Modification des caractères biochimiques :

L'étude des ces modifications sur des galeries Api 20 NE, nous a permis de voir que *P. aeruginosa* au cours de son incubation en eau

MODIFICATION DES CARACTERES BIOCHIMIQUES ET PHENOTYPIQUES DE *PSEUDOMONAS AERUGINOSA* APRES UN SEJOUR DE 6 À 12 ANS DANS L'EAU DE MER

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Résumé

Pseudomonas aeruginosa est un germe ubiquitiste, fréquent dans l'environnement: eau, sol et plantes. Sa survie dans l'environnement a intéressé plusieurs chercheurs. L'action de certain sur la survie de *Pseudomonas aeruginosa* doit être considérée étant donné qu'elle évolue, en milieu marin, vers des formes filtrables à travers des membranes de 0.45mm de porosité (1). Comme cela été montré par Gauthier *et al*., (2) dans le cas d'*E. Coli* la survie de *Pseudomonas aeruginosa* dépend de sa pré-adaptation à cette eau. Dans ce travail, nous allons nous intéresser aux modifications phénotypiques et biochimiques de *P. aeruginosa* après une incubation entre 6 et 12 ans dans l'eau de mer.

Mots clefs : Pseudomonas aeruginosa, stress, eau de mer

Tableau 1 : Modifications des caractères biochomiques de *Pseudomonas aeruginosa* au cours de son incubation en eau de mer

souche	*D*	*GUL*	*AD*	*UR*	*ESC*	*GE*	*PNP*	*GL*	*AR*	*MN*	*MA*	*NA*	*MA*	*GN*	*CA*	*ADI*	*ML*	*CIT*	*PA*
Pa		+	+	-	-	+	-	+	-	-	+	+	-		+	+	+	+	-
Pn 12																			
	24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3j	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
	10j	-	+	+	-	-	+	-		+	+		+	+	-	-	-	-	-
Pn 6																			
	24h	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	48h	-	+	+	+	-	+	+	-	+	+	-	+	-	+	-	+	+	-
	72	-	+	+	+	--	+	+	-	+	+	-	+	+	+	-	+	+	+
	10j	*	+	+	+	+	+	+	-	+	+	-	+	+	+	-	+	+	+
Pn 6-1																			
	24h	*	+	*	-	-	-	-	+	+	+	+	+	+	+	-	+	+	-
	48h	-	+	+	*	-	-	+	+	+	+	+	+	+	+	-	+	+	+
	72	-	+	+	+	-	-	+	+	+	+	+	+	+	+	-	+	+	+
	4j	*	+	+	+	+	*	+	+	+	+	+	+	+	+	-	+	+	+
	10j	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
Pn 10																			
	24h	*		+	+	+	+	+	+	+	+	+	+	+	-	-	+	+	-
	48h	*		+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
	4j	*		+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+
P. N.																			
	18h	-	+	+	+	*	-	-	-	*	-	-	-	-	-	-	-	-	-
	24h	*	+	+	+	*	-	-	-	*	-	-	-	-	-	-	-	-	-
	48h	-	+	+	+	*	-	-	-	*	-	-	-	-	-	-	-	-	-
	5j	-	+	+	+	+	-	-	-	*	-	-	-	-	-	-	-	-	-
PO																			
	48h	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-	-
	5j	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Pn 12 . *P. aeruginosa* incubée pendant 12 ans dans l'eau de mer, **Pn 10** *P. aeruginosa* incubée pendant 10 ans dans l'eau de mer, **Pn 6, Pn 6-1** *P. aeruginosa* incubée pendant 6 ans dans l'eau de mer, **PN** : colonie noir de *P. aeruginosa*, **PO**: Colonies orangée issue de PN, **D** : durée d'incubation dans l'Api 20NE, * : caractère douteux

de mer, acquiert de nouvelles activités et en perd d'autres. Ceci dépend du milieu de récupération et de la durée d'incubation dans l'eau de mer.

Discussion

P. aeruginosa s'est avéré particulièrement résistant, il a pu survivre sous des formes non cultivables avec des modifications morphologiques allant des formes géantes aux formes naines filtrables à travers la membrane de 0.45 mm de porosité. Incubée pendant des années dans l'eau de mer, il y a transformation complète de l'aspect des colonies des colonies qui deviennent rugueuses et pigmentées en jaune et orangé qui devient noir par vieillissement Les colonies pigmentées généralement obtenues après de longues périodes d'incubation sur GN, en BN présentent un pigment jaune qui, après 24 heures d'incubation, est faiblement visible mais par vieillissement la pigmentation devient plus intense.

Conclusion

Pour des longues périodes d'incubation *Pseudomonas aeruginosa* ne disparaît pas mais donne des colonies jaunes et oranges. Les modifications acquises par *Pseudomonas aeruginosa* peuvent avoir une influence sur la validité des méthodes utilisées pour son dénombrement dans l'échantillon marin.

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INFLUENCE OF BIOTIC FACTORS ON METALLOTHIONEIN LEVELS IN MULLUS BARBATUS COLLECTED FROM THE IBERIAN MEDITERRANEAN COAST.

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Abstract

The objective of this study was to determine the influence of some biotic factors (gender, size and sexual maturity) on the concentration of hepatic metallothionein (MT) in the demersal fish *Mullus barbatus*, as a initial step for the ultimate identification of basal levels of this biomarker. The influence of biotic factors was assessed applying polynomial regression models and one-way ANOVA. The results confirm previous findings (1) that the biotic factors considered must be taken into account in biomarker monitoring as they could affect the fish MT system.

Key words: Mullus barbatus, bio-indicators, pollution, Western Mediterranean, coastal waters.

Introduction

Metallothioneins (MTs) are a family of low-molecular-weight, cysteine-rich proteins that have a high affinity for divalent ions. MTs play important roles in the regulation of essential trace metals, such as zinc and copper, and in the detoxification of heavy metals, such as cadmium and mercury. Recently, MT level has become a major biomarker for monitoring metal pollution in fish, and it has been included in several Monitoring Programmes, such as the Joint Assessment Monitoring Programme (JAMP) or the Mediterranean Pollution Monitoring Programme (MEDPOL), as an early indicator of biological effects of heavy metals.

Material and methods

Specimens of *Mullus barbatus* were caught by trawling before (May 1999) and after (October 1999) the spawning season, in six areas along the Iberian Mediterranean coast (Fig. 1) exposed to different degrees of anthropogenic activities. Water temperature and salinity was recorded at each sampling. Individual striped mullet were sexed, weighed, length measured and liver removed. MTs content was measured applying the spectrophotometric assay, adapted from Viarengo et al (2, 3), based on the estimation of the sulfhydryl content of MT proteins using Ellman's reagent.

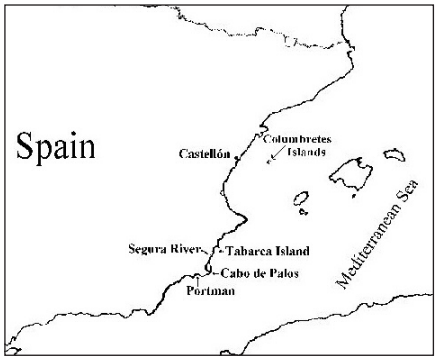

Figure 1 : Map of sampling sites.

The influence of size in hepatic MT was studied applying a curvilinear regression analysis in order to obtain the determination coefficients (R^2) for different models. The relationships between both variables were evaluated applying the F-test with regression ANOVA using specimens, with the same gender, captured in six areas, before and after spawning.

The influence of gender in hepatic MT was studied applying one-way ANOVA on log-transformed data. Specimens within the size range 14 to 18 cm, captured in three different areas before and after spawning, were used in this analysis.

The influence of maturation state in hepatic MT was assessed applying one-way ANOVA on log-transformed data. Specimens within the size range 14 to 18 cm, captured in two different areas before and after spawning, were used in this analysis.

Results and Discussion

The results of the regression analysis showed the existence of significant positive relationship between size and MT content in the six cases studied ($p < 0.05$; Fig. 2). Furthermore, variability of the data was better explained by the power model $[MT] = b_0 + size^{b1}$ ($R^2 = 0.203$; $p < 0.05$). Significant differences in MT levels between male and female specimens were found in all cases during prespawning but not during postspawning period ($p < 0.05$). Mean MT was always bigger in females (Table 1). We have also found significant differences in MT levels between specimens (belonging to the same gender) captured in prespawning and postspawning period in all cases studied. Mean MT was always higher during prespawning period (Table 1).

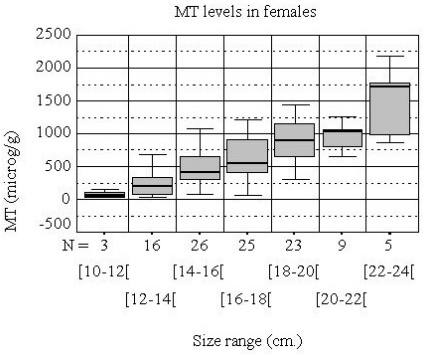

Figure 2 : Influence of size on MT levels in *Mullus barbatus* collected in May 1999 at Portman. R^2= 0.373, b_0 = 0,8731, b_1 = 0,1118.

Table 1. Results of the influence of gender and sexual maturity on MT contents (µg /g hepatic tissue) in *Mullus barbatus*. (*) Statistically significant differences.

Gender	Date	Site	n	MT Mean	St. Error	F	p
Male	May	Segura river	18	19,213	0,065	86,060	0,000*
Female		Segura river	61	25,828	0,025		
Male	May	Tabarca I.	29	18,143	0,063	33,158	0,000*
Female		Tabarca I.	30	22,734	0,046		
Male	May	Columbretes I.	10	18,256	0,055	62,545	0,000*
Female		Columbretes I.	18	23,637	0,036		
Male	October	Cabo de Palos	36	12,689	0,057	4,591	0,037*
Female		Cabo de Palos	17	13,311	0,072		
Male	October	Tabarca I.	16	13,896	0,031	0,244	0,624
Female		Tabarca I.	26	14,013	0,043		
Male	October	Columbretes I.	13	13,372	0,052	0,565	0,575
Female		Columbretes I.	14	13,612	0,047		
Date	**Gender**	**Site**	**n**	**MT Mean**	**St. Error**	**F**	**p**
May	Female	Tabarca I.	37	22,311	0,046	381,1	0,000*
October		Tabarca I.	40	14,019	0,035		
May	Female	Columbretes I.	31	23,112	0,034	467,9	0,000*
October		Columbretes I.	14	13,612	0,047		
May	Male	Tabarca I.	52	17,671	0,045	69,61	0,000*
October		Tabarca I.	17	13,880	0,030		
May	Male	Columbretes I.	30	17,321	0,056	73,81	0,000*
October		Columbretes I.	14	13,416	0,050		

Conclusions

Our results showed that the use of MT levels in *Mullus barbatus* necessitates the utilization of specimens within a same size range in order to reduce variability and allow standardized comparisons. Considering that specimens within a size range 14 to 18 cm were most abundant and their liver size was appropriate for analysis, we propose this size class for comparative purposes. The reported influence of gender and maturation state on MT levels have shown the necessity to establish the sampling time and to study independently specimens of different sex. Since variability of data was lower in postspawning periods than in prespawning, it is advisable to carry out the sampling outside the prespawning period.

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IN SITU PCR AMPLIFICATION OF 16SRDNA AND *GYRB* GENE IN *ACINETOBACTER VENETIANUS* CELLS

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Abstract

The *in-situ* polymerase chain reaction (*in-situ* PCR) is a molecular technique combining the extreme sensitivity of the PCR with the *in-situ* hybridization. *In-situ* PCR is used to detect very low quantities of DNA in intact cells. We present a protocol, which has been used to amplify the 16S rDNA and the *gyrB* gene in *Escherichia coli* and in *Acinetobacter venetianus* cells. The latter has been isolated from the Venice Lagoon and is able to perform the efficient oxidation of *n*-hydrocarbons and could be used for bioremediation purposes in polluted areas.

Keywords: in-situ PCR, Acinetobacter venetianus, Escherichia coli, FISH.

In-situ PCR is a modification of PCR in which the amplification and the detection of specific target nucleic acid sequences are carried out inside intact cells rather than on extracted nucleic acid. The detection of the amplification signal is performed by fluorescent *in-situ* hybridization (FISH). In line of principle, individual genes, mRNA, and rRNA are all candidate targets for this technique. In this way genetic abilities and their expression, and taxonomic information are all potentially accessible on the individual cell level. This approach has been used successfully in eukaryotic cells, whereas very little is know about the possibility to amplify DNA or RNA sequences in whole prokaryotic cells. The application of this approach to microbial ecology should enable the *in-situ* analysis of gene content in bacteria, also including the tracking of conjugative plasmids or transposable elements. Cells might also be analyzed in their natural or experimental environment, as in the case of complex microbial communities (1). Up to now, few data are reported regarding this issue, and concern with *Escherichia coli* and *Pseudomonas* cells (1, 2, 3), but, in line of principle, this methodology could be applied to every (micro) organism. Therefore, this approach could be extremely useful for the analysis of natural microbial communities isolated from polluted areas.

In this study, we present the set up *in-situ* PCR for the detection of *A. venetianus* VE-C3 cells. This bacterium has been isolated, as a component of a microbial community, from polluted seawater of Venice Lagoon (5). It has been previously demonstrated that this strain is able to perform efficient oxidation of diesel-fuel (5), opening the possibility of its use as a biosensor. Therefore, the availability of a technique enabling the measurement of the distribution of this bacterium in polluted environments, and also the expression of genes involved in biodegradation of *n*-hydrocarbons would be of great importance.

The following experiments were carried out on pure cultures of *A. venetianus* VE-C3 and *E. coli* Xl1-blue cells. Cells of the two bacterial strains, cultured in LB medium, were fixed in 4% paraformaldehyde; cell wall permeabilization was then achieved by the use of lisozyme. PCR was performed on whole cells by using two primers allowing the amplification of nearly the entire 16S rDNA. During PCR, the amplified sequences were also labelled with digoxigenin11-dUTP. Samples were then spotted on slides and incubated with a hybridization solution containing alkaline phosphatase - labelled anti-DIG antibodies conjugate with FITC. Slides were analyzed under a fluorescence microscope and the target cells labelled with FITC were visualized under blue-green light excitation (488 nm). Results are shown in figures 1 and 2; data obtained showed the successful amplification of 16S rDNA in whole *A. venetianus* cells (Fig. 1), whereas no fluorescent signal was found in the control experiment (Fig. 2). The same results were obtained with *E. coli* Xl1-blue cells (not shown).

In order to check the possibility of using other target sequences for *in-situ*- amplification, we choose the *A. venetianus gyrB* sequence (encoding the b-subunit of DNA gyrase) as target in the further experiments. For this purpose, the VE-C3 *gyB* sequence was firstly amplified *via* PCR by using the primers previously described by Yamamoto et al (4). The amplification product was cloned, and its nucleotide sequence determined.

Two oligonucleotides were then designed on this sequence and used as primers in *in-situ* PCR experiments on whole *A. venetianus* VE-C3 cells. Data obtained (not reported) revealed the amplification of the *gyrB* sequence inside the *A. venetianus* cells.

This body of data suggested that in-situ PCR can be successfully used to amplify DNA sequences within *Acinetobater* cells and might represent a powerful tool for identification and monitoring of this bacterium in microbial communities.

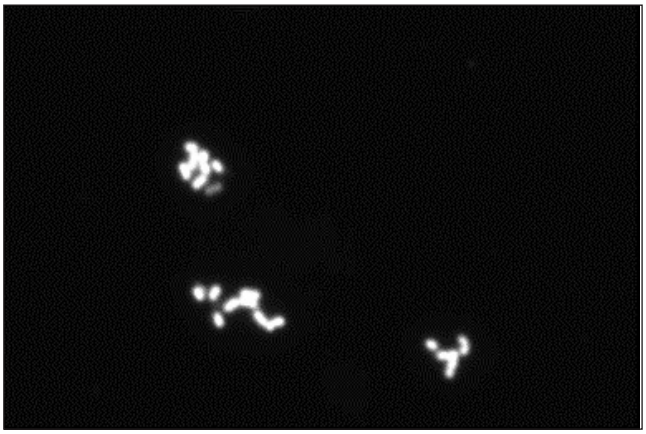

Fig. 1. *In-situ* PCR amplification of 16S rDNA sequence in VE-C3 *Acinetobacter venetianus* fixed cells.

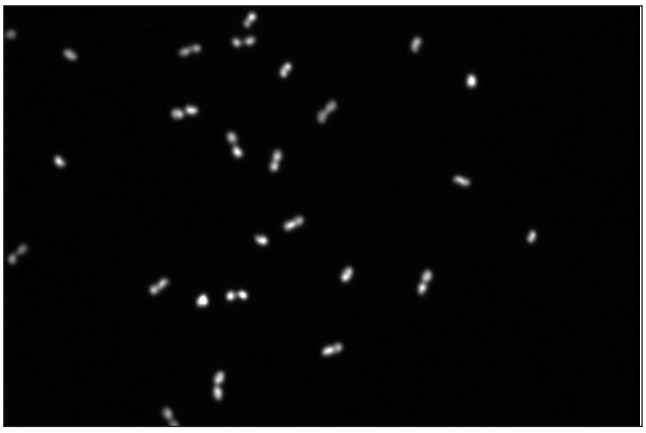

Fig. 2. *In-situ* PCR control reactions.

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UN PRINCIPE BIOLOGIQUE NATUREL MARIN OBTENU DU TRYGON PASTINACA

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Résumé
L'extrait hépatique du "chat de mer" *Trygon pastinaca*, a été étudié du point de vue physico-chimique et biochimique par des méthodes d'absorption spectrale en UV / VIS, a 200-700 nm, et des qualités de principe bio actif ont été mises en évidence, avec des effets photo-protecteurs. La composition biochimique de l'extrait est la suivante: vitamines liposolubles A, D et E; acides gras saturés et non-saturés, triglycérides, cholestérine et phospholipides. On a effectué des expérimentations biochimique et pharmacologiques. Les données obtenues indiquent que l'extrait hépatique de *Trygon pastinaca* peut être utilisé dans l'obtention de certains onguents photoprotecteurs, en dermatologie et en cosmétique.

Mots-cles: Trygon pastinaca; extrait hépatique, vitamines A, D et E; acides gras non-saturés; phospholipides

Il est reconnu que les organismes marins sont une source des composantes ou préparations naturelles ayant des propriétés bioactives variées. Les recherches présentées ci–dessous ont été effectuées en vue d'obtenir un principe bioactif à effets photoprotecteurs, à partir du foie du poisson *Trygon pastinaca* du littoral roumain de la mer Noire.

Dans ce qui suit, on présente les résultats préliminaires de l'étude entreprise. C'est ainsi que les résultats présentés dans le Tableau 1 indiquent que les lipides hépatiques de *Trygon pastinaca* ont un indice d'iode de 190.35 g I_2/100 g lipides, ce qui prouve un haut degré de non-saturation. De même, l'indice de saponification et celui d'estérification correspondent à la présence de certains acides gras avec un grand nombre d'atomes de C leur molécule.

Table 1 – Indices de caractérisation analytique des lipides du foie de *Trygon pastinaca* du litoral roumain de la mer Noire

Indicateurs physico-chimiques	Valeurs des indicateurs physico-chimiques
Index d'acidité	1,2 mL KOH/g lipides
Index d'iode	190.35 g I2/100 g lipides
Index de saponification	200-201 mL KOH/g lipides
Index estère	198.88 mL KOH/g lipides

Dans la Table 2 sont présentées les données concernant la composition en lipides de l'extrait de foie étudié. On peut noter que les lipides totaux représentent 83.8% (g/v) dont le cholestérine libre 9.4%, les acides gras libres 5% et les phospholipides 2.4% (2).

Table 2 – La composition de l'extrait du foie de *Trygon pastinaca*

No.	Composantes lipidiques	Contenu des composantes lipidiques	
		g/gsu/mL	% (g/v)
1	Lipides totaux	0.198	83.8
2	Triglycerides	0.132	66.0
3	Acides gras libres	0.004	2.02
4	Cholestérine libre	0.019	9.59
5	Cholestérine estérifiée	0.038	19.19
6	Cholestérine totale	0.057	29.78
7	Phospholipides		2.4

g/gsu/mL = gramme/gramme de substance séche/mL d'extrait

Le phosphore anorganique se trouvait dans une concentration basse – de 0.001 g/gsu/mL, et de 0.49% respectivement des lipides totaux.

Dans la Table 3 est présentée la composition en vitamines liposolubles (A, D et E) de l'extrait de foie du *Trygon pastinaca* dont il résulte 3% vitamine E, 2.5% vitamine D et 1.37% vitamine A. La teneur totale en vitamines liposolubles est de 7.87% (1).

Les spectres d'absorption de la Figure 1 indiquent que l'extrait hépatique de *Trygon pastinaca* présente un maximum d'absorption situé entre 350 et 400 nm par rapport à la solution standard de vitamine E, qui a le maximum d'absorption toujours entre 340 et 400 nm (1).

Table 3 - La composition en vitamines liposolubles del'extrait du foie de *Trygon pastinaca*

No	Vitamines liposolubles	Contenu en vitamines liposolubles		
		µg/gsu/mL	UI/gsu/mL	%(g/v)
1	Vitamines A		9267.3	1.37
	- acetate de vitamine A1	3187.9		
	- beta-carotene	5560.2		
	- vitamine A1	2780.1		
	- provitamines A	0.01875*		
2	Vitamines D		23881.0	2.50
	- vitamines D2	5097.0		
	- vitamines D3	5097.0		
3	Vitamines E		150054.0	3.00

gsu/mL = gramme substance seche/ml d'extrait
** = mL/gsu/ml extrait*

En conclusion, le foie du poisson *Trygon pastinac*a du littoral roumain de la mer Noire nous a offert un extrait d'une haute teneur en substances bioactives (vitamines A, D et E, acides gras, triglycérides). Cet extrait à effets photoprotecteurs, étant incorporé dans des bases d'onguents variés et adéquats, peut être utilisé en dermatologie et cosmétologie.

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ÉTUDE DES PHOSPHOLIPIDES DE QUELQUES ESPÈCES D'INVERTÉBRÉS ET DE POISSONS DE LA MER NOIRE

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Résumé
L'objectif de l'étude présente est d'obtenir un extrait phospholipidique des huiles préparées du foie de deux espèces des poissons *Trygon pastinaca* et *Squalus acanthias*. Les phospholipides ont été mis en évidence par chromatographie en couche mince, en mesurant ensuite l'extinction au spectrophotomètre à λ=720nm. Pour les échantillons testés on a établi une valeur de 61.63±3.16 pour *Squalus acanthias* et de 58.04±3.91 pour *Trygon pastinaca*, ce qui correspond aux cephalines. L'analyse a mis en évidence une plus grande concentration des cephalines chez *Squalus acanthias* – 28.84 mg/dl d'extrait, que chez l'espèce *Trygon pastinaca* – 4.81mg/dl d'extrait. Chez *Mytilus galloprovincialis* et *Rapana thomasiana* on a identifié: PE, PC, LPC, PS. C'est ainsi que chez *Rapana thomasiana* celles-ci représentent 17.7% des lipides totaux, tandis que chez *Mytilus galloprovincialis* 35.5% des lipides totaux.

Mots-clés: invertébrés, poissons, phospholipides, chromatographie en couche mince

Les déterminations ont été faites par chromatographie en couche mince sur plaques de silicagel, en calculant le facteur de rétention R_fX100, en mesurant ensuite l'extinction au spectrophotomètre à λ=720nm. Les résultats obtenus prouvent que chez *Mytilus galloprovincialis* l'extrait phospholipidique contient: PE, PC, LPC, PS, et chez *Rapana thomasiana* : PE, PC, LPC et PS. Chez *Mytilus galloprovincialis*, les phospholipides représentent 35.5% des lipides totaux, et chez *Rapana thomasiana* 17.7% des lipides totaux. Si l'on compare le taux des extraits de phospholipides avec la composition des lipides des muscles rouges ou blancs de *Gadus morhua* (2), on constate que *Mytilus galloprovincialis* en a environ une moitié (35.3% phospholipides), tandis que le taux de *Rapana thomasiana* est plus faible, 17.7%

Les extraits phospholopidiques isolés des huiles obtenues du foie des poissons *Squalus acanthias* et *Trygon pastinaca* contiennent des phosphatidil éthanolamines et des phosphatidilserines, des complexes qui sont appelés par certains auteurs "céphalines" (1).

Les valeurs du facteur de rétention R_fx100 déterminés dans les échantillons analysés sont reproduites dans le Tableau 2, en comparaison avec les valeurs des substances pures établies expérimentalement dans les mêmes conditions (Tableau 1).

Table 1- Valeurs des Rf x100 pour les phosphlipides pures

No.	Phospholipide	Rfx100=hRf
1	Lisolecithine (LPC)	21±4
2	Sphingomyeline (Sph)	29±5
3	Lecithine (LC)	39±5
4	Céphalines (phosphatidil ethanolamine -PE et phoaphatidil serine - PS)	57±8
5	Cerebrosides	78±8
6	Cardiolopines	92±2

Table 2 – Valeurs R_fx100 obtenues à la separation des céphalines des extraits phospholopidiques

No.	Extrait phospholipidique	Valeur moyenne Rfx100 (x)	Déviation xs	Coefficient Variable v%
1	*Squalus acanthias*	61.63	7.73	12.54
2	*Trygon pastinaca*	58.04	9.32	16.06

On a utilisé le test Student Cochrane; n=8

Une analyse des valeurs de R_fx100 obtenues montre que celles–ci sont de 61.63±3.16 et respectivement de 58.04±3.91, correspondant aux valeurs standard de R_fx100 =57±8, pour les céphalines. Donc le résultat confirme la présence des cephalines dans les huiles obtenues du foie des deux espèces des poissons étudiées. Les résultats obtenus au dosage des céphalines des extraits phospholipidiques sont présentés dans le Tableau 3.

Analysant les données il apparaît que *Squalus acanthias* contient des cephalines en plus grande quantité (phosphore lipidique - 1.15mg/dl d'extrait et céphalines - 28.84 mg/dl d'extrait/ml huile) que *T. pastinaca* (phosphore lipidique - 0.192 mg/dl d'extrait et cephalines - 4.807mg/dl d'extrait/ml huile); Figures 1 et 2.

Tableau 3- Teneur en phospholipides chez les espèces de poissons étudiées des extraitsphospholipidiques

No.	Extrait phospholopidiques	Phosphore lipidique mg/ml d'extrait/ml huile	Céphaline mg/dl d'extrait/ml huile
1	*Squalus acanthias*	1.15	28.84
2	*Trygonpastinaca*	0.192	4.807

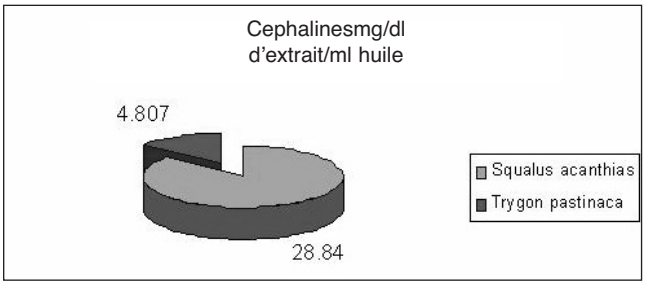

Figure 1 -Teneur en céphalines chez les espèces de poissons étudiées des extraits phospholipidiques

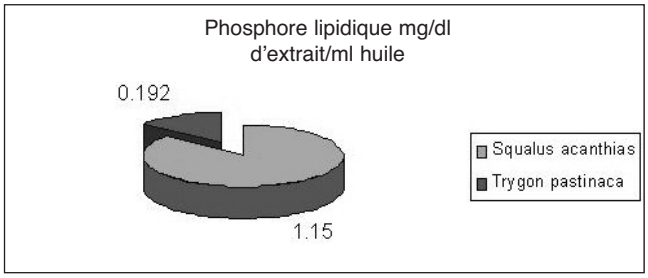

Figure 2 - Teneur en phosphore lipidique chez les espèces de poissons étudiées des extraits phospholipidiques

En conclusion, les extraits étudiés constituent des sources naturelles importantes pour l'obtention des phospholipides.

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EXTRACELLULAR ENZYMATIC ACTIVITIES IN WATER AND SEDIMENT: FIRST EVALUATION IN THREE SITES DESIGNATED FOR MARICULTURE

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Abstract

Extracellular enzymatic activities (leucine aminopeptidase, β-glucosidase and phosphatase) and heterotrophic bacterial density were investigated both in water and sediment samples of three marine sites of the Mediterranean Sea, in order to point out any variations related to mariculture activity. The preliminary data obtained before the beginning of fish farming experiments showed significant variation patterns among the sites for all the parameters examined even in undisturbed conditions.

Key-words: enzymes, bacteria, aquaculture

Introduction

Microbial hydrolysis of natural polymers through extracellular enzymes is considered a fundamental step in the degradation of the organic matter in both pelagic and benthic environments (1). Enzyme activities are known to be highly sensitive to environmental changes and respond differently to the organic matter supply (2, 3). Microbial abundance and metabolic activities may undergo substantial alterations, i.e. such as in intensive aquaculture farms (4) or in mariculture sites (5).

In the framework of a multidisciplinary research program aimed at evaluating the impact of fish-farming plants on the environment, extracellular enzyme activities and heterotrophic bacterial abundance were studied in order to evaluate changes in their distribution induced by mariculture activities. The preliminary data, reported here, outline a preliminary picture of the metabolic potentialities of bacterial communities present in natural undisturbed conditions, before the beginning of fish-farming experiments.

Material and methods

Surface water (0.5m) and sediment (0-1.5cm) samples were collected from two areas located along the Tyrrhenian coast, Castellammare Gulf (A) and Capo d'Orlando (B), in both spring and summer (area A: late March and June 2000; area B: May and July 2000). A third area, Portopalo of Menfi (C), in the Mediterranean Sea, was sampled only in summer (July 2000). Three extracellular enzymes (leucine aminopeptidase, LAP, b-glucosidase, glu, and phosphatase, phos), involved in the hydrolysis of proteins, mucopolysaccharides and organic phosphates respectively, were estimated using specific fluorogenic substrates (L-leucine-7-amido-4-methylcoumarin, 4-methylumbelliferyl(MUF)β-D-glucopyranoside and MUF-phosphate) (2, 6). Measurements were performed after 3 hours at the *in situ* temperature in a TD-700 Turner fluorimeter, at 380/440 excitation/emission wavelengths, for LAP, and at 365/455 for glucosidase and phosphatase. Enzyme levels in sediments were also normalised to grams of dry weight. Bacterial heterotrophic density was evaluated on Marine agar 2216 (Difco) plates incubated at 22°C for 7 days. A three-way Anova test (F-test) (areas X months X stations) was used to assess statistical significance of variations in the variables measured.

Results

The mean values of enzyme levels measured in water samples showed a strong variability from site to site; bacterial density values were more homogeneous (range 1.4-1.9x10^3CFU/ml). In area A, aminopeptidase (68.4±7.9-541.3±9.1nM/h/l in spring and summer respectively) and phosphatase (9.2±1.8-99.3±1.7nM/h/l in the two sampling periods) predominated; glucosidase was detected only at low concentrations (3.6±1.7-17.0±5.1nM/l/h in spring and summer respectively). Area B displayed high phosphatase and glucosidase (peak value 91.8±6.5nM/h/l) values. In Area C phosphatase levels reached their maximum (1.8±0.3μM/h/l). Within each area temporal variations were also observed, mainly in summer for LAP and phosphatase values in area A.

In sediments, the mean values of enzyme activities were 2-3 orders of magnitude higher than those reported for water. Phosphatase activity prevailed over the other enzymes in the three sampled areas (range 1.5±0.05-98.1±0.1μM/l/h). High aminopeptidase levels were also recorded in areas C (16.8±1.6μM/l/h) and B (14.6±3.2μM/h/l). This latter was characterised by the highest values (4.9±0.3μM/l/h) of glucosidase activity. Enzyme activities, in particular phosphatase, were consistently higher in summer. Bacterial densities were on average one order of magnitude higher than in waters (range 7.8x10^3-2.9x10^4CFU/ml).

The ANOVA test of data showed highly statistical significant differences, due to the variables "areas", "months" and "stations", for phosphatase (F=7.77, 4.61, 15.48 respectively) and density (F=8.44, 9.72, 8.91 respectively) data. In sediments, variations in glucosidase and density levels were ascribable to variable "stations" (F = 4.63 and 4.70, respectively). Pearson's correlation coefficients revealed significant ($P<0.05$) relations between aminopeptidase and glucosidase only in summer in the waters of area A (r=0.84) and C (r=0.99) and in the sediments of area C (r=0.98). Significant relationships between bacterial abundance and both LAP and phos (r=0.99, $P<0.05$) were evidenced in summer in the sediments of area B only.

Discussion

Enzyme values obtained in this study are the first available in the areas examined and may add some useful information to knowledge of the metabolic capabilities of microorganisms involved in organic matter decomposition. This preliminary study points out how the distribution of bacterial abundance and enzyme activities in water and in sediments did not follow a clear pattern; changes in activity levels were apparently independent from changes in bacterial abundance. The summer increase in heterotrophic bacterial concentration is probably a consequence of higher temperature and of a seasonal nutrient supply both in water and sediment. The occurrence of enzyme activity in surface sediments with remarkably higher values than in water suggests the high catabolic potentiality of heterotrophic bacteria and a faster organic matter turnover due to the presence of a higher fraction of active bacterial cells (7). Further studies carried out at intermediate and final step of the establishment of productive activities will allow to follow the course of metabolic processes and verify it or identify microbial functional alterations related to mariculture activity. In particular, heterotrophic bacterial communities present in marine sediments, able to respond to short term environmental changes more rapidly than those present in water column (8), could potentially be used as early warning indicators of environmental disturbance.

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BIODEGRADATION DE L'INDIGO PAR UNE BIOMASSE MARINE ACCLIMATEE

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Résumé

La biodégradation de l'indigo, colorant majeur dans les rejets industriels textiles, est testée en présence de six biomasses acclimatées ayant différentes origines. Une biomasse marine prélevée de la zone côtière de Monastir s'est montrée la plus intéressante. Son activité est optimale quand elle est cultivée en batch sous agitation à des pH élevés. Le suivi spectrophotométrique de la densité optique (DO) d'une solution de l'indigo soumis à l'action de cette biomasse a permis de voir que cette DO augmente au cours de trois premières heures, puis diminue régulièrement jusqu'à au moins 21 heures. Cette évolution de la DO est suivie d'une diminution du pH de la suspension de façon à ce que la suspension présente un pH neutre ou proche de la neutralité quelque soit sa valeur initiale. L'analyse bactériologique de cette biomasse a permis de voir qu' elle est formée en grande partie par des bactéries du genre *Pseudomonas* dont cinq espèces prédominent: *P. stutzeri*, *P. cepacia*, *P. pikittii*, *P. mali* et *P. mendocin*a.

Mots clefs: biodégradation, biomasse marine, traitement, indigo, Pseudomonas.

Introduction

Au cours de ce travail, nous avons essayé d'acclimater de nombreuses biomasses à l'eau de rejet de l'industrie textile. Nous avons testé l'effet de chacune de ces biomasses sur l'indigo. Les plus actives sont soumises à des études approfondies pour optimiser les conditions de traitement biologique des rejets industriels textiles.

L'acclimatation de ces souches aux rejets de la SITEX nous a permis de sélectionner une biomasse marine dont les activités épuratrices ont été particulièrement abordées. Nous avons essayé de dégager les caractéristiques qui peuvent être mises à profit pour le traitement des eaux usées de l' industrie textile et qui sont susceptibles d'être modifiées. C'est le cas du pH, de l'aération et de la durée de séjour des bactéries en présence de l'indigo.

Matériel et méthodes

Station de prélèvement : station de traitement des rejets textiles de la SITEX (Tunisie). Nous avons utilisé trois milieux de culture :

- agar préparée avec de l'eau ESS (Eau de la Station de la SITEX stérile) qui sert de substances nutritives;
- gélose nutritive préparée avec l'eau (ESS) : GNESS;
- bouillon trypcase préparé avec l'eau (ESS).

Résultats

Effet de la biomasse marine acclimatée sur l'indigo

Nous avons choisi une biomasse marine cultivable sur milieu GNESS pour voir son activité sur l'ESS, l'indigo et le Black B. Après ensemencement de la biomasse marine et incubation pendant 48h à 25°C, les colonies sont raclées avec une pipette Pasteur. Les résultats ont montré que l'indigo est l'élément le plus facile à dégrader par cette biomasse. Le Black B ne semble pas être dégradé par cette biomasse.

A partir de cette biomasse, nous avons étudié l'activité des colonies pourpres cultivables sur GNESS : ce sont des bacilles Gram (-). Leur activité sur l'ESS, l'indigo et le colorant au soufre est étudiée. La dégradation de l'indigo par les bactéries dans les conditions expérimentales décrites (culture discontinue en batch) a été suivie par spectrophotométrie à une longueur de 677 nm qui correspond au maximum d'absorption de l'indigo solubilisé. Nous avons trouvé que ces bactéries sont plus actives sur l'indigo à un pH=9. La diminution maximale de la couleur est obtenue au bout de 21 à 22 heures.

Effet de la température

Nous avons mis dans 4 béchers 50 ml d'indigo, additionné de la biomasse marine. Ces béchers sont mis à différentes températures. Nous avons pu voir que la température la plus favorable à la dégradation de l'indigo par la biomasse marine est de 37°C.

Évolution de l'hydrophobicité de la biomasse marine

Après incubation des boites GNESS ensemencées par la biomasse marine, nous avons fait un dénombrement des colonies dont nous avons étudié l'hydrophobicité :

- bactéries hydrophobes : 107 300 germes/ml.
- bactéries hydrophiles : 54 000 germes/ml. Le pourcentage des bactéries hydrophobes est 66,54%; le pourcentage des bactéries hydrophiles est 33,46 %.

Cette hydrophobocité est un facteur important qui gouverne le mécanisme d'adhésion des bactéries et par suite la formation des flocs et leur décantation (1). Par cette technique de détermination de l'hydrophobocité, comparable à celle utilisée par Gerson (2) et par Jorand (3), on a pu voir que ce taux est fort par rapport à celui trouvé par ces chercheurs. Jorand *et al*. ont également montré que cette hydrophobocité est liée aux conditions expérimentales ainsi qu'à la disponibilité des nutriments, elle dépend encore de la phase de croissance des souches purifiées.

Composition de la biomasse marine

Bien qu'étant formée essentiellement de vibrions, cette microflore après acclimatation s'est montrée très riche en *Pseudomonas* : cinq espèces différentes ont été isolées *P. stutzeri*; *P. cepacia*, *P. pikitti*, *P. mali* et *P. mendocina*., à côté de quelques souches non identifiées. Ces bactéries ont des temps de génération courts comparées aux autres bactéries, mycobactéries, actinomycètes et tolèrent des taux élevés en NaCl allant jusqu'à 23 g NaCl/l. Ceci les rend préférables aux A*ctinomycètes* qui sont souvent utilisés dans les boues activées textiles (4).

Discussion et conclusion

La comparaison des densités optiques observées dans la plupart des expériences faites avec un témoin confirme cette constatation. L' exploitation des résultats reste limitée du fait que les produits donnés ne sont pas connus et leur effet sur les paramètres de détermination de la qualité de l'eau (DCO, DBO5) n'est pas étudié. Cependant sur le plan appliqué, on voit que la biomasse marine sélectionnée se prête à une utilisation industrielle. Elle pourrait améliorer la qualité de l'eau, en matière de DCO et couleur essentiellement. L'installation d'une station pilote a été faite pour poursuivre la modélisation et l'optimisation des conditions de traitement par utilisation de cette biomasse.

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CYCLOBUTANE PYRIMIDINE DIMERS DETECTION IN MARINE PHYTOPLANKTON *ISOCHRYSIS GALBANA* FOLLOWING UV IRRADIATION

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Abstract
The effect of artificial and solar UV irradiation on DNA of marine phytoplankton *Isochrysis galbana* was investigated. Cultures grown under 16/8 light/dark regime contained smaller amount of photosynthetic pigments and UV absorbing compounds and showed greater sensitivity to UV light than the cultures grown under 24/0 light regime. For specific detection of cyclobutane pyrimidine dimers (CPDs) in *I. galbana* alkaline DNA filter elution using T4 endonuclease V was adapted. Artificial UV irradiation increases CPDs in dose-dependant manner. After 1 h of sunlight exposure, the level of DNA damage increase significantly but prolonged exposure decreased it due to the efficiency of *I. galbana* DNA repair mechanisms.

KEYWORDS: phytoplankton, pigments, UV, sunlight, cyclobutan pyrimidine dimers

Oxygen and sunshine (UV) are two major genotoxic agents that all photosynthetic organisms are obliged to be exposed to. One way to assess the importance of enhanced UV irradiation as a potential source of biological damage in marine organisms is to determine UV- induced DNA damage and the capacity for DNA repair. Cyclobutane pyrimidine dimers (CPDs) are exclusive UV product and make 75% of the UV-induced DNA damage products (1), having an inhibitory effect on transcription and replication as well as mutagenic effect. We measured incidence of CPDs in marine phytoplankton *Isochrysis galbana* cultures (2) grown under different light/dark regimes after artificial UV exposure. CPD content in *I. galbana* cells was expressed as SSF (strand scission factor) - measure of CPD sites as single strand breaks (3) after T4endonuclease V digestion. In cells grown under 16/8 h (light/dark) regime after exposure to artificial UV (0-37.5 kJ/m^2) more CPDs was detected than in the cells grown under constant illumination (24 h) (Fig.1).The latter contained higher amount of photosynthetic pigments (chlorophyll a) as well as UV absorbing compounds (Table 1). These results revealed correlation between light exposure, UV-absorbing compounds content and sensitivity to UV light, suggesting strong influence of photoprotective compounds in reducing the susceptibility to UV damage in phytoplankton cells.

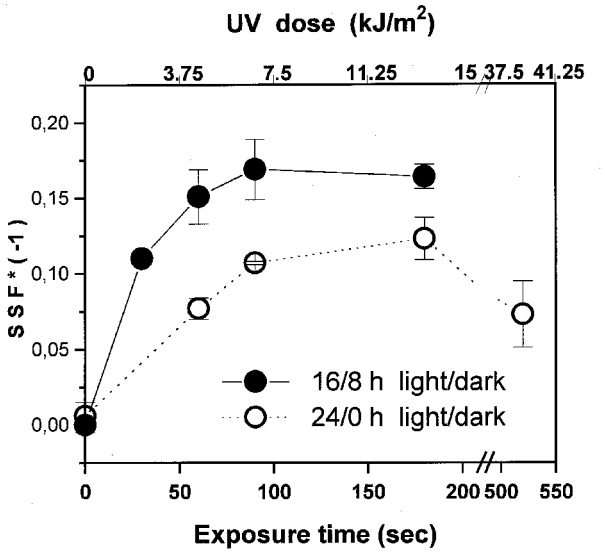

Fig. 1. Dependence of SS to artificial UV radiation for *Isochrysis galbana* cultures grown under differents light/dark regimes

Table1. Chlorophyll a and UV-absorbing compounds content in *Isochrysis galbana* cells grown under different light/dark regimes.

Illumination light/dark (h)	Chlorophyll *a* (µg/10^6 cells)	UV - absorbing components (A_{300}/10^7 cells)
24/0	0.353	0.792
16/8	0.192	0.158

Besides protection there is a great importance of the existence of DNA repair mechanisms as a part of biological response of phytoplankton cells to UV irradiation. DNA photodamage and DNA repair capacity in *I. galbana* cells exposed to ambient solar irradiation was measured on August 6 and 20,1996 (Table 2). After 1 hour, DNA damage increased and after 3 hours of exposure, it decreased to the 40% of the damage obtained after first 1 hour. Thus, DNA protection and damage elimination mechanisms successfully lowered CPDs accumulation, suggesting that sunlight exposure induces DNA damage that could be repaired even when the DNA damage and repair are happening simultaneously.

Table 2. CPDs accumulation and their repair in *Isochrysis galbana* cells during sunlight exposure in the Northern Adriatic (45o 05` N, 13o 30` E, Rovinj, Croatia).

SUNLIGHT EXPOSURE	August 6, 1996	August 20, 1996
Time/h	SSF	
11:00	-0.006 ± 0,019	-0,006 ± 0,019
12:00	-0,055 ± 0,015	-0,037± 0,002
14:00	-0,007 ± 0,018	-0,015 ± 0,003

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EVALUATION DE LA POLLUTION D'UN MILIEU MARIN PAR LES HYDROCARBURES PÉTROLIERS ET LA DECONTAMINATION PAR BIODÉGRADATION MICROBIENNE

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Résumé

L'objet de cette étude est d'évaluer la décontamination d'un milieu marin pollué avec des hydrocarbures pétroliers par la biodégradation bactérienne. Des échantillons d'eau ont été collectés à partir de la raffinerie (STIR) de Bizerte en Tunisie, d'autres du milieu environnant. L'étude organique des hydrocarbures (HC) réalisée sur les échantillons montre : que le traitement effectué par la raffinerie ne permet pas d'éliminer les HC et que la biodégradation est responsable en grande partie de l'élimination des HC légers. L'identification des bactéries actives sur les HC montre la présence des bactéries du genre Burkholderia, Pseudomonas, Brevundimonas, Acinétobacter, Serratia à côté des bacilles Gram+ sporulés.

Keywords : petroleum, sea water, bacteria, pollution

Les hydrocarbures (HC) pétroliers libérés dans le milieu marin, auront des conséquences graves aussi bien sur le plan économique que sur le plan écologique, en causant souvent la dégradation des écosystèmes. Une fois libérés, le devenir de ces HC sera fonction des différents facteurs abiotiques et biologiques (1).

Certaines études ont montré que plusieurs espèces bactériennes ont la capacité de biodégrader les composés pétroliers en les utilisant comme source de carbone et d'énergie (2). C'est dans ce cadre que cette étude a été entreprise afin de déterminer le degré de pollution marine causée par la raffinerie (STIR) de Bizerte en Tunisie, qui utilise l'eau de mer pour le nettoyage de ses réservoirs ainsi que ceux des bateaux. Cette étude a aussi pour but d'évaluer la décontamination du milieu marin par la biodégradation bactérienne.

Plusieurs échantillons ont été collectés à partir de la raffinerie elle même à savoir les eaux des bassins de décantation et l'eau de rejet. Des échantillons sont aussi collectés du milieu environnant : l'eau de mer, l'eau interstitielle, les sédiments marins ainsi que l'eau de mer d'une station située à quelques kilomètres du milieu de rejet. Une étude organique a été réalisée sur tous les échantillons, elle consiste à faire une extraction des (HC) par un solvant organique le chloroforme, un fractionnement de l'extrait chloroformique par chromatographie en phase liquide sur colonne en silice. L'étude organique se termine par une étude qualitative des (HC) saturés et insaturés non aromatiques par chromatographie en phase gazeuse.

Les résultats obtenus montrent que tous les échantillons présentent des teneurs en HC totaux assez élevées allant jusqu'à 92 ppm pour les sédiments marins. L'examen des pourcentages pondéraux des fractions constituant l'extrait chloroformique montre une grande richesse en HC légers (toujours > 70 %) par rapport aux composés lourds (toujours < 30 %) (voir tableau 1), on peut conclure que les (HC) présents dans ces échantillons ont nécessairement une origine pétrolière (3).

L'étude qualitative des HC saturés et insaturés non aromatiques par chromatographie en phase gazeuse permet d'identifier une distribution régulière des n-alcanes montrant une décroissance des plus légers vers les plus lourds rappelant le chromatogramme d'un pétrole brut (4). Par conséquent le traitement de l'eau de rejet réalisé par la raffinerie ne permet pas de la décontaminer.

L'évaluation de la biodégradation bactérienne des HC pétroliers a été réalisée au laboratoire en effectuant une étude organique quantitative et qualitative des HC sur une 2ème portion des échantillons de départ placés à l'air libre pendant une période de 3 mois.

Les résultats obtenus montrent une diminution importante des teneurs en HC totaux pour tous les échantillons (10 ppm à 86 ppm) et une chute des pourcentages pondéraux de la fraction légère (HC saturés et insaturés non aromatiques et aromatiques) qui varie de 0 % à 54 % par rapport à la fraction lourde (résine et asphaltène) qui varie de 47 % à 100% (voir tableau 1).

Ces données permettent désormais de conclure que les micro-organismes et en particuliers les bactéries attaquent principalement la fraction légère alors que la fraction lourde n'est pas significativement utilisée.

L'analyse des chromatogrammes des HC saturés et insaturés non aromatiques montre en premier lieu la présence des "humps" représentatifs des UCM au niveau des n-alcanes moyens à lourds traduisant

Tableau 1: Teneurs en HC totaux (HCT) exprimées en ppm, HC saturés et insaturés non aromatiques (HCS) exprimées en % des (HCT), HC aromatiques (HCA) exprimées en % des (HCT) et composés lourds (NSO) exprimées en % des (HCT) dans les échantillons.

- Eau du 1er bassin : eau du 1er bassin de décantation.
- Eau de mer (1) : eau de mer du milieu de rejet.
- Eau de mer (2) : eau de mer d'une station située à quelques kilomètres du milieu de rejet.
- Eau interstitielle : eau interstitielle des sédiments marins.

	Teneurs initiales en HC				Teneurs en HC 3 mois plus tard			
	HCT en ppm	HCS en 10^{-4} g	HCA en 10^{-4} g	NSO en 10^{-4} g	HCT en ppm	HCS en 10^{-4} g	HCA en 10^{-4} g	NSO en 10^{-4} g
Eau du 1 er bassin	30	8	5	2	14	1	0	6
Eau du rejet initial	30	10	2	3	16	0	0	8
Eau du rejet final	38	6	9	4	10	0	0	5
Eau de mer (1)	36	9	4	5	8	3	0	1
Eau de mer (2)	30	10	1	4	10	2	0	3
Eau interstitielle	18	8	1	0	68	1	1	32
Sédiments marins	92	23	15	8	86	23	0	20

l'intervention d'une activité microbienne (5), on remarque aussi une dégradation des pics représentatifs des n-alcanes. On peut conclure alors que la biodégradation microbienne est responsable en grande partie des changements chimiques de la composition des HC pétroliers. Ceci est conforme aux résultats de certaines études qui ont montré qu'en culture pure, la biodégradation des HC saturés et insaturés non aromatiques est plus importante que celle des aromatiques. Toutefois, les résines et les asphaltènes (fraction lourde) résistent à l'attaque microbienne (6).

L'identification des bactéries hydrocarbonoclastes actives sur les hydrocarbures a été réalisée à l'aide des galeries biochimiques API 20 E et API 20 NE (bio-Mérieux). Elle montre la présence des bactéries du genre Burkholderia, Pseudomonas, Brevundimonas, Acinétobacter, Serratia à côté des bacilles Gram+ sporulés.

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DIESEL FUEL DEGRADATION : PHYSIOLOGICAL AND MOLECULAR CHARACTERIZATON OF ACINETOBACTER VENETIANUS STRAINS ISOLATED FROM VENICE LAGOON

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Abstract

The bacterial strain VE-C3, belonging to the new species *Acinetobacter venetianus*, isolated from Venice Lagoon and involved in diesel fuel degradation, was characterized by a combination of molecular and physiological techniques. *A. venetianus* VE-C3 cells were able to grow in the presence of n-hydrocarbons by forming cell aggregates which adhere to hydrocarbon drops. A 23.8 KDa protein appeared to be involved in the formation of cell aggregates. The oxidation of n-hydrocarbons was carried out by Alk proteins homologous to the *Pseudomonas oleovorans alk*BFGH gene products and whose genes were located on the VE-C3 chromosome and in plasmid pAV2.

Keywords: diesel fuel, Acinetobacter venetianus, alk genes

Twenty-five bacterial strains isolated from Venice Lagoon and able to degrade *n*-alkanes, *n*-alkanols, *n*-alkanals and *n*-alkanoates, were previously characterized at the molecular and physiological level (1, 2). Only strains belonging to the new species *A. venetianus* grew in minimal medium containing *n*-alkanes (C_{10}, C_{14}, and C_{20}) (2) and their respective oxidation products as the sole carbon and energy source. The other strains thrived on n-alkane oxidation products, giving rise to a sort of "functional complementation", in that single members of the community perform different step(s) of the degradation process. The *A. venetianus* VE-C3 cells initiate diesel fuel degradation by oxidizing n-alkanes, providing organic residues suitable for the other bacteria of the community.

The analysis of plasmid content revealed that *A. venetianus* VE-C3 cells harboured two plasmid molecules, pAV1 and pAV2, of 10Kb and 15Kb, respectively. Hybridization experiments also showed that pAV2 contained sequences homologous to the *Pseudomonas oleovorans* alkBFGH genes.

The *A. venetianus* VE-C3 cells were able to degrade diesel fuel by a mechanism requiring the formation of cell aggregates and their further adhesion to diesel fuel drops, via the synthesis of a polysaccharide capsule (3). This process was studied in *A. venetianus* mutants, obtained through the conjugal transfer of pRK290, a 20 kb broad-host range plasmid, from *Escherichia coli* to VE-C312 (a spontaneous Rif^r mutant) cells. Most of ex-conjugants showed large rearrangements in plasmid profile, mainly consisting in loss of plasmid pAV1 (such as in mutant C312/3); other mutants showed a molecular rearrangement of this plasmid (mutant C312/30). Mutants C312/3 and C312/30 were further characterized at physiological and molecular level; they showed a reduced ability to grow in the presence of diesel fuel or hexadecane as the sole carbon and energy source. This was probably due to a reduced ability of aggregation and the further adhesion to hydrocarbons, as shown in figure 1. Moreover in cell-to-surface adhesion experiments, performed by MATH test, VE-C3 and VE-C312 cells appeared to be hydrophilic when grown in a complex medium but became hydrophobic when incubated in mineral medium with diesel fuel as the sole carbon and energy source (not shown). The same test, carried out on mutants C312/3 and C312/30, showed that both of them were always hydrophobic, even when grown in a complex medium without diesel. The mutant phenotype could be due to the loss (or mutation) of genes (very likely located on plasmid pAV1) encoding proteins involved in cell to cell aggregation and that might be localized on cell envelope. To check this hypothesis, membrane proteins were extracted from VE-C3 cells grown in the complex medium and in the mineral medium with diesel fuel as sole carbon and energy source. PAGE analysis of these proteins showed the presence of a 23.8 KDa protein only in A. venetianus VE-C3 cells grown in the presence of diesel fuel. This protein was absent in cell extracts of VE-C3 cells grown in the absence of hydrocarbons. The 23.8 KDa protein is induced by hydrocarbons and is probably involved in adhesion of bacteria to hydrocarbons. Studies are in progress in order to understand the role of the protein in the cell adhesion to hydrocarbon process.

The study of hydrocarbon degradation in A. venetiuanus VE-C3 was also carried out by cloning of alk genes. For this purpose polymerase chain reaction (PCR) experiments were carried out in order to amplify alk sequences from both VE-C3 chromosome and plasmids. PCR reactions were performed using two primers previously designed for the amplification of alk sequences from different microorganisms. We obtained the amplification of a 600-bp DNA fragment from the VE-C3 chromosome, whose nucleotide sequence was determined. The comparative analysis of this sequence with those available in databases revealed that it shared a high degree of sequence similarity with alkM genes from different hydrocarbon-degrading bacteria. This suggested that, at least some genes involved in diesel fuel degradation in A. venetianus are located on the bacterial chromosome. Studies of this gene, as well as the nucleotide sequencing of plasmids pAV1 and pAV2, are in progress.

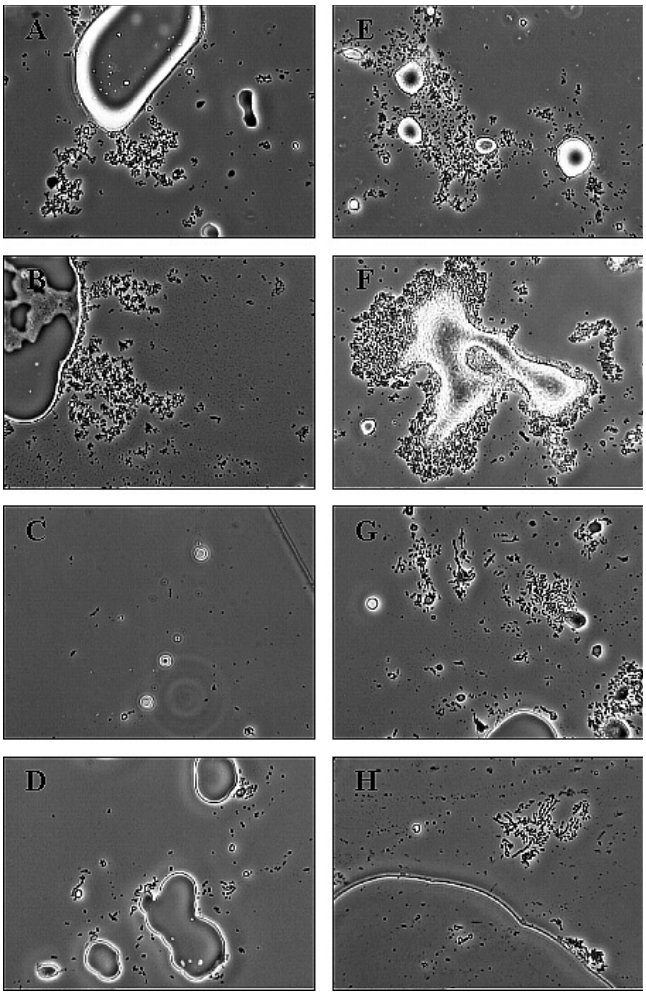

Figure 1. Analysis of cell aggregation of *A. venetianus* strains grown on diesel fuel (A-D) or on *n*-hexadecane (E-H). (A, E) *A. venetianus* VE-C3; (B, F) *A. venetianus* C312; (C, G) *A. venetianus* C312/3; (D, H) *A. venetianus* C312/30.

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MICROBIAL COMMUNITY STRUCTURE OF DEEP SEA CARBONATE CRUSTS: NOVEL ARCHAEA INVOLVED IN ANAEROBIC METHANE OXIDATION ?

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Keywords: Eastern Mediterranean, carbonate crust, bacteria, deep sea ecology

Three carbonate crust samples collected from distant mud volcanoes in the eastern Mediterranean were used in a multidisciplinary study to gain insight in the processes that lead to carbonate crust formation and the role of anaerobic methane oxidation in these processes. The combination of lipid biomarker analysis and microbial community structure studies based on analyses of 16s rRNA gene sequences identified a highly diverse methane-consuming archaeal community composed mostly of novel species.The results obtained, suggest that the ability to oxidise methane under anoxic conditions by archaea may be phylogenetically more widespread within the Archaea than previously suggested.

Methane is an important greenhouse gas and recent geologic and glacial studies have shown its potential impact on climate change (1). As a consequence, controls on methane production and consumption are important considerations in the discussion on climate change. Authigenic carbonate crusts are sinks for methane carbon originating from depth or shallow gas hydrates (2,3). Understanding their formation by anaerobic methane oxidation is important in assessing the contribution of ocean-atmosphere carbon exchanges to global warming.

In the eastern Mediterranean, seven mud volcanoes (1600 and 2000 m depth) were explored with the *Nautile* submersible during the Medinaut cruise of the R/V *Nadir* in 1998. Their central parts actively seep methane to the bottom waters and are covered by thick carbonate crust pavements (4). In a multidisciplinary study, three carbonate crust samples from distant mud volcanoes (MN16BT2, MN14BT3 and MN12BT4, respectively) were used to study the processes that lead to carbonate crust formation and to detect microbes involved in anaerobic methane oxidation. Special emphasis was placed on the possible role of anaerobic microorganisms in this process. To this end the microbial community structure was analysed (16S rRNA studies) and results were combined with lipid biomarker analysis and compound-specific carbon isotope measurements.

Analyses of cellular lipid biomarkers showed the presence of diverse and novel isoprenoidal alkyl diethers, tetraethers and irregular isoprenoids that are diagnostic of archaea (5,6) in crusts MN16BT2 and MN13BT4, whereas MN14BT3 showed little abundance of such markers. These compounds were strongly depleted in ^{13}C ($-101‰ < \partial 13C < -69‰$) indicating assimilation, rather than production, of ^{13}C-depleted methane by Archaea (7). In addition, lipid biomarkers indicative for sulphate reducing bacteria (SRB) were detected in all three crusts. These SRB biomarkers were also depleted in ^{13}C . These low $\partial^{13}C$-values of cellular lipid biomarkers and the co-occurrence of SRB with Archaea are consistent with the hypothesis that anaerobic methane oxidation is carried out by consortia of these prokaryotes (8,9).

DNA appeared to be present in large amounts in the crusts. Analyses of the microbial community structure based on 16S rDNA sequences showed the presence of bacterial and archaeal communities in crusts MN16BT2 and MN13BT4. In crust MN14BT3 16S rDNA of members of an archaeal community were not detected. All three crusts showed little similarity between the bacterial communities. These bacterial communities consisted of phylogenetically diverse organisms, most of which appear to be novel species. Based on 16S rDNA analysis, only crust MN16BT2 showed the presence of organisms related to sulphate reducing bacteria (∂-proteobacteria).

Analysis of the archaeal community of crust MN16BT2 revealed the presence of three archaeal clusters, two of which appear to be related to Archaea previously identified in cold seep sediments (10). One of these two clusters has been suggested to be involved in anaerobic methane oxidation (10). The third cluster comprised novel, previously undetected archaeal sequences. In crust MN13BT4, two clades, consisting of ten new archaeal species comprising several lineages were identified. All these clusters in crust MN13BT4 are distinct from those of crust MN16BT2 and have not been previously reported for any setting.

The combination of lipid biomarker analysis and microbial community structure studies indicated the presence of a highly diverse methane-consuming archaeal community composed of mostly novel species. The occurence of anaerobic methane oxidation by archaeal communities both in the absence and presence of SRB may suggest that the ability to anaerobically oxidise methane may be phylogenetically more widespread within the Archaea than previously suggested.

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CELLS AND ELECTRODE, STICKING TOGETHER IN SEAWATER

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Abstract
Potential controlled electrode surface propertiesoffer a possibility for direct studiesof non-specific interactions between living cells, non-living particles during aggregation processes or biofilm formation in seawater. Our approach is based on measuring electrical signals of double-layer charge displacements caused by adhesion of single cells or particles. Unicellular marine alga, *dunaliella tertiolecta* of micrometer size and flexible cell enveloppe was used as a model particle. The dropping mercury electrode acted *in situ* adhesion sensor and the electrochemical technique of chronoamperometry allowed precise measurement of the spread cell-electrode interface area and the distance of the closest approach of a cell.

Keywords : algal cells, electrochemistry, fouling, interface.

Introduction

Microorganisms in nature generally live and grow in aggregated forms such as biofilms and flocks. Appearence of biofilms in natural and technological environments causes severe problems. We still do not understand completely how cells sense the surface no the underlying mechanism of adhesion (1). Employing mercury electrode as in situ sensor offers detection/identification of single algal cells at freshly exposed electrode/seawater interface. Mercury electrode with dynamic growth and hydrophobicity can mimic natural fluid interfaces while adhesion force can be fine tuned by the changing applied potential (2).

Experimental

Electrochemical measurements : Dropping mercury electrode was used because of its well-defined interfacial properties and renewable surface. The electrochemical experiments were performed in a standard Methrom vessel 3-electrode system. The mercury electrode was directly immersed in cell suspension in oxygen-free aqueous 0.1 M NaCl (pH at 8.2) solution or in seawater. *Cell culture : Dunaliella tertiolecta* Butcher cells are suitable for electrochemical detection because of their size, membrane properties, euryhaline nature, and their ability to form stable suspensions of single cells due to their pronounced motility and low stickness. The cells (maximum dimension 6-12 μm) were grown in seawater enriched with F-2 medium in batch culture. Cells were separated after 8 days of growth with mild centrifugation and washed several time with filtered seawater. Viability of cells was controlled by microscopic observation of cell motility.

Results and discussion

Attractive interaction between a cell and electrode results in a double layer charge displacement as represented by a scheme in Figure 1. The transient flow of current reflects the dynamics of adhesive contact formation and subsequent spreading of a cell. The signals of individual cells from suspension differ only slightly in the peak current and duration, indicating attachments from a nearly monodisperse particle population. The rate of adhesion and spreading of cells is enhanced by the hydrodynamic regime of electrodeís growing fluid interface. Adhesion signals of cells appeared at characteristic potential range, while outside of this potential range the cells act as inert particles (even in dense suspension). Potential range for cell adhesion depends on surface cell properties and their aging. The spike-shaped signals have the peak current in μA range, duration of 5-10 ms and displaced charge in nC range. Surprising similarities to adhesion signals of droplets of liquid hydrocarbons suggest that collective properties of cell exterior govern the dynamics of adhesion and rate of spreading, with fluidity playing a major role. The electrochemical technique thus allows a precise measurement of the contact area between the cell and the substrate (Table 1).

TABLE 1. Contact areas (A_C) of algal cells of different species and sources (A, B) at the positively and the negatively charged electrode surface.

The variation in A_C values can be ascribed to the distribution of cell sizes in the culture. The contact interface area, A_C, exceeds cross-section area of a free cell by two orders of magnitude. Evidently, *D. tertiolecta* cell ruptured during the spreading process. It is known for vesicles that strong adhesion always leads to vesicle rupture (2). The distance of the closest approach of an adhered cell can be estimated with certainty as equal or smaller than the outer Helmholtz plane i.e. 0.3-0.5 nm.

ALGAL CELLS	LENGTH /µm	CONTACT σ_{Hg} = +3.8 µC/cm^2	INTERFACE/ x 10^{-4} cm^2 σ_{Hg} = -6.5 µC/cm^2
D. tertiolecta (A)	6-12	2.88 ± 0.53	1.73 ± 0.23
D. tertiolecta (B)	6-9	1.25 ± 0.23	0.68 ± 0.15
I. galbana	3.7-7.5	1.02 ± 0.6	0.57 ± 0.3
C. maculata	12-20	7.83 ± 3.67	3.64 ± 0.81

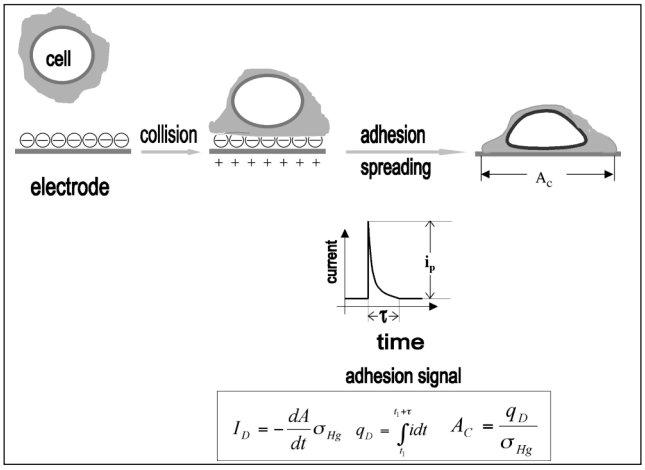

Figure 1. Attractive between cell and positively charged mercury electrode in seawater. The adhesion signal is caused by the double-layer charge displacement from the contact area A_C.

Conclusion

Our results demonstrate a general significance of adhesion phenomena in single cell-substrate interactions in seawater. The characteristic potential range of adhesion can serve to study the interplay of complex surface forces involved in soft particle interactions in seawater and resulting ìstickiness coefficientî. This electrochemical approach also meets requirements for *in situ* single particle analysis (3).

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DNA DAMAGE DETERMINATION IN GILLS OF THE MUSSEL *MYTILUS GALLOPROVINCIALIS* L. (MOLLUSCA: BIVALVIA) BY FAST MICROMETHOD®

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Abstract

Fast Micromethod® was applied in the determination of DNA damage as strand breaks alkali-labile sites and incomplete excision repair in cell suspensions or tissue homogenates in single microplates. The chemical xenobiotics (4-nitroquinoline-N-oxide and blepmycine) and different doses of γ-rays, generated by Cs^{127}, were used to induce DNA damage in native DNA and sponge cells. The method was used in a monitoring program in the Adriatic Sea to detect the effect of mixed marine pollutanta.

Keywords : Adriatic Sea, bio-indicators, bivalves, ecotoxicology, monitoring

Introduction

The estimation of genotoxic potential in the marine environment can be carried out by measuring genetic endpoints which exhibit primary DNA damage such as strand breaks. The Fast Micromethod® measures changes in the pattern of DNA denaturation by directly altering DNA integrety in cell or tissue lysates at alkaline pH, and following their time dependence (1). Two of the major advantages of the method are small amount of sample (cells suspension or solid tissues) needed and the short time of analyses. The aim of this study was to establish the applicability of the Fast Micromethod® for its use in marine ecotoxicological monitoring research.

Methods and materials

The Fast Micromethod® is performed according to Batel *et al*. (2). The time course and the extent of DNA denaturation are followed directly in the microplate by measuring the fluorescence of the DNA/PicoGreen complex for 30 mn. Results are calculated after 7-10 minutes of denaturations and expressed as strand scission factors (SSFs) calculated as:

$$SSF = \log_{10} (\%\ dsDNA_{\text{treated sample}}/\%dsDNA_{\text{control sample}})$$

Double-stranded DNA percentages were calculated in relation to fluorescence values at 0-time denaturations after correction for blank readings which represents relative 100% of ds-DNA before denaturation in samples. Thus SSF=0 assumes absence of DNA strand breaks and alkali labile sites, while SSF<0 indicates increasing frequencies of strand breaks and alkali labile sites in samples. For pratical reasons the SSF (strand scission factors) in graphical presentations were multiplied by (-1).

Results and discussions

The effect of 0-50μM Bleomycin-Fe(II) complex on the induction of DNA strand brakes in *Holothuria tubulosa* (3567A) cells has shown a dose dependent response with SSFx(-1) values from 0.047 to negative control to 0.537 respectively. The dose-response histogram for 0-500 rad γ-irradiated sponge *Suberites domuncula* cells has shown that average SSFx(-1) varied from 0.020 (control cells) to 0.082 for 500 rad (irradiated cells).

Mussels *Mytilus galloprovincialis*, injected with 0-1 μg NQO/g mussel, showed dose-dependent DNA damage with SSFx(-1) values from 0.000 for negative control to 0.168 for 1μg NQO/g. The effect of 0-83.3 μM Bleomycin-Fe(II) complex on the induction of DNA strand breaks in mussel gills has shown SSFx(-1) values 0.000 (control mussel) to 0.140 respectively.

A different amount of DNA damage (SSFx(-1) values from 0.738 to -0.610) from different locations along the Adriatic coast (Fig. 1) was detected during two years of observations (August 2000-June2000). In the cases where histograms (SSFx(-1- values) were negative, it was presumed, according to Vukmirovic (3), that the DNA-DNA and/or the DNA-protein crosslinks are presented.

This study represents a suitable Fast Micromethod® for DNA damage in native DNA isolated from cotton-spinner *Holothuria tubulosa,* marine sponge cells *Suberites domuncula* and mussel gill (*Mytilus galloprovincialis*) tissue.

The Fast Micromethod® is applicable for measurement of DNA integrity of small samples for genotoxicity assessment in environmental monitoring for genotoxic effects of lower taxa or sesile organisms (sponges, mussels). Sensitivity and preciseness of the Fast Micromethod® is comparable with the widely used Comet assay (4) which makes the former suitable for the assessment of pollution impact on aquatic organisms that can be used as bio-indicators.

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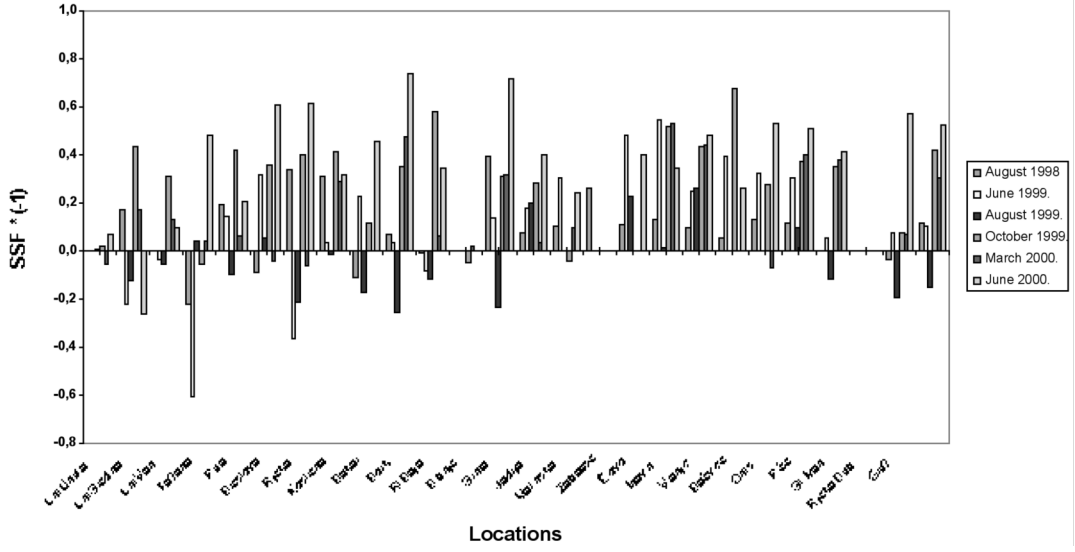

Fig. 1. - Results of SSF values for *Mytilus galloprovincialis* gill homogenates collected from different locations on the Adriatic coast during 2 years (August 1998 – June 2000).

TOTAL AND SULFUR BACTERIA DURING HOLOMICTIC PERIOD AND PERIOD OF STRATIFICATION IN THE SALINE ROGOZNICA LAKE (CENTRAL ADRIATIC)

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Abstract

Establishment of the anoxic water column with increasing H_2S concentrations in the Lake was followed by the development of a dense population of photosynthetic sulfur bacteria. The data presented in this paper discuss the relationship between photosynthetic sulfur bacteria and total bacteria during the holomixis and during the period of stratification in the Lake.

Key words: total bacteria, sulfur bacteria, holomixis, stratification

Introduction

The Rogoznica Lake is a small, intensely eutrophied saline lake, situated on the eastern coast of the Adriatic Sea. It has an area of about 5300 m^2 and a maximum depth of 15 m. The Lake has no visible connection with the surrounding sea, but lake tides are detectable on the cliffs indicating that underground water connection exists. Despite permanent water exchange between the Rogoznica Lake and the surrounding sea through the porous karst, anoxic conditions prevail in deeper layers of the Lake, probably due to remineralization of organic matter produced in the period of intensive primary production. Anoxic deep water is rich in sulfur (up to 900μM), especially in the form of sulfide or elemental sulfur (1).

The Rogoznica Lake is particularly interesting from biological point of view because of its specific flora and fauna. Specifically, in the Lake there are living some phytoplankton species that are relatively rare in surrounding sea (*Hermesinum adraticum*, Eunotia sp., *Prorocentrum arcuatum*) and only one copepode species (*Acartia italica* Steuer) (2, 3). Although, very poor qualitatively, phytoplankton and zooplankton communities are quantitatively very rich. Furthermore, in some periods a monospecific bloom appears in the Lake and probably contributes to the mass mortality that occasionally occurs in the Lake. The last mass mortality of the organisms in the Lake occurred in September 1997. The presence and distribution of total and sulfur photoautotrophic bacteria in the condition of mass mortality of the organisms in the Lake (holomictic period) and throughout the time scale of the anoxic water renewal (period of stratification) were studied.

Materials and methods

Measurements and samplings were done biweekly from the beginning of October until the end of December 1997 at 2 m intervals from the surface to the bottom (12 m).

The thermohaline features were measured by CTD multi probe IDRONAUT OS316.

Enumeration of total number of bacteria was made by epifluorescence microscopy using the standard AODC technique (4). Abundance of phototrophic sulfur bacteria were estimated from fresh samples using autofluorescence microscopy (5).

Results and discussion

The holomixis observed right after mass mortality in the Lake was followed by development of anoxic conditions with proportionally high concentration of reduced sulfur compounds (6,2). Maximum number of total bacteria has been occurred during the holomixis right after the mass mortality of the organisms in the Lake due to the intensive processes of remineralization of dead organisms. An average of total bacteria was $2.2x10^7$ cells ml^{-1} with maximum values in the surface layer and minimal values at the bottom. The presence of sulfur bacteria has been observed in relatively high concentration throughout the water column as well (average $3.7x10^9$- cells ml^{-1}), but their vertical abundance gradually increased from the surface to the bottom. Presence of anaerobic photosynthetic sulfur bacteria could explain proportionally high abundance of elemental sulfur in anoxic water column of the Lake since the bacteria partially transform sulfide to elemental sulfur (1).

Two weeks after the mass mortality of organisms occurred (sampling of 14th October), the values of total bacteria drastically felt to an average of $5.11x10^6$ cells ml^{-1} and contemporaneously the number of sulfur bacteria decreased up to an average values of $0.49x10^6$ cells ml^{-1}. Vertical distribution of both total and sulfur bacteria was similar, i.e. they were uniformly distributed through the whole water column. It is significant that the presence of sulfur bacteria was evident throughout the water column in high concentrations until 27th October, that was during the holomixis (period of the low oxygen concentration). According to the salinity, temperature and oxygen vertical profiles in the Lake after 27th October, stratification of the water column progressed and vertically stratificated water column was kept until the sampling of 29th December. In that period the concentration of oxygen was increasing in the Lake, specially in the surface layers what is a direct result of phytoplankton community activity (6). With an increase of oxygen content of the Lake the number of sulfur bacteria drastically decreased and their vertical distribution was changed. In the upper oxygenated layers where the oxygen saturation is particularly high, there were no sulfur bacteria at all, whereas in the layer under the thermocline they were far less presented than in the period of holomixis (average value of $0.02x10^6$ cellsml^{-1}). To resume, with the increasing of oxygen content the abundance of sulfur bacteria decreased and their vertical distribution changed depending of the vertical distribution of O_2 and H_2S. Similar results have been established by Cohen *et al*. (7), studying the distribution of sulfur photosynthetic bacteria in Solar Lake, and Mazumder and Dickman (8) in Crawford Lake suggesting that the development of the photosynthetic sulfur bacteria communities was closely related to the simultaneous establishment of an anoxic zone with increasing H_2S concentrations toward the bottom.

According to the results shown above, it could be stressed the role of autotrophic sulfur bacteria in the process of photosynthesis during holomyxis (anoxic period). In such conditions an autotrophic sulfur bacteria have very important ecological advantage regarding their capability to utilize high concentrations of H_2S for the process of photosynthesis.

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VIBRIOS INCREASE AS INDICATOR OF MUSSEL - FARM IMPACT IN COASTAL MARINE ENVIRONMENT

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Abstract.

Counts of cultivable bacteria were made in order to determine the impact of a mussel farm on the quality of the water and sediment, in a coastal area of the Tyrrhenian Sea. Bacterial parameters were examined from March, 1997 to February, 1998 at mussel and control stations. A significant correlation between temperature and *Vibrio parahaemolyticus* was reported at the control and mussel stations. Vibrio distribution in the water column is not related to the biodeposition of the mussel farm. Mussel farms determined an increase in density of vibrios in sediments, suggesting that these bacteria are good indicators of organic enrichment.

Key-words: bacteria, Mediterranean Sea, aquaculture

Introduction

Aquaculture activities (particularly mussel farms) are undergoing a rapid expansion in many parts of the world, resulting in an increasing interest and concern for their potential impact on coastal marine environments (1). Mussel cultivation produces large biodeposits of pseudo-faeces and faeces (2), which affect the quality and quantity of particulate organic matter available for benthic organisms (3) and stimulate microbial biomass and productivity (4). Bacteriological monitoring (i.e. vibrios) is of great importance especially in aquaculture, in fact areas suitable for productive purposes must possess optimal quality levels (5, 6, 7). In order to assess the effects of mussel farming on the coastal marine environment of a temperate area of the western Mediterranean, cultivable vibrios were studied in both water column and sediments beneath a mussel farm and compared with a control site.

Materials and methods

This study was conducted from March 1997 to February 1998 in the Gulf of Gaeta (Tyrrhenian Sea, NW-Mediterranean Sea). Sediment and water samples (at a depth of 0 and 10 m) were collected, respectively, by SCUBA divers and by using 9-liter Niskin bottles on a monthly basis at two stations: the Mussel station located inside the mussel farm and the Control station (about 1 km away from the mussel farm) in a southern area not occupied by the aquaculture plants. All stations were located at a depth of 10 m.

The temperature (T, °C) was measured by a portable multiparametric probe (Hydrolab, Inc. Austin, USA). To evaluate the density of halophilic vibrios research was carried out by filtering various amounts of each sample (1, 10 and 100 ml) through Millipore membrane (0.45 μm) and placed on TCBS agar (Difco). Incubation was carried out at 20 and at 37 °C for 24 h in order to enumerate respectively the total presumptive vibrios (PV), usually present in the marine environment, and PVP (presumptive *Vibrio parahaemolyticus*), a group of potentially pathogenic species able to grow at 37 °C.

Results and discussion

The average values (± se) relative to vibrio-like organisms are reported in Table 1. In water column, presumptive vibrio abundance was not significantly higher than in the Control (t-test, $p = 0.46$ and $p = 0.31$ for surface and bottom water, respectively), even though it was constantly high, (in surface and bottom layer) during the warmest months (June – September), when the water temperature ranged from 16.5 to 25.7 °C. In farm sediments, the density of total vibrios (on average, $6.3 \pm 5.9 \times 10^4$ CFU g^{-1}) was higher than in the Control (on average $4.0 \pm 3.2 \times 10^4$ CFU g^{-1}) even though this difference was not significant (t-test, $p = 0.22$). PVP density in the Mussel station showed a course similar to the Control and was significantly correlated to temperature (r ranging from 0.76 to 0.91; $p<0.01$ at surface and bottom layer, respectively) for all stations, indicating that temperature exerts a major control on this bacterium. Moreover *V. parahaemolyticus* was distributed homogeneously with no variation between the control and the mussel station influenced by the biodeposition of the mussel farm (8).

The density of total vibrios in mussel farm sediments was higher than at the Control, whereas no clear differences were observed for water column probably due to the higher hydrodynamic regime and dilution (9). These results indicate that these bacteria are good indicators of organic enrichment and suggest that mussels concentrate vibrios, which are then released, through faeces and pseudo-faeces to surface sediments. Larger sinking particles such as faecal aggregates (10) and marine snow (11) may constitute substrate for bacteria colonization. In fact the results confirm that vibrios and particularly *V. parahaemolyticus* are frequently found in surface sediments when the surrounding water column conditions are unfavorable (i.e. low temperature, 12) or on suspended substrata (13). The microorganisms present in the sediment of the Gulf of Gaeta, a highly retentive system (i.e., accumulation system), is increased by organic loads resulting from mussel biodeposition.

Table 1. Average values of presumptive vibrios (PV) and presumptive Vibrio parahaemolyticus (PVP) in the water and sediment samples of the Gaeta Gulf.

	PV		PVP	
	Control	Mussel	Control	Mussel
samples	x ± se	x ± se	x ± se	x ± se
Surface water[a]	$3.5\pm2.9 \times 10^3$	$3.6\pm2.5 \times 10^3$	$4.6\pm3.5 \times 10^2$	$5.0\pm4.7 \times 10^2$
Bottom water[a]	$1.4\pm1.0 \times 10^4$	$4.2\pm2.4 \times 10^3$	$2.6\pm1.6 \times 10^2$	$9.2\pm1.7 \times 10^2$
Sediment	$4.0\pm3.2 \times 10^4$	$6.3\pm5.9 \times 10^4$	$6.0\pm1.0 \times 10^3$	$4.5\pm3.5 \times 10^3$

a The number of vibrios is referred to CFU 100 ml-1 for bottom and surface water.
b The number of vibrios is referred to CFU g-1 for sediment samples.

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EFFET DES FACTEURS ENVIRONNEMENTAUX SUR LA SURVIE DES AEROMONAS SPP. AVANT ET APRÈS LEUR REJET EN MILIEU MARIN

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Résumé

Les rejets des eaux usées et des déchets d'activités humaines contribuent à la dissémination des germes pathogènes dans le milieu marin. Parmi ces germes on trouve les *Aeromonas spp*., bactéries pathogènes opportunistes, qui causent des infections intestinales ou extra-intestinales souvent liées à une contamination hydrique. Dans ce cadre nous avons étudié l'influence des facteurs physico-chimiques sur les abondances des *Aeromonas* avant et après leur rejet en milieu marin afin de comprendre leur mécanisme de survie en fonction des facteurs physico-chimiques du milieu. Pour ce faire, une modélisation statistique des dénombrements bactériens en fonction des paramètres du milieu, basée sur la méthode d'analyse par régression linéaire multiple, a été proposée. Cette modélisation a été portée sur les *Aeromonas* ainsi que les Coliformes fécaux, le groupe de bactéries indicatrices de contamination fécale le plus étudié. Les résultats ont montré que les coliformes fécaux montrent une sensibilité élevée et plus au moins conservée aux facteurs environnementaux avant et après rejet en milieu marin; par contre les *Aeromonas* montrent des modifications importantes après rejet en milieu marin manifestant des capacités d'adaptation plus poussées que les coliformes fécaux en fonction des facteurs du milieu.

Mots Clés : Rejet d'eaux usées, Aeromonas spp., Coliformes fécaux, milieu marin, facteurs physico-chimiques.

Le rejet d'eaux usées épurées en zones marines côtières, pose un problème de santé publique qui concerne la survie et la dissémination des bactéries pathogènes dans le milieu marin. Les travaux de recherche sont actuellement focalisés sur l'étude de quelques bactéries pathogènes déversées en milieu marin tels que *Escherichia coli, Vibrion, Salmonelles*.

Cependant la communauté scientifique ne sait que peu de chose sur la survie des *Aeromonas*, bactéries pathogènes opportunistes et les risques épidémiologiques liés à la dissémination de leur pouvoir pathogène en milieu marin. Il serait donc intéressant de rechercher l'effet des facteurs environnementaux qui pourraient être impliqués dans la survie de ces bactéries avant et après leur rejet en milieu marin.

Deux stations d'échantillonnage ont été choisies: le rejet final de la station d'épuration de Sfax (Sud Est de la Tunisie) notée S_1 et une station marine, station Gargour notée S_2, située à 9 Km du rejet final.

Au cours d'un cycle annuel (octobre 1998-septembre 1999), nous avons étudié l'effet des facteurs suivants sur les abondances des *Aeromonas*: Rayonnement R (w/cm^2), Température (T°C), Salinité S (‰), Turbidité Tr (NTU), Oxygène dissous OD (mg/l), pH, Conductivité C (ms/cm) et la concentration de la variable bactériologique au temps t-1 c'est-à-dire deux semaines avant le prélèvement. Cette étude a été comparée à celle des coliformes fécaux (C) groupe de bactéries témoin de contamination fécale le plus étudié. Pour ce faire, une modélisation statistique a été proposée utilisant les techniques de régression linéaire multiple (1). Elles conduisent à un modèle de type corrélatif décrivant les relations possibles entre les variables bactériologiques et les variables environnementales.

Les résultats de l'analyse par les techniques de régression multiple sont donnés sur la figure 1.Ces résultats ont montré que parmi les huit variables soupçonnées d'avoir un effet sur les CF seulement cinq montrent une influence directe significative quelle que soit la station: ce sont le R, la T, la Tr et la concentration des CF à t-1 ainsi que l'OD pour S_1 et le pH pour S_2.

Le modèle choisi explique 68 % de l'évolution des CF dans l'effluent épuré et 75 % de leur évolution en S_f; ceci est en effet confirmé par la qualité d'ajustement entre les valeurs observée (valeurs expérimentales) et les valeurs calculées prédites d'après l'équation de régression qui relie les CF aux différents facteurs environnementaux (figure 2). Pour les *Aeromonas* on remarque que les facteurs qui agissent sur leur abondances sont différents entre S_1 et S_2 ainsi si les *Aeromonas* sont corrélées positivement avec la S et la T et négativement avec OD au niveau de S_1 leur abondance se trouve corréler négativement au R et la T mais positivement à l'OD.

Le modèle explique 43 et 42 % de l'évolution des abondances des *Aeromonas* respectivement dans S_1 et S_2; ces valeurs sont toujours significatives, ceci est confirmé par la courbe des valeurs observées et prédites d'après l'équation de régression qui relie les abondances des *Aeromonas* aux facteurs environnementaux (figure 3).

Ces valeurs sont plus fortes que celles obtenues par Hazen en 1983 (R^2 = 0,33) pour un modèle de régression décrivant l'évolution d'abondance d'*Aeromonas hydrophila* dans un estuaire, mais moins fortes que les valeurs obtenues par Bahlaoui en 1990 (2) sur les *Aeromonas* en sortie d'un lagunage secondaire (R^2 = 0,53). Le modèle utilisé semble être moins performant pour expliquer la variabilité d'abondance des *Aeromonas spp*., les valeurs de R^2 sont en fait plus faibles que celles obtenues pour les CF.

Contrairement au CF qui montrent une sensibilité élevée et plus au moins conservée aux facteurs environnementaux dans les deux milieux, les *Aeromonas* montrent des modifications importantes lors de leur transit du rejet en milieu marin. Ceci peut être expliqué par le fait que les Aeromonas représentent un peuplement au moins en partie d'origine aquatique et donc capable de développer des capacités d'adaptation plus poussées que les CF.

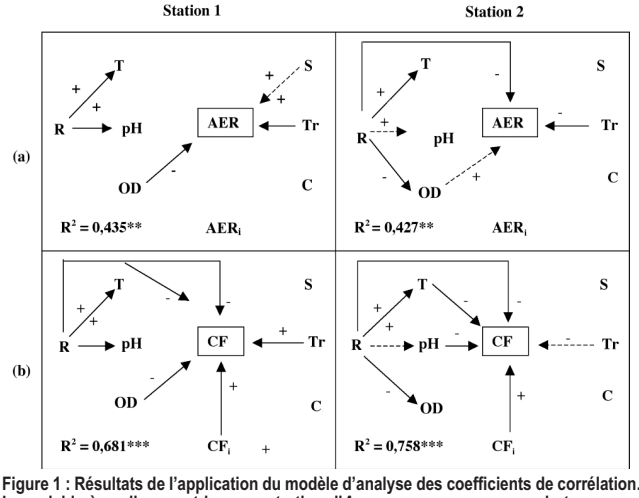

Figure 1 : Résultats de l'application du modèle d'analyse des coefficients de corrélation. La variable à expliquer est la concentration d'*Aeromonas spp.* au cours du temps aux stations 1 et 2.

*La variable à expliquer est la concentration des coliformes fécaux au cours du temps aux mêmes stations. Les flèches en trait plein indiquent un effet significatif d'une variable ou d'une autre au seuil de 5%, celles en petits tirets, un effet significatif au seuil de 10%. Les signes sur les flèches indiquent le sens des effets. R^2 = Coefficient de détermination : *** a=0,001 ; ** a=0,05.*

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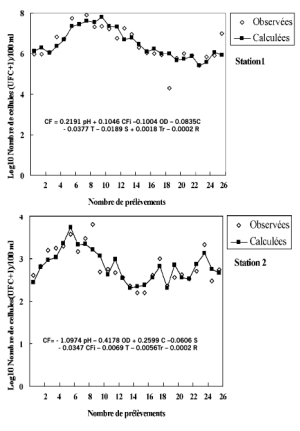

Figure 2 : Valeurs observées et valeurs calculées des abondances des coliformes fécaux aux stations 1 et 2..

Les valeurs prédites ont été calculées à partir des équations indiquées au bas de chaque figure.

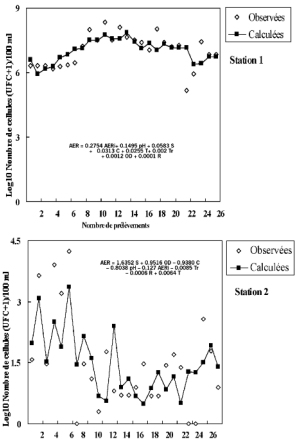

Figure 3 : Valeurs observées et valeurs calculées des abondances d'Aeromonas spp. aux stations 1e t 2 .

Les valeurs prédites ont été calculées à partir des équations indiquées au bas de chaque figure.

ISOLATION OF SIX NOVEL SPECIES OF THERMOPHILIC BACILLI FROM SHALLOW MARINE VENTS

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Abstract

Six aerobic thermophilic bacilli, capable of growing at 65°C, were isolated from water and sediment samples collected at shallow hydrothermal vents of Vulcano, Lipari, Panarea and Stromboli islands of Eolian Archipelago (Italy). On the basis of physiological and genetic characteristics, these isolates were demonstrated to be different from other well described reference species of the genus *Bacillus* and were classified as novel species.

Key -words: bacteria, biodiversity, thermal vents

Around Eolian Islands many marine hydrothermal systems are from shallow to a depth of 800 m, with temperature values from 25 to 95 °C and rich in dissolved gases (CO_2, CH_4, H_2, and H_2S). From these sites, a wide variety of Eubacteria and Archea have been described reflecting the very varied physical and chemical conditions around the shallow thermal vents (1-7). In the framework of the European project (MAST III-95-0034) titled "Microorganisms in deep sea vents and marine hot springs as sources of potentially valuable chemicals", studies on bacterial diversity at hydrothermal system of Eolian Islands have been undertaken by direct and cultural techniques (8). Here we report the isolation of novel prokaryotes and their cultural, biochemical and genetic characteristics.

Materials and methods

The enrichment of aerobic, heterotrophic, thermophilic bacteria was obtained from water samples filtered through membrane filters. Filters were inoculated into Bacto Marine Broth 2216 (Difco) and liquid Medium D (9). The media were incubated at 65°C for three days in aerobic conditions. Isolation was made on the same media supplemented with agar (2%). Optimal growth was tested after incubation at different temperatures (range 37 - 75 °C), pH (5.5 – 9.0) and salt concentration (0 - 10%). Biochemical properties were screened (8). Genetic characterization was carried out according to Sunna *et al*. (10).

Results and discussion

Eighty-seven thermophilic bacilli were isolated from water and sediment samples collected close to the vents (11). Numerical analysis of their phenetic characteristics showed a high diversity in respect to thermophilic reference strains (8). Also the restriction patterns of their amplified 16S rDNA were different from those of reference strains. Eighteen representative strains from groups of isolates having identical patterns were selected for subsequent analyses. Genetic characterization of the selected isolates demonstrated the novelty of six of them. In fact, comparison of their 16S rDNA sequences with those of reference *Bacillus* spp. gave similarity values in a range of 93-99.1%. Phylogenetic analysis indicated the position of most of isolates within the radiation of the *Bacillus* rRNA group 5 including thermophilic strains. DNA-DNA reassociation studies yielded less than 70% homology between these six isolates and the phylogenetically closest species, finally allowing their classification as novel thermophilic Bacillus species. One of them, strain 3s-1, has been already described as Bacillus vulcani DSM 13174^T (12).Table 1 shows the chemo-taxonomic properties of the six novel species in comparison with thermophilic type strains of *Bacillus* rRNA group 5. Strain 3s-1, strain 4-1, and strain 1bw were isolated from Vulcano, strain 7S from Panarea, strain 5-2 from Lipari, and strain 10-1 from Stromboli. The new species had optimal growth at 55-60 °C and neutral pH, with NaCl 2%, since of their marine origin. They were adhesive on substrate as polystyrene and were able to produce exopolysaccharides. All were resistant to heavy metals such as cadmium and zinc, and some of them also to mercury, silver and arsenic. They are indeed interesting for biotechnological applications as other thermophilic *Bacillus* spp. yet described (13).

Table 1. Phenotypic characteristics of the new thermophilic isolates and taxonomically related reference strains

Characteristics	*B. thermodenitrificans* DSM 465^T	*B. stearothermophilus* DSM 22^T	*B. thermoleovorans* DSM 5366^T	strain 3s-1 *B. vulcani* DSM13174^T	*Bacillus* sp. strain 4-1	*Bacillus* sp. strain 1bw	*Bacillus* sp. strain 7s	*Bacillus* sp. strain 5-2	*Bacillus* sp. strain 10-1
G+C mol (%)	50.3	52.6	51-56	53	40.8	45	39	43.2	42.7
Growth at 37 °C	-	+	-	+	+	-	+	-	-
Growth at 70 °C	+	+	+	+	-	+	-	+	+
Growth at pH 5.5	+	-	-	+	-	-	-	-	-
Growth at pH 9	-	-	-	+	+	+	+	-	+
NaCl (0%)	+	+	+	+	-	-	-	+	+
NaCl (3%)	+	+	-	+	+	+	+	+	+
Nitrate reduction	+	+	+	+	-	-	-	-	+
Denitrification	+	-	v	nd	nd	nd	nd	nd	nd
Anaerobic growth	+	w	v	-	nd	nd	nd	nd	nd
Hydrolysis of :									
starch	+	+	+	+	+	+	-	-	+
casein	w	+	w	-	+	-	-	+	+
Utilization of:									
citrate	-	-	v	-	+	+	-	-	-
Production of:									
acetoin	-	+	-	-	+	+	-	+	-
Acid from:									
glucose	+	+	+	+	-	+	-	+	+
sucrose	+	+	+	+	-	+	+	+	+
mannose	+	+	+	+	-	+	-	+	+
fructose	+	+	+	+	+	+	-	-	+
cellobiose	+	-	+	+	-	+	-	-	-

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CELL CYCLYING ALTERATIONS IN THE BLUE MUSSEL *MYTILUS GALLOPROVINCIALIS* CAUSED BY ENVIRONMENTAL CONTAMINATION

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Abstract

Flow cytometry (FCM) was employed to determine cell cycling alteration caused by environmental contamination in mussel *Mytilus galloprovincialis* haemocytes and gills. The G_1-arrest and G_2-delay have been detected in haemocytes of mussel in "mussel watch" experiment, when mussels have been transferred from mariculture area to the location under direct influence of industrial and urban runoff near a fish cannery. The cell cycling alterations in haemocytes and gills mussels collected from some polluted sites along the Adriatic coast were observed as well.

Keywords : Ecotoxicology, Bivalves, Pollution, Cell

In recent years, FCM, by virtue of a growing diversity of measurable parameters, has become an important tool in areas of cell biology related to cell proliferation, differentiation and response of cell damage. Use of FCM in identifying the cytological results of exposure to environmental pollutants is still in infancy. Nevertheless, early work has shown that FCM is a powerful tool for identifying and measuring effects of environmental contaminants on the vertebrate genome (1, 2). As far as mussels are concerned, FCM was performed in determination of abnormalities in DNA content distribution and progression in neoplastic disorders (polyploid forms) of mussels from heavily polluted area such as Puget Sound, Washington, USA (3). Therefore, our study has focussed in determination of cell cycling alternations in mussel haemocytes caused by environmental contamination in "mussel watch" experiment as well as from haemocytes and gills of mussels collected from different locations of different polluted areas along the Adriatic coast.

For the mussel watch experiment, mussels (average weight 10 g) were transferred from mariculture area to the selected site and were held in a net anchored at the low neap tide level. After different time intervals, 6 hours and 1,2,3,6,14 and 28 days, mussels were collected and their DNA content in haemocytes was analyzed by FCM. For biomonitoring purposes mussels (average weight 6 g) were collected at different locations so called "hot spots" along the Adriatic coast. Haemolymph was withdrawn from the posterior adductor muscle of individuals, dispersed in DAPI/DMSO (4,6-diaminido-2-phenyl indol/dimethylsulphooxide) solution. A piece of gills were removed from mussels (average 2 mg) and stored as well as haemolymph DAPI/DMSO solution under the liquid nitrogen until FCM analysis was performed. Stained samples were analyzed on PAS II flow cytometer (Partec, Münster, Germany) under the following conditions: excitation - 100 W mercury lamp, UG 1 (290-490 nm, 3mm), chromatic beam splitter (TK 420), emission beam splitter (TK420, TK560), barrier filter (GG 455) for DAPI signals. The data are shown as one parameter frequency histograms or as a percentage of DNA in different cell cycle stages.

Time dependent effect of industrial waste on DNA content distribution in mussel haemocytes are shown in Table 1. During two days of exposure, mussels under direct influence of industrial and urban runoff near a fish cannery showed the increased number of haemocytes in G_2/M cell cycle state (2.9 ± 2.0 up to 13.3 ± 2.9%), while the percentage of DNA in S-phase remained unchanged (3.6±1.3 to 3.3 ± 1.9 %). Further differences between starting conditions of mussels transferred from uncontaminated area and conditions after 6 days of exposure of mussels to contaminated area, could not be detected. The variations in G_0/G_1 and G_2/G_M phases could be attributed to the G_1-arrest and G_2-delay in haemocytes DNA that provide more time for repair of damaged DNA as it was detected after 6 days of exposure. Besides mussels watch experiments we applied the FCM for determination of cell cycle alteration in mussels collected from differently polluted sites along the Adriatic coast. Preliminary results showed the presence of contaminants at one sampling site that altered the cell cycle in mussel haemolymph the (Fig.1c) as well in mussel gills (Fig.1b). Cell cycle alteration of gills DNA content of mussel collected from location 1 showed a reduction of G_0/G_1 phase concomitant with selective loss of G_2/M phase which could be attributed to the apoptotic process (confirmed by electroforetic "ladder-like" DNA pattern, data not shown). The type of alteration in mussels which occurred in mussel collected at location 2 could be due to the occurrence of subpopulations of haemocytes whose whole chromosomes may be lost or gained. This phenomenon has to be elucidated with further investigations (*e.g.* chromosome analysis).

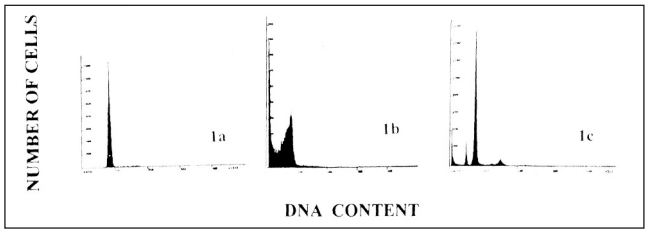

Figure 1. Comparison of DNA histograms of haemocytes or gills of mussels collected from reference site and so called "hot spots" along the Adriatic coast.
1a. Haemocytes of control mussel.
1b. Gills of mussel collected at location 1 along the Adriatic coast.
1c. Haemocytes of mussel collected at location 2 along the Adriatic coast.

Table 1. Cell cycle variation in haemocytes of mussel *Mytilus galloprovincialis* exposed to waste waters of fish cannery.

Time of exposure	G_0/G_1	S	G_2/M
0	93.5 ± 1.7	3.6 ± 1.7	2.9 ± 2.0
2 days	82.6 ± 3.6	3.3 ± 1.9	13.3 ± 2.9
6-28 days	92.3 ± 0.6	3.9 ± 0.5	3.8 ± 0.7

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PRELIMINARY OBSERVATIONS CONCERNING THE INFLUENCE ON THE DECOMPOSITION OF GELATINOUS MARINE ORGANISMS OF THE LIFE OF SOME PLANKTONIC ALGAE

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Abstract

In recent decades, in the Black Sea ecosystem many changes occurred associated with the effect of anthropogenic pollution; but a significant number of these changes are due to the introduction of exotic species. Among the these are the soft shell clam *Mya arenaria*, the gastropod *Rapana thomasiana* and the gelatinous ctenophore *Mnemiopsis leidy* all of which we consider to be biological pollution. Four species of gelatinous animals are common in the Black Sea: two scyphozoares-*Aurelia aurita* and *Rhyzostoma pulma* and two ctenophores-*Pleurobrachia pileus* and *Mnemiopsis leidyi*. In this paper we present data about pH, salinity, proteins content, carbohydrates, ammonia, and urea in sea water after the decomposition of gelatinous organisms and the influence of this phenomenon on algal proliferation.

Keywords: Aurelia aurita, Mnemiopsis leidy, Prorocentrum sp, Diatoms spp.

At the beginning of the 1980 the accidental introduction of the north western Atlantic ctenophore *M. leidyi* radically affected the entire pelagic fauna of the Black Sea. As the *M. leidyi* inhabits the same depth range and utilizes the same food resources as *A. aurita*, a large population of *A. aurita* was nearly replaced by *M. leidyi*.These two species, *A. aurita* and *M. leidy* were studied recently with regard to their biological and ecological characteristics [1, 2]. According the available literature [3] the concentration of the biogenic elements in the bodies of *M. leidyi* is smaller than the concentration of the same elements in the body of *A. aurita*. As a result of chemical analysis it is established that the mass development of *M. leidyi* has a negative effect on the hydrochemical structure of the Black Sea [3].

When recalculated in terms of total dry weight, the bodies of these "gelatinous organisms" contain an order of 10 tons of the elements, C, N, P, Si. The reference material does not include data concerning the contribution of these organisms to general flow of organic substances in marine waters sediments. The aims of this work is to present some observation concerning the alteration of the marine environment characteristics after the dying of the gelatinous organisms in the water and the influence of their decomposition on the life of some plankton organisms. The observations are based upon laboratory experiments. The tests had in view the kinetics of the decomposition of gelatinous organisms in marine water and the influence of this phenomenon on the algal proliferation. In an experiment in the stationary conditions of the laboratory the gelatinous organism was introduced in marine filtrate water, in a ratio of 1:20g/ml; the samples were draw periodically and in laboratory cultures of *Prorocentum* spp and *Diatomeae* the liquid mass and the powdery extracts were introduced respectively in a ratio of 1% and 100 micrograms/ml; the effects were established by the algal density measurement and their comparison with a control sample. The modification of the environment characteristics as a result of the introduction of the dead gelatinous organisms is evident. Thus:

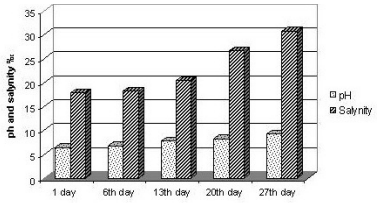

Fig. 1. pH and salinity in experimental condition

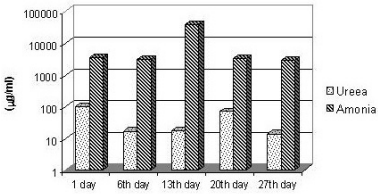

Fig. 2. Variation of the concentration of amonia and urea in experimental condition

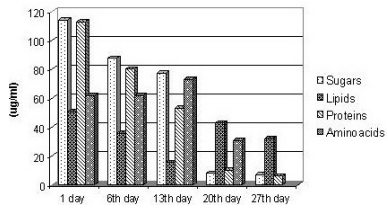

Fig. 3. Presence of carbohydrates, proteins and aminoacids in experimental condition

1) the pH and the salinity showed an evident increase, the pH became highly alkaline (Fig. 1);

2) the contents of urea and ammonia vary differently, however. Their accumulation and maintaining are clear (Fig. 2);

3) the concentration of organic compounds analyzed generally decrease (proteins, carbohydrates, amino acids) with the exception of the lipids which at onetime show an maximums (Fig. 3).

This diversity is probably due to the biochemical and microbiological support of the environment but, for the aim of the paper are relevant in some aspects :

1) the maintaining and the duration of the biotransformation which includes decomposition and accumulation;

2) the alteration of the experimental environment .

As to the behavior of the marine organisms in the experimental conditions our observations concerning the marine microalgae, *Diatoms spp* and *Prorocentrum sp* underline their response capacity to the presence in the environment of the substances resulting from the decay of the gelatinous organism. Thus:

1) those two species had a different behavior in the environments inoculated with the marine gelatinous marine extracts;

2) the *Diatomeae* had a similar behavior against the liquid extracts from medusa *A. aurita* ctenophores *M leidy* and the mixture of them (as we found them in the natural environment. (Fig. 4);

3) their growth achieved a maximum after four days followed by a diminution of the number of cells after seven days (Fig. 4);

4) a different response was seen with the powder obtained from the same organisms and introduced in the water which induced an appreciable multiplication of cells. This may be due to the consequence of the drying operation;

5) the culture of *Prorocentrum spp*, had a different manner of response; the introduction of extracts from medusa had an inhibitory effect on the growth of algae but the same type of extracts from ctenophores actually showed some slight stimulatory activity (Fig. 5).

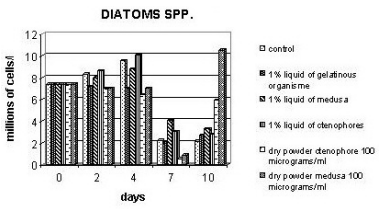

Fig. 4. The experiment of the growth of the algal culturs *Diatoms* spp.mixed with gelatinous organismsomogenated liquid and powdery extracts

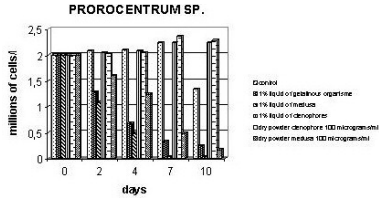

Fig. 5. The experiment of the growth of the algal culturs *Prorocentrum* sp .mixed with gelatinous organismsomogenated liquid and powdery extracts

The results of laboratory experiments may contribute with some information related to the ecological response. However our data can not be extrapolated directly to the natural environment yet, but may suggest modeling experiments such as physical factors together with chemical and eco-biochemical results.

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BACTERIAL COMMUNITY COMPOSITION OF FREE-LIVING *VERSUS* ATTACHED BACTERIOPLANKTON IN THE WATER COLUMN OF THE EASTERN MEDITERRANEAN SEA: EVIDENCE OF MAJOR DIFFERENCES IN SUBSTRATE UTILIZATION BETWEEN SURFACE AND DEEP WATER BACTERIA

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Abstract

The bacterioplankton species composition of the water column of 2 stations in the Southern and Northern Aegean Sea, respectively, was determined by terminal restriction fragment length polymorphism (T-RFLP). Generally, the number of operational taxonomic units (OTUs) remained remarkably constant throughout the water column down to 1000 m depth for both the free-living and the attached bacterial community. Only a small fraction of the OTUs detected in the free-living community was also present in the attached bacterial community. Distinct surface bound as well as specific deep water OTUs were present in both the free-living and the particle-attached bacteria.

Keywords: Bacteria, community composition, Mediterranean Sea, molecular analysis

Knowledge on the composition of the bacterioplankton is still in its infancy due to the lack of distinct morphological characteristics of bacterioplankton and the limitations to culture them (1). It is now well recognized that only a small fraction (usually well below 5 % of the bacterial community) can be brought in culture. Thus other methods are required to obtain information on the community composition of bacterioplankton. Molecular techniques provide the resolution required to obtain insights into the dynamics of bacterial consortia (2, 3). Terminal restriction fragment length polymorphism (T-RFLP) has been used in this study to unravel the dynamics of the community composition in the water column of 4 selected stations in the eastern Mediterranean Sea (3). Distinction has been made between the composition of the free-living versus particle-attached bacterial community in order to address the following questions: 1) are there any distinct compositional differences between the free-living and attached bacterial community? 2) Does the composition of community change with depth and if so, 3) does the number of species decline in a similar way as does the abundance of bacteria? If there is a distinct shift in the bacterioplankton community with depth what is then the potential substrate for these bacteria?

Raw seawater (RSW) was collected at 4 stations in the eastern Mediterranean Sea (24-26°E, 36-40°N) during a cruise on R/V Aegaeo in March 1998. Several depth layers were sampled with 10 liter-Niskin bottles attached to a Sea-Bird CTD profiler. Fifty ml subsamples of RSW were fixed *with 0.2 µm-filtered formaldehyde* (2 % v/v final concentration) and stored at 4°C for later bacterial enumeration. For molecular characterization of the bacterial communities, 3-5 liter of RSW was filtered through Whatman GF/C filter to collect 'particle-attached' bacteria. These filters were stored in sterile tubes (Greiner). The fraction of the bacterial community passing the Whatman GF/C filters was considered as the 'free-living' bacteria. These free-living bacteria were collected onto 0.2 μm Sterivex cartridges (Millipore). All filters for molecular characterization of the attached and the free-living bacteria were stored at –80°C. Nucleic acid extraction, purification and cDNA synthesis and subsequent PCR and T-RFLP analyses have been performed as described elsewhere (4).

Generally, attached and free-living operational taxonomic units (OTUs) differed considerably throughout the water column, with only ≈ 35 % for the South Aegean and ≈ 24 % for the North Aegean of all OTUs in both free-living and attached OTUs. Fig. 1 shows the distribution pattern of the (OTUs) of free-living bacteria. Three distribution categories (i.e. ubiquitously occurring, station specific and specific for either the South or the North Aegean Sea) comprised ≈ 50 % of the total number of OTUs of the free-living bacteria found in the different depth layers (Fig. 1). In contrast to the attached bacteria (Fig. 2), no increasing contribution of these three distribution categories towards greater depth was detectable when compared to the total number of OTUs. The number and the percentage of station specific OTUs was significantly lower in the free-living than in the attached bacteria (Wilcoxon, P=0.028, n=6) while no general trend was detectable in the number and percentage of OTUs specific for either the South or the North Aegean Sea. A higher number and percentage of unique OTUs was found in the free-living bacteria and a more complex deep water community than in attached bacteria. The distinct *deep water* community present, particularly in the free-living mode, might indicate that these bacteria are specifically adapted to the specific nutrient regime present there. The composition of the free-living deep water bacterial community appears to be as complex as the surface water bacterial community.

Acknowledgments. We thank the captain and crew of the RV Aegaeo for their help during sampling and especially Stella Psarra, Vassilis Zervakis, Vivi Pitta and Tassos Tselepidis. We further thank Harry Witte for speeding up T-RFLP analysis with *home-made* macros. Financial support was provided by a grant from the European Union to GJH (MAST-MTP II, MATER, *No*. MAS3-CT96-0051).

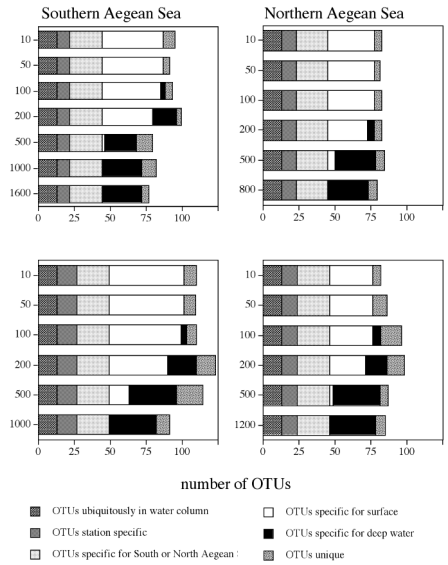

Fig. 1. Analysis of the spatial distribution of OTUs for free-living bacteria using 16S rDNA and T-RFLP at 2 stations (upper and lower panel) in the southern and northern Aegean Sea.
The number of OTUs obtained from the 16S rDNA is grouped in 6 different categories of occurrence: OTUs found at every station at every depth (ubiquitously occurring); OTUs found only at a single station but throughout the water column (station specific); OTUs found at either in the South or North Aegean Sea but throughout the water column (Specific for South or North Aegean Sea); surface specific OTUs found only at one station; deep water specific OTUs found only at one station; OTUs unique for a specific depth layer.

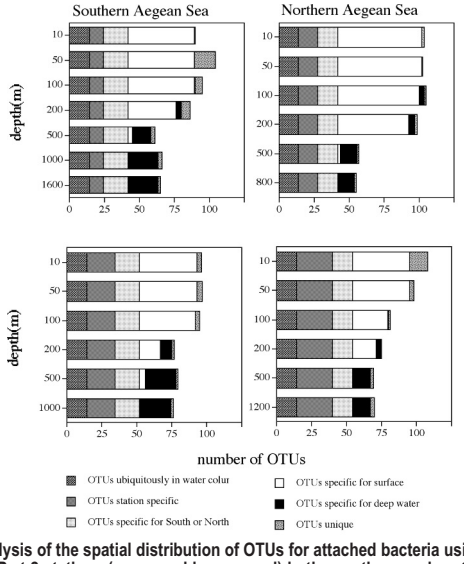

Fig. 2. Analysis of the spatial distribution of OTUs for attached bacteria using 16S rDNA and T-RFLP at 2 stations (upper and lower panel) in the southern and northern Aegean Sea. *Grouping into categories of occurrence was performed as described in Fig. 1.*

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NOTE PRÉ LIMINAIRE SUR LA SURVIE DE CERTAINS ENTÉ ROVIRUS DANS LES SABLES MARIN ET DE RIVIÈRE

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Résumé
On a étudié la survie d'une souche du poliovirus 3 et d'une souche du coxsackie B3 dans le sable marin et de rivière, stérile et non stérile, de zones polluée et non polluée après 1, 3, 7, 15, 30, 45 et 60 jours, à 4°, 22° et 37°C. Le poliovirus a survécu moins que le coxsackie, la survie étant favorisée par la température de 22°C pour le poliovirus et de 4° C pour le coxsackie. Cette recherche sera poursuivie avec d'autres virus.

Mots clefs : survie, entérovirus, sable marin et de rivière.

Les recherches que l'un de nous a effectué pendant quatre années (1975-1978) ont démontré la présence de certains entérovirus (coxsackie et écho) tant dans l'eau de mer du littoral roumain de la Mer Noire que dans le sable des plages de ce littoral (1, 2). Des recherches effectuées dans d'autres pays, dont celles de Bitton *et al*. (3), ont démontré aussi que l'eau de mer peut être contaminée par des virus entériques qui y persistent quelque temps.

En ce qui concerne le sable des plages marines (sauf le sable de dune) (4), à notre connaissance, ni la présence et ni la persistance des virus n'ont été recherchées jusqu'à présent par d'autres auteurs . Mais le sable des plages marines a une importance peut-être plus grande que l'eau de mer à cause du contact généralement prolongé du corps des baigneurs, surtout de celui des enfants. C'est pourquoi nous nous sommes proposé de rechercher aussi la survie des virus entériques dans ce milieu.

Matériel et méthodes

• Sable de plage d'une zone polluée par des eaux d'égout et d'une autre zone, non polluée, du littoral roumain de la Mer Noire et sable de la rivière Somes (Roumanie) aussi d'une zone polluée et l'autre non polluée.

• Souches des virus: poliovirus type 3 (P3) et coxsackie B3 (CB3) de la collection du notre laboratoire, les tous deux étant maintenus dans des cultures cellulaires.

Préparation du sable pour l'expérimentation:

Des quantités suffisantes de chaque sorte de sable, de plage marine et de rivière, polluée et non polluée ont été divisées en deux moitiés; l'une a été stérilisée en autoclave et l'autre est demeurée non stérile.

En adaptant d'après Hurst *et al*. (5), à chaque sorte de sable, stérilisé ou non, on a ajouté séparément des suspensions de P3 et CB3 en concentration finale de 1x105 unités infectieuses cytopathogènes. Les sables ainsi préparés ont été ensuite repartis par 2 grammes dans des éprouvettes de 100/10 mm et maintenues aux températures de 4°, 22° et 37° C, jusqu'a leur examen. À ce moment, dans deux éprouvettes avec chaque préparation de sable on a étudié la survie de virus. A chaque éprouvette on a ajouté 4 ml de éluant (solution Hanks) à pH 8.0, puis elles ont été agitées mécaniquement pendant 10 min et centrifugées pendant 15 min à 2500 r/m. Le supernatant ajouté au pH7.0 et décontaminé antibactérien et antifongique par éther; a été inoculé dans des cultures cellulaires pour déterminer la survie du virus par l'examen de l'effet cytopathogène spécifique.

Résultats et commentaires

Les résultats provisoires ont montré que les deux types de virus ont des temps différents de survie dans ces deux sortes de sable.

Premièrement, on a constaté que dans ces sables le poliovirus a survécu moins que le coxsackie virus, le maximum de la survie étant de 45 jours pour le poliovirus, tandis que la survie de coxsackie a atteint 60 jours plusieurs fois en l'ensemble des aspects visés à ces deux sortes de sable (stériles ou non, de zones polluées ou non, les températures de maintien).

Ce qui semble aussi très intéressant c'est que le poliovirus a survécu bien plus dans le sable marin que dans celui de rivière, surtout à 22°C, qu'à 4°C et 37°C, un aspect qui nécessite d'être approfondi. Au contraire, la température optimale de survie pour le coxsackie virus a été plus longue que celle du poliovirus, le temps de survie de celui-la étant plus de 60 jours dans plusieurs observations.

En ce qui concerne la survie de ces deux virus par rapport aux autres aspects (sable non stérile ou autoclavé, ou celui provenant des zones polluées ou non) les différences ont été apparemment non conclusives à ce stade de la recherche. Il s'en suit que cette expérimentation doit être approfondie avec les deux types de virus mentionnés et avec d'autres virus (écho, colifage).

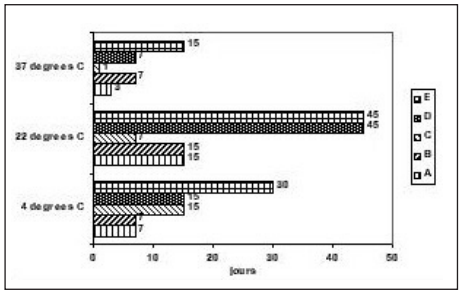

Fig. 1. Persistance de poliovirus 3 dans le sable de mer.

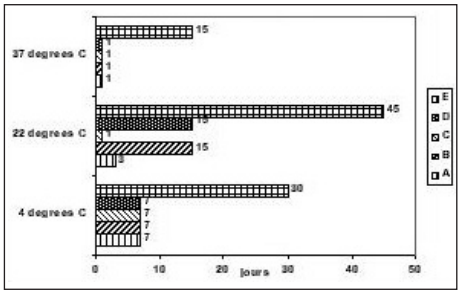

Fig. 2. Persistance de poliovirus 3 dans le sable de rivière.

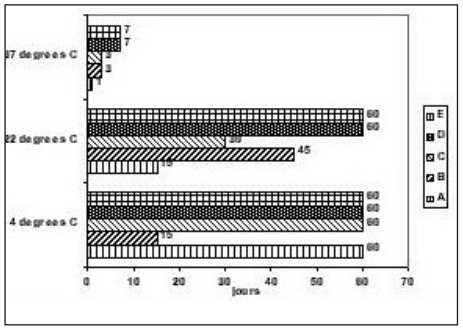

Fig. 3. Persistance de coxsackie virus dans le sable de mer

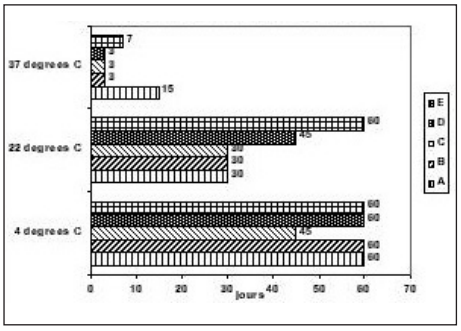

Fig. 4. Persistance de coxsackie virus dans le sable de rivière

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Legende des figures :
A = virus sans sable; B = virus + sable non pollué stérile; C = virus + sable non pollué non stérile; D = virus + sable pollué stérile; E = virus + sable pollué non stérile

PHOSPHOLIPASE A2 IN MARINE INVERTEBRATES

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Abstract

Phospholipase A2 (PLA2) catalytic activity was determined by a radiochemical assay in tissue extracts from 21 species belonging to five phyla of marine invertebrates that were collected from the Great Barrier Reef, Queensland, Australia. The highest PLA2 activities were found in hard coral, fire coral, crown-of thorns starfish and sea cucumber. High PLA2 activities were found in a number of echinoderms and sea anemones, whereas annelids, crustaceans and molluscs contained relatively low amounts of PLA2 activity. The results demonstrate the presence of PLA2 activity in a number of marine invertebrates. The molecular structure, classification and physiological functions of these PLA2s remain to be studied.

Key words : Cnidaria, echinodermata, mollusca, toxins

Introduction

Phospholipases A2 (PLA2) form a large family of lipolytic enzymes (1). PLA2 is a major component of snake and other venoms, digestive secretions of the gastrointestinal tract, as well as secretions of various mucous surfaces including tears and seminal fluid. In addition to toxic and digestive functions, PLA2 has effective bactericidal properties and participates in the regulation of inflammation by releasing arachidonic acids from cellular membrane phospholipids for eicosanoid synthesis. The purpose of the current study was to investigate the occurrence of PLA2 in marine invertebrate tissues.

Material and methods

Specimens were collected at 0-20 m depth from the Great Barrier Reef, Northern Queensland, Australia. Samples were immersed in 50 mM acetate buffer, pH 5, containing protease inhibitors, and frozen at -18°C. After thawing, the specimens were homogenised by Ultra Turrax or shaken vigorously in a glass container (coral specimens) and centrifuged at 5 000 g. The supernatants were assayed for PLA2 activity by using 14C-labelled phosphatidylcholine in mixed micelles as a substrate. Protein was determined by a standard dye-binding assay.

Results and discussion

The highest PLA2 activities were found in the extracts of hard coral, fire coral, crown-of thorns starfish and sea cucumber (Table 1). The high PLA2 content in the puffer fish intestine is similar to mammalian intestine where the enzyme is expressed in mucosal Paneth cells (2). High PLA2 activities were found in a number of echinoderms and sea anemones, whereas the annelids, crustaceans and molluscs tested had relatively low PLA2 activity. The functions of PLA2 in invertebrates are not well known. The action of PLA2 on phospholipids initiates the synthesis of eicosanoids present in most animal species including invertebrates (3). Insect immune response to bacteria is mediated by eicosanoids (4). PLA2 activity has been reported in the granular amebocytes, important immunocompetent cells of the horseshoe crab, *Limulus polyphemus* (5). PLA2 is a well-characterised digestive enzyme in mammals (1). Digestive PLA2s have been found in the tiger beetle *Cicindella circumpicta* (6) and the starfish *Asterina pectinifera* (7). The presence of PLA2 in snake venoms has been known since the 1890' (1) and has been reported in numerous invertebrate venoms including that of the marine snail *Conus magus* (8), the scorpion *Pandinus imperator* (9), the ant *Pseudomyrmex triplarinus* (10), the sea anemone *Aiptasia pallida* (11) and the jellyfish *Rhopilema nomadica* (12). It is pertinent that the highest levels of PLA2 observed in echinoderms in the present study were found in tissues that are associated with toxins; **E.G.** the spines of the crown-of-thorns starfish have a powerful neurotoxin. Pyloric cecae of echinoderms contain PLA2 that may function as a digestive enzyme.

The current results demonstrate the presence of PLA2 activity in a number of marine invertebrates. The molecular structure, classification and physiological functions of these PLA2s remain to be studied.

Table 1. Phospholipase A2 activity concentration (U/g protein) in tissue extracts. Where a specific tissue is not indicated the assay was undertaken on whole animal extract.

	U/g (SD)	n
Cnidaria		
Soft coral *Sinularia flexibilis*	22 (6)	2
Soft coral *Sarcophyton elegans*	82 (91)	4
Soft coral *Dendronephthya sp.*	64 (12)	10
Hard coral *Acropora* sp.	267	1
Hard coral *Pocillopora damicornis*	945 (540)	10
Hydrozoan fire coral *Millepora* sp.	735	1
Sea anemone *Stoichactis* sp.	207 (35)	2
Sea anemone *Actinia australis*	90 (24)	2
Annelida		
Worm *Phyllodoce novaehollandiae*	29 (32)	4
Crustacea		
Ghost crab *Ocypode cordimana*	3 (2)	7
Prawn *Panaeus monodon*		
Hepatopancreas	52 (79)	3
Muscle	0.5 (0.2)	2
Mollusca		
Rock-oyster *Saccostrea cucullata*	1	1
Clam *Donax cuneatus*	2 (1)	6
Nudibanch *Phyllida* sp.	65	1
Echinodermata		
Crinoid *Colobometra perspinosa*	124	1
Brittle star *Ophiocoma erinaceus*		
Disc	33	1
Arm	29	1
Starfish *Gomophia* sp.	253	1
Starfish *Fromia* sp.	288	1
Starfish *Linckia laevigata*	244	1
Crown-of-thorns starfish *Acanthaster planci*		
Skin	97	1
Spines	1625	1
Body wall	117	1
Pyloric ceca	498	1
Sea cucumber *Stichopus chloronotus*		
Body wall	5423	1
Intestine	235	1
Rete mirabile	614	1
Vertebrata		
Pufferfish *Arothron manilensis*		
Skin	177 (87)	5
Muscle	4 (2)	5
Liver	78 (73)	5
Intestine	2753 (1058)	5

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ON A MATHEMATICAL MODEL TRANSPORT AND TRANSFER OF THE RADIONUCLIDES IN DANUBE RIVER, ROMANIAN SECTOR

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Abstract

The attention has been focused on those radionuclide species which are the most frequently encountered into the radioactive polluted waters or laboratory and many results about their behaviour are reported.

Key words : Danube river, mathematical model, radionuclides transport in river , Black Sea.

Introduction

The movement of radionuclides throughout water body (streams, lake, sea, estuary, etc) is a hydrodynamic transport process depending, additionally, on many, interaction between the radionuclides and physical, chemical and biological components of environmental system. These interactions cause the retention of certain quantities of radionuclides into the system and decrease the fraction transported by flow. The intensity and time duration of the radionuclides retention depend on many features of the environment. A large fraction from the detained radioactivity is then gradually restituted to the flowing water and is transported hydrodynamically downstream. It is obvious that a mathematical model governing such processes may be developed making use of mass-transfer Equations [1, 2] .

The governing equations

Assuming that there is only one radionuclide specie which joins the system, but there are more types of sorbants into the natural stream. Then, the mathematical model for general transport and retention of radionuclides could be the following:

$$\frac{\delta(AC)}{\delta t} - \frac{\delta}{\delta x}\left(AE\frac{\delta C}{\delta x}\right) + \frac{\delta(QC)}{\delta x} = -\lambda CA + \sum_{n=1}^{N} S_n \qquad (1)$$

where C - the radionuclide concentration in water expressed as radioactivity (dis.s^{-1}.L^{-1});

λ - the radioactivity decay constant;

S_n - the rate exchange of the radionuclid between the sorbant n;

N - the total number of sorbant interacting with the radionuclides

$$S_b = B\frac{\delta s_b}{\delta t} \qquad (2)$$

Taking into account that the bed of the Danube river after Turnu Severin Power Dam till Cervavoda is made of silty clay, the following interaction between the bed river and the water may be written:

where B - the water width at water free surface

$\partial s_b / \partial t$ - the exchange rate upon the unit area of bottom .

$$\frac{\delta R_b}{\delta t} = k_b (K_b C - R_b) - \lambda R_b \qquad (3)$$

But, the term $\partial s_b / \partial t = k_b F_b$ where kb is the mass-transfer coefficient between water and bottom sediment; F_b must have the dimension of the radioactivity (disintegrations per unit time unit)

Then, $S_b = B k_b (R_b - K_b C)$ (4)

K_b - the equilibrium distribution coefficient of the radionuclide. This, can be explained by the following equation :

The radionuclides uptaked by the animals and plants are calculated by analogy with bed load sediments.

For the radionuclide interaction with the aquatic plants attached of the bed river, if one accepts that these belong to only one species and therefore react in a similar manner with the radionuclides, it seems acceptable to assume that the intensity of such reaction is proportional with the weight of plants. Denoting as Mp and Sp the weight of plants and the corresponding bottom, relatively, then from Eq. (1), there:

$$S_p = B\, M_p R_p F_p \qquad (5)$$

Substituting the relationships for S_b and S_p into Eq. (1) is obtained the mathematical model governing the radionuclides transport and transfer. The equations systems are composed by three simultaneous equations with the unknown C, K_b and C_p. Any of these systems can be solved using a finite scheme designed for one efficient time step (based on the splitting technique mode) on a compound vector .

Results and discussion

The model has been tested for the simulation of the radionuclides transfer and transport along the Danube river (Romanian sector) to the Black Sea. [3].

It must be outlined, that a similar mathematical model has been applied even to the entry of the Danube river in Romania, till the Turnu Severin Iron Gates dam, in different cases of the flow water [1]. The hydrodinamic parameters are taken for the cross-sections of Danube river at Bechet, Turnu Magurele, Giurgiu, Ceatal Izmail. Into these sections the cross-section flow discharge Q[mc/s] and the top width at water-surface B[m] are 4440 mc/s ÷ 6220 mc/s and 427 m ÷ 757 m [3].

The flow parameters of the Danube from the entrance in Romania, at Bazias, till the beginning of the Danube delta at Ceatal-Izmail for years 1996-1997, are discussed .

The mass-transfer k_b and distribution K_b were selected by experimental data for bottom sediments for natural stream (30 % clay, 40% quartz , 22% calcite) for the specified radionuclides (^{85}Sr, ^{90}Sr, ^{137}Cs, ^{144}Ce, ^{65}Zn).

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ENZYMES INVOLVED IN OSMOLYTE TRANSPORT PROCESSES IN THE ADRIATIC LOBSTER HOMARUS GAMMARUS

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Abstract
Transport related enzymes Na,K-ATPase and carbonic anhydrase (CA) were studied in the branchiostegite and antennal gland of the commercially important Adriatic lobsters Homarus gammarus acclimated to seawater (SW; 38 ppt) and dilute seawater (DSW; 20ppt) . In homogenates of branchiostegite from DSW-acclimated lobsters, specific activities of Na,K-ATPase was about 2- fold higher of the native (3.2 mmol Pi h-1 per mg protein) and saponin treated homogenates (6.6 mmol Pi h-1 per mg protein) than those of the SW-acclimated lobsters. In DSW –acclimated Homarus, CA activity of branchiostegite homogenates was 5.6-fold of activities reported in SW (4.42 U per mg proteins). In DSW specific activity of the Na,K-ATPase in antennal gland native homogenates was 2- fold increased of the SW lobsters (3.2 mmol Pi h-1 per mg protein). However, the CA in antennal gland was not activated keeping Enhanced activity of branchiostegites CA and not these in the antennal gland when acclimated to DSW suggest different strategies of the enzyme fitting in these osmoregulatory tissues.

Key words. Lobster, Homarus gammarus, branchiostegite, antennal gland, Na,K-ATPase, Carbonic anhydrase

There is a lack of information on the biochemical aspects of adaptivness to various seawater osmoconcentration in commercially important Adriatic lobster Homarus gammarus. The osmoregulatory role of the branchiostegite, as a epidermal tissue underlying carapace in the region of the trichobranchiate chamber as well as these of antennal gland is unknown. We have studied effect of 38 ppt seawater (SW) and 20 ppt dilute seawater (DSW) on the branchiostegite and antennal gland activities of the Na,K-ATPase and carbonic anhydrase (CA), enzymes which are respectively involved in the primary-driven Na pump, and in supply of the carriers for secondary active transport of osmolytes.

Preparation of the homogenates of branchiostegite and antennal gland and measurements of the enzymes was carried out by modified procedures described in details (1, 2). The Na,K-ATPase was measured in native homogenates and saponin treated homogenates of the branchiostegite (1). CA was determined following the rate of hydration and dehydration of CO2 comparing the uncatalysed (slightly buffered saline) and catalysed (branchiostegite homogenate in slightly buffered saline) reaction times of the enzyme (3). The total carbonic anhydrase was measured in detergent Tryton-100 treated homogenates. In the lobsters two weeks acclimated to DSW, the Na,K-ATPase activity in the branchiostegite homogenates (6.2 mmol Pi h-1 per mg protein) and in saponin treated homogenates (12.8 mmol Pi h-1 per mg protein) was 1.96 and 1.94 times higher of the respective activities in the SW acclimated lobsters (Fig.1.). Moreover, under the identical experimental conditions CA activity in the branchistegite was 5.6 –fold over the seawater acclimated lobsters. When lobsters acclimated to DSW the increased Na,K-ATPase activity are consistent with the previously published results on the enzyme activation in trichobranchiate gills and epipodites of the osmoregulating lobster Homarus gammarus (2, 4) and no activation in stenohaline conforming Crustacea occur (5). Enzymes activation was followed by keeping osmoconcentration gradient between the haemolymph and hypoosmotic DSW. Increased activity of CA in DSW in gills (6) and branchiostegite (this study) supporting the conclusion that branchiostegite CA plays important role in ion regulation processes (Fig.1). However, when lobster acclimated to DSW, there was no activation of the CA in the antennal gland homogenates of the SW and DSW acclimated lobsters. Slightly increased Na,K-ATPase in the antennal gland homogenates in DSW-acclimated lobsters, suggests probably active role in divalent ions regulation and in elimination of nitrogenous waste products.

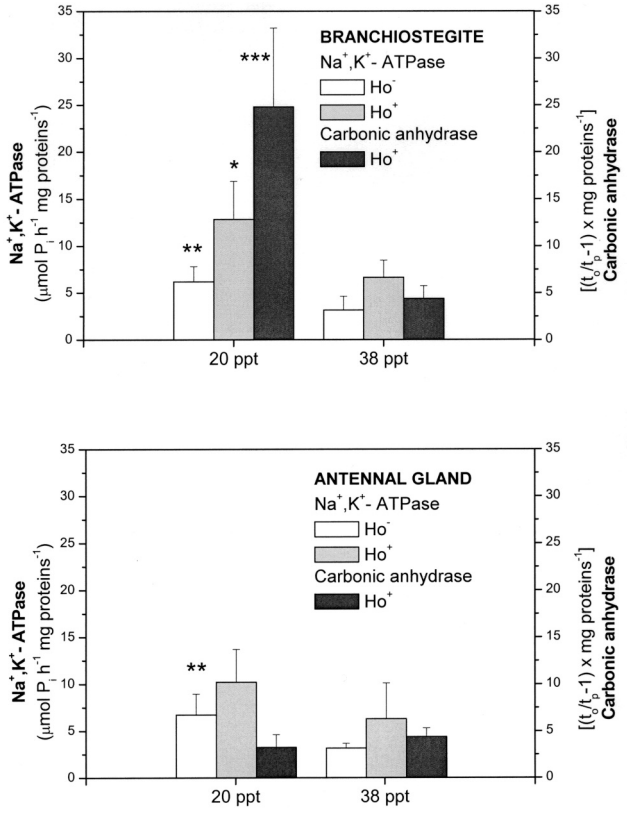

Fig.1. Na,K-ATPase and carbonic anhydrase activities in branchiostegite and antennal gland of the lobster *Homarus gammarus* acclimated to seawater (38ppt) and dilute seawater (20ppt).
H-0 = native homogenate; H+0 = saponin (Na,K-ATPase), and Tryton-100 (CA) treated homogenates. Mean values for 4-6 individual samples are given, error bars indicated SE. Asterix denote Student's t-test a value significantly different from the seawater value
(P<0.04; ** P<0.02; ***P<0.006).*

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GRAZING IMPACT OF PLANKTONIC CILIATES IN THE MEDITERRANEAN SEA

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Abstract

Ciliate assemblages were studied at 9 stations along the Mediterranean Sea in June 1999. The cell content of all ciliates was examined for *Synechococcus* (Syn) and photosynthetic algae (PN). Tintinnids contained similar quantities of PN and Syn (1.04±0.59 PN tin^{-1}, 0.94±0.87 Syn tin^{-1}) and the same was true for aloricates. Tintinnids ingested more prey than aloricates by a factor of 5. It was estimated that ciliates consumed 26% of primary production in the Western, 41% in the Central and 70% in the Eastern Mediterranean.

Key-words: planktonic ciliates, Mediterranean, grazing, cell content

Introduction

In oligotrophic systems, where nano- and picoplankton are the dominant primary producers, ciliates are expected to be the main grazers. The grazing impact and feeding activity of planktonic ciliates have been investigated in many studies (1). However, a direct method, the determination of the cell content of grazers in seawater samples, has been employed to estimate ingestion and digestion of single species of ciliates (2). This is the first study to report an estimation of the grazing impact of ciliates on the community level in field samples.

Materials and methods

In June 1999, nine off-shore stations were sampled in the Mediterranean Sea along a West-East transect (5° to 35° E). Samples were collected from 1 to 200 m water depth, preserved with borax-buffered formaldehyde (final conc. 2%), stored at 4° C in the dark and examined within 3 months of collection. All ciliates were examined for fluorescent prey. Under blue light, *Synechococcus* (Syn, orange fluorescence) and photosynthetic algae (PN, red fluorescence) were visible in the food vacuoles of ciliates. The ingestion rate of ciliates on PN or Syn (number of prey per ciliate per hour) was calculated according to Dolan and Simek (2).

Results

The ingestion rate (Table 1) showed no difference from station to station along the Mediterranean transect (ANOVA, $p>0.05$). Aloricates and tintinnids presented similar ingestion rates for PN and Syn (ANOVA, $p>0.05$). However, the ingestion rate of tintinnids for either prey was 3-4 times higher than that of aloricates.

Table 1. Ingestion rate (prey cil-1 h-1) of tintinnids and aloricates. Values are averaged for each sampling station

	Tintinnids		Aloricates	
Stations	PN h^{-1}	Syn h^{-1}	PN h^{-1}	Syn h^{-1}
S1	0.48	1.70	0.10	0.20
S2	0.37	0.01	0.18	0.02
S3	1.14	0.14	0.19	0.02
S4	1.05	0.46	0.28	0.16
S5	0.19	0.59	0.12	0.32
S6	0.16	0.10	0.05	0.06
S7	1.11	0.04	0.02	0.02
S8	0.83	0.47	0.23	0.16
S9	0.20	0.17	0.11	0.16
average	**0.61**	**0.41**	**0.14**	**0.13**
SD	0.42	0.53	0.08	0.10

Discussion

Both prey categories (PN and Syn) were present in equal quantities in the food vacuoles of both tintinnids and aloricates. Since the concentration of algae in the field was one order of magnitude lower than that of *Synechococcus* (3), it would be reasonable to suggest that either ciliates show a preference for algae or the digestion rate of these two prey categories is unequal. However, Dolan and Simek (2) measured similar digestion rates for *Synechococcus* and algae in cultures of the ciliate *Strombidium sulcatum*.

In the literature there is contrasting evidence regarding the role of *Synechococcus* in the diet of ciliates. In earlier studies this organism has been reported as poor food for choreotrichs (4). However, according to Christaki *et al*. (5), in a laboratory experiment, *Synechococcus* was directly ingested by *Strombidium sulcatum*, a typical planktonic aloricate ciliate. Coccoid cyanobacteria have been routinely observed in the food vacuoles of nanoplankton-sized aloricate ciliates (6), thus implying that these organisms are suitable for feeding of small-sized ciliates.

Using data on primary production acquired during the same cruise (K. Pagou and O. Gotsis-Skretas, NCMR, unpublished data), we have estimated that the ciliate community consumed 26% of the primary production in the Western, 41% in the Central and 70% in the Eastern Mediterranean Sea daily. The values of primary production consumption found during this study are generally within the range reported in other studies (7, 8).

According to the present study ciliates consume a relatively small part of the picoplankton production (17-36%) which is higher in the Eastern Basin by a factor of 1.5-2 compared to the Western one (9). In contrast, they consume quite an important part of the algal production, especially in the Eastern Mediterranean, where they have the potential to graze 121% of the algal production. Besides, analysis of the ciliate cell content suggests selectivity for algal cells.

Overall, these data underline the crucial importance of ciliates in channeling a part of this small-sized primary production to higher trophic levels, especially in the ultra-oligotrophic Eastern Basin as has also been found in previous studies (10).

Acknowledgements.

Thanks are due to Dr. K. Pagou and Dr. O. Gotsis-Skretas for providing primary production data. This study is a contribution to the MTP-II project "MATER" funded by the European MAST-III Programme (contract: MAS3-CT96-0051).

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BIOSYNTHETIC ORIGIN OF FURANOSESTERTERPENES IN THE SPONGE IRCINIA FELIX.

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Abstract

The present results strongly suggest that heterotrophic bacteria found in great abundance within the sponge tissues are involved in the production of furanosesterterpenes in *Ircinia felix*. Taken together, their increase after inflicted injuries and their antibacterial activity indicate that they might play a role in limiting bacterial proliferation during the process of wound healing.

Keywords: Bacteria – antibiotics – secondary production – Porifera

Sponges are a source of a great diversity of secondary metabolites presumably used for antipredation, competition for space and control of invading microorganisms. Some of these natural products may be of use for man as drugs, anti-fouling substances and a variety of other functions. Many sponges harbour large numbers of prokaryotic endobionts and it is often assumed that they may be involved in the production of these substances. In this context, we have investigated the marine sponge *Ircinia felix*. This species, common in the Caribbean Sea, is known to contain numerous bacteria and cyanobacteria and to produce bioactive compounds, in particular furanosesterterpene tetronic acids (1). The aim of this study was to identify the biosynthetic origin of these metabolites and to understand their ecological significance, especially after wounding.

Sponges were collected by SCUBA diving in the Caribbean Sea off Curaçao at 30 m. They were immediately transported in seawater to the laboratory where they were processed. A piece of the ectosome and the choanosome were carefully cut off and mechanically dissociated through a 100 μm nylon mesh into cold Ca^{++} / Mg^{++} - free artificial seawater, 10 mM EDTA. The remaining part was put back into the sea for 24 h, and then the sponge tissues were again dissociated as described above. The endosomal and ectosomal cell suspensions from the intact and injured specimens were centrifuged for 10 mins, respectively at 300 g (C1 fraction) and 1000 g (C3 fraction); the corresponding supernatants were further centrifuged at 4000 g for 15 mins (C2 and C4 fractions). Phase-contrast and UV microscopy observations showed these cell fractions to be enriched either in sponge cells (C1), cyanobacteria (C3) or bacteria (C2 and C4). However bacteria present in large amounts in sponge tissues were still present in significant numbers in the C1 and C3 fractions. On the contrary, cyanobacteria were almost absent from C1 and C2 choanosomal fractions.

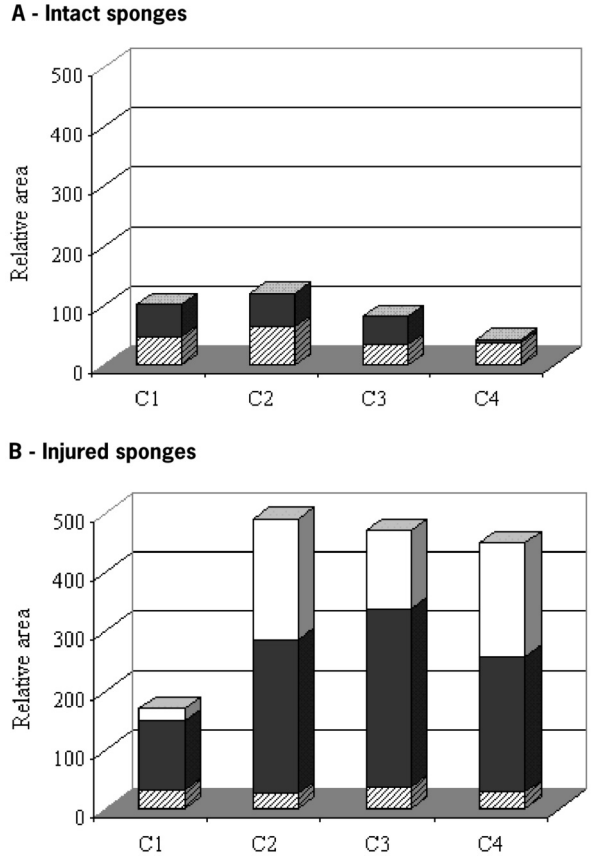

Fig. 1. Distribution of metabolites in cell fractions (relative area calculated to MeOH as internal standard).

The extraction of the cell fractions with methanol followed by Reverse Phase HPLC analyses revealed the existence of two main groups of secondary metabolites, furanosesterterpenic derivatives of the variabilin-type (V1 and V2) and sulfircin-like compounds (S). No significant differences of S content were observed between fractions before and after wounding (A, B). On the contrary, 24 hours after wounding, a significant rise of V1 was observed as well as high amounts of V2 detected only in the injured sample (B). (V1 + V2) /S ratios increased, several-fold principally in the C2, C3 and C4 fractions.

These findings agree with those of Zea (3) who observed a strong increase of variabilin in *Ircinia felix* tissues when sponges were purposely injured. Our results extend these observations at the cellular level and suggest that heterotrophic bacteria rather than sponge cells or cyanobacteria would be responsible for the production of variabilin-type furanosesterterpenes. The fact that these metabolites occur in different species and genera of the family Ircinidae and the Orders Dictyoceratida/ Dendroceratida together with the presence of a constant large number of bacteria in *I. felix* give further support to our proposal.

Standard disc bioassays (500μg/disc) showed a moderate antibacterial activity of C2, C3, C4 and to a lesser extent C1 fractions against *Escherichia coli* but no activity against *Bacillus subtilis* and *Saccharomyces cerevisiae*. The antibacterial activity appeared slightly enhanced in injured sponges. These results indicate that furanosesterterpenes may act as internal antibiotic protection as suggested by Zea (3).

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EXTRACTION DRUGS OF SEA ORGANISMS (INVERTEBRATES AND SMALL SEA FISH) WITH PREVALENTLY ANTIHYALURONIDASIC (PHI) ACTIVITY

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Abstract

The extraction drugs of sea organisms, invertebrates and small sea fish with prevalently antihyaluronidasic activity are anti-rheumatic, anti-inflammatory and antialgic, bring the profactors (precursors) of the aggregates from the ground substance and PHI (physiological hyaluronidase inhibitor). Their content in free amino acids, small peptides, carbohydrates (glycogen, mucopolysaccharide polymers, hexoses, pentoses etc.), micro-elements as Na, K, Ca, Mg, Fe, Cu, Zn; ensure recovery of the macromolecular structures which are disorganized in the diseases with prevalently degenerative and inflammatory components, stimulating the biosynthesis of the hyaluronic acid, of the proteoglycans and of the binding proteins, simultaneously with hyaluronidase inhibition; modulate the increased turnover of osseous calcium, inhibiting the activity of osteoclasts, diminishing the cartilage and bone degradation, through the recovery of the ground substance.

Key words: antihyaluronidase activity, extraction drugs, marine organisms

The bioactive concentrate of antihyaluronidase type from marine organisms (1), invertebrates : *Mytilus galloprovincialis*, *Mya arenaria*, *Loligo pealei* and *Euphausia superba dana* and small sea fish: *Odontogadus merlangus euxinus*, *Alosa tanaica nordmanni*, *Engraulis encrassicolus ponticus*, *Sprattus sprattus sprattus*), obtained by original biotechnology (few patents), has the composition represented in Table 1.

Table 1 : Chemical composition of an aqueous natural extract with 1% active substance,obtained from small sea fish

Active substance: 1,1g%
Antihyaluronidase activity: 100 UI/ml;
Ash: 0,070 g%;
Mineral elements: Na, K, Ca, Mg, Fe, Cu and Zn have been identified
Pb- absent, Cd-absent, Cr-absent;
Total nitrogen: 0,13 g%;
Small peptides: 0,50 g%;
Total amino acids: 0,95 g%:
- cysteine+ cystine: 0,07 g% - alanine: 0,06 g%
- lysine: 0,02 g% - proline: 0,06 g%
- histidine: 0,05 g% - g aminobutyric acid: 0,23 g%
- arginine: 0,02 g% - tyrosine: 0,01 g%
- serine: in trace - valine: 0,04 g%
- aspartic acid: 0,06 g% - phenylalanine: 0,18 g%
- glycocoll: 0,01 g% - leucine: 0,08 g%
- glutamic acid: 0,06g
Free amino acids: 0,48 g%
The same amino acids, as to the above point have been identified.
Total carbohydrates: 0,12 g%;
Glycogen: 0,10 g%;
Reducing carbohydrates (hexoses, pentoses, methyl-pentoses etc.): 0,02 g%
Acidic mucopolysaccharides: 0,01 g%

The Diffusion Test of China ink in the rat skin (Table 2), proves "in vivo" an appreciable effect of decreasing the skin permeability, due to the inhibitory action on hyaluronidase, and "in vitro" experiments prove a strong antihyaluronidasic activity, comparable with Merck chondroitinsulphates solution (Table 3). The anti-inflammatory and tissue-restitutive effect consists, on the one hand, in inhibition of the hyaluronidase that becomes unable to depolymerize the hyaluronic acid and, on the other hand, under the action of hyaluronidase as a starter of the enzyme-substrate relation, in stimulation of hyaluronic acid biosynthesis process. Thus, in the presence of the enzyme and plenty of specific chemical compounds (Table 1), "in vivo" biosynthesis of hyaluronic acid occurs from theirs components (2). Also, the two phenomena, on the one hand enzyme inhibition resulting in neutralization of hyaluronic acid depolymerisation and, on the other hand, under the action of the same enzyme, the hyaluronic acid synthesis from its components in a "environment" consisting of a set of specific chemical compounds, including cations with a very important contribution lead synergically to a joint final result, that is the anti-inflammatory and tissue-restitutive effect, also initiating other enzymatic restructuring processes like the cartilage structures. From the above data, it results that the anti-hyaluronidasic activity and tissue-restitutive effect is given by the ensemble of specific chemical compounds. Thus, the anti-inflammatory effect of the Romanian drugs called *ALFLUTOP*^{R} and *ARMADENT*^{R} consists in the inhibition of the hyaluronidase and probably in the activation of the superoxide dismutase, inhibiting the process of breakdown of the hyaluronic acid and chondroitinsulphates (3). In conclusions, taking into account that the cell proliferation and inflammation depend on the destruction of the ground substance by the cellular hyaluronidase, there are two pathways of therapy control in which the excessive cell proliferation is a harmful feature:

1. The increase of the ground substance resistance against the enzymatic destruction or the regeneration of the ground substance due to the administration of ancestors (precursors), necessary for the biogenesis of the acidic mucopolysaccharides (hyaluronic acid and chondroitinsulphates).
2. The direct neutralisation of the cellular hyaluronidase due to the decrease of the production by the cells or to the inhibition of its enzymatic action which offer more rapid therapy possibilities.

The cellular proliferation process is controlled by the presence in the tissues and in blood of a substance called physiological hyaluronidase inhibitor (PHI). The serum PHI (antihyaluronidase) exists in a normal, well determined concentration in health state. The orthomolecular medicine approaches both health preservation and treatment of diseases through the quantitative variation in the human body of certain substances that are also normally present in it.Thus, the biologically active extraction concentrate of sea organisms with prevalently antihyaluronidasic activity, obtained by us, bring the ancestors (precursors) of the aggregates of the ground substance and PHI (physiological hyaluronidase inhibitor). Thus, free amino acids, small peptides, carbohydrates (glycogen, mucopolysaccharides, hexoses, pentoses etc,), microelements as Na, K, Ca, Mg, Fe, Cu, Zn; ensures recovery of the macromolecular structures which are disorganised in the diseases with prevalently degenerative and inflammatory components, stimulating the biosynthesis of the hyaluronic acid, of the proteoglycans and of the binding proteins, simultaneously with hyaluronidase inhibition; modulates the increased turnover of osseous calcium, inhibiting the activity of osteoclasts, diminishing the cartilage and bone degradation, through the recovery of the ground substances, the fine balance between synthetic and degrade processes which are of significance in both health and disease.

Table2 : "In vivo" specific antihyaluronidasic activity

	Blank	Hyaluronidase (H)	H+P1	H+P2	H+P3	H+P4	H+P5
Content in 0,1 ml aqueous solution		7,54	7,54+10mg	7,54+10mg	7,54+10mg	7,54+10mg	7,54+10mg
Average value of diffusion surface in mmp	107,3 78,6 91,9	175,9 199,8 174,9	58,5	16,5	43,2	25,8	11,9
Permeabilising effect (percentage - %)		+64 +154 + 90					
Antihyaluronidasic effect (percentage - %)			-67 6,9 p.0,001	-91 11,1 p.0,001	-79 6,1 p.0,001	-87 7,1 p.0,001	-94 5,0 p.0,001
Skin permeability decreasing effect			171%	232%	129%	143%	196%

Table 3 : Antihyaluronidasic activity of the bioactive preparation obtained from different species of marine organism in comparison with data in the speciality literature

Preparation	Antihyaluronidasic activity	Literature
Sodium Chondroitine Sulphate (Merck)-0,1% solution	50 IU/ml = 5,0 IU/mg	ROSOIU, 1982
Antihyaluronidase from *Loligo pealei*	79 IU /ml = 7,9 IU/mg	ROSOIU, 1982
Antihyaluronidase from *Euphausia superba dana*	84 IU /ml = 8,4 IU/mg	ROSOIU, 1982
Antihyaluronidase from *Alosa tanaica nordmanni*	73 IU /ml = 7,3 IU/mg	
Antihyaluronidase from *Odontogadus merlangus euxinus*	83 IU /ml = 8,3 IU/mg	ROSOIU, 1982
Antihyaluronidase from Engraulis encrassicholus ponticus	93 IU /ml = 9,3 IU/mg	ROSOIU, 1982
Sulphomucopolysaccharides from *Mytilus galloprovincialis*	3,2 IU /mg	MOLNAR *et al.*, 1976
Sulphomucopolysaccharides from *Mya arenaria*	5,0 IU /mg	MOLNAR *et al.*, 1976
Sulphomucopolysaccharides from fowl small intestine	4,8 IU /mg	MOLNAR *et al.*, 1976
Sulphomucopolysaccharides from cattle duodenum	5,0 IU /mg	MOLNAR *et al.*, 1976

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ENZYME KINETCS DATA OF A-AMYLASE EXTRACTED AND PURIFIED FROM MARINE MOLLUSCS *MYTILUS GALLOPROVINCIALIS* LMK. AND *MYA ARENARIA* L.

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Abstract

The amylolytic activity in *Mytilus galloprovincialis* and *Mya arenaria*, from Romanian Bleak Sea Coast is similar to that in the benthonophage fishes and the higher mammals – rabbit, cow, dog – and it is several times greater than in the crustaceans and the predatory fishes. The purified a-amylase of *Mytilus galloprovincialis* Lmk. and *Mya arenaria* L. has an optimum activity at pH 6.0 at, 35°C, and, at pH 6.9 - 7.0 at 32°C. $CaCl_2$, NaCl and $MgCl_2$ in concentrations between 1-10 mM activate the α-amylase and protect it against thermal inactivation. The Ca^{2+} an Cl^- are essential for the enzymatic activity of marine mollusca α-amylase.

Key words: α-amylase, marine molluscs, enzyme kinetic.

Amylase, 1,4-α-glucan-glucanohydrolase (3.2.1.1.) enzyme which catalyses hydrolysis of the α - 1.4 glycosidic bounds of polysaccharides, have been the object of many research projects carried out with marine organisms all over the world during the recent period. This paper represents original data on a-amylase investigates in *Mytilus galloprovincialis* Lmk. and *Mya arenari*a L.Similar data obtained on unpurified protein extracts from hepatopancreas and whole body, as well as on the purified a-amylase from hepatopancreas and whole body, indicate the presence of a single enzyme with amylolytic activity in both bivalves. On the other hand, the more intense enzymatic activities, associates with the hepatopancreas, show that this is the organ which concentrates the amylase. Amylase activity was detected also in non digestive organs, such as mantle and branchie, as well as in hemolymph. The presence of amylase in those organs indicates a complementary role of the enzyme in the rapid mobilization of the sugar reserves in certain physiological states of the organisms (Table 1).

Table 1. Activity of a-amylase in Mytilus galloprovincialis and Mya arenaria. Distribution in organs and tissues.

Species (organ,tissue)	Amylase activity (mU/mg protein/minute) partially purified enzymatic preparation	crude protein extract
MOLLUSCA BIVALVIA		
1. *Mytilus galloprovincialis*		
total body	7,050	438.00
mantle		112.00
hepatopancreas		1,102.00
gills		182.55
2. *Mya arenaria*		
total body	1,241	105.00
hepatopancreas		587.00

We found that the α-amylase activity in hepatopancreas, mantle, gills and hemolymph of the mussel is in direct proportion to the glycogen content and closely connected with the internal biological rhythm of the mollusca during the osmotic control process (Figure 1).

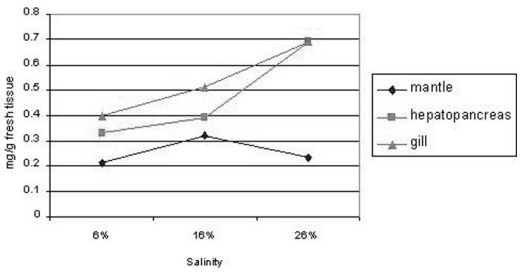

Fig. 1. Variation of glycogen concentration in *Mytilus galloprovincialis* in hepatopancreas, mantle, gills and hemolymph in conditions of variable salinities.

Our data show an increased amylolytic degradation of glycogen, under hypo- and hypersalinity states of the mussel (Figure 2). Glucose, the final product of glycogen amylolytic degradation, is involved in the process of glycogen synthesis, and on the other hand, stimulates forming of lactic acid via glycolysis. Our data show an increased amylolytic degradation of glycogen, in both hypo- and hypersalinity states of the mussel (1).

The amylase activity in *Mytilus galloprovincialis* (1,102 mU/mg/minute) is comparatively higher than the amylase activity in *Mya arenaria* (587 mU/mg /minute).

The purified α-amylase of the hepatopancreas and whole body of Mytilus galloprovincialis Lmk., has an optimum activity at pH 6.0 and 35°C, and the purified α-amylase of the hepatopancreas and whole body of *Mya arenaria* L. has an optimum activity at pH 6.9 - 7.0 and 32°C (2).

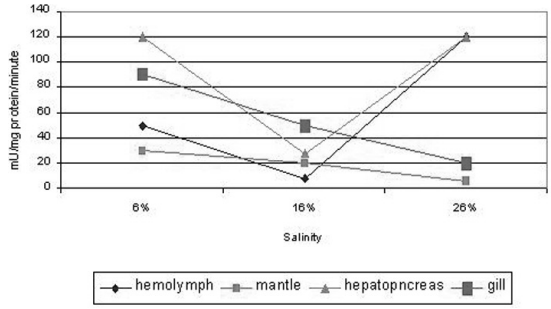

Fig 2. Amylase activity in *Mytilus galloprovincialis* in hepatopancreas, mantle, gills and hemolymph in conditions of variable salinities (determined by Metais-Bieth's method using starch as substrate).

In our assays for stabilization of the isolated and purified α-amylase of *Mytilus galloprovincialis* and *Mya arenaria*, we used different ingredients, such as: amino acids, small molecular mass proteins, glycogen, starch and glycerol. Stability of the purified α-amylase was enhanced by aspartic acid, glycine and a mixture of serine, tyrosine and tryptophan while valine, cysteine and bovine serum albumin activated the amylase (Table 2). The purified α-amylase it self shows stability, over time. After four months refrigerating (+4°C), 100% of its enzymatic activity was still found, in the absence of any ingredient. $CaCl_2$, NaCl and $MgCl_2$ in concentrations between 1-10 mM activate the a-amylase and protect it against thermal inactivation (3).

Table 2 - Time - stability of purified a-amylase of Mya arenaria

Ingredient added to enzymatic preparation	Specific amylase activity (mU/mg proteine/minute at pH 6.8 and 370C)				
	Initial	After 2 weeks	After 4 weeks	After 2 months	After 4 months
CONTROL Vaccuum-dried enzymatic preparation	4,350	4,127	4,305	4,926	4,504
aspartic acid	5,345	6,734	6,695	5,127	5,005
valine	29,600	8,343	9,290	5,732	5,700
glutamic acid	3,067	3,117	3,238	2,872	2,990
glycine	4,548	7,987	5,055	5,819	5,201
cysteine	20,500	9,283	9,427	8,235	7,300
amino acid mixture - serine - tyrosine - tryptophan	4,667	7,824	7,158	6,629	6,310
bovine serum albumine	28,182	10,345	7,647	7,125	7,480
glycogen	6,549	6,504	7,297	4,886	4,897
starch	9,680	8,196	6,126	4,307	4,245
glycerine	8,020	2,931	2,257	2,344	2,463

The Ca^{2+} an Cl^- are essential for the enzymatic activity of mollusca α-amylase. In conclusions, the amylase activity in *Mytilus galloprovincialis* and *Mya arenaria*, from Romanian Bleak Sea Coast is similar to that in the benthonophage fishes and the higher mammals - rabbit, cow, dog - and it is several times greater than in the crustaceans and the predatory fishes.

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FOSSIL FUEL POLLUTION IN WADI GAZA AND BIODEGRADATION OF PETROLEUM MODEL COMPOUNDS BY CYANOBACTERIAL MATS

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Abstract

Coastal and sea water pollution is one of several serious problems currently affecting the Gaza Strip. Sediments and cyanobacterial mats in Wadi Gaza are exposed to various levels of pollution mainly with diesel oil. Screening experiments show that petroleum model compounds (pristane, n-octadecane, phenanthrene, and dibenzothiophene) are efficiently biodegraded by cyanobacterial mats from Wadi Gaza. Within forty days, the aromatic compounds disappeared completely, and the aliphatic compounds were degraded to a large extent.

Keywords: Pollution; petroleum hydrocarbons; cyanobacterial mats; biodegradation.

Introduction

The Gaza Strip along the eastern Mediterranean Sea is a coastal area of about 365 km^2 (45 km long and 6-12 km wide). Coastal and sea water pollution is one of several serious problems currently affecting the Gaza Strip (1). At present, significant oil pollution exists along the Eastern Mediterranean coast (2). Wadi Gaza is the only surface water in Gaza Strip. It is used for disposal of sewage water, solid waste, and agricultural and industrial waste water (3). The eastern part of the wadi is influenced by untreated waste-water discharge. The effluent from the Gaza City treatment plant is discharged into Wadi Gaza and then disappears in the dunes and partly reaches the sea (4). Cyanobacterial mats (CBM) develop in the western part of the wadi close to the coast of the Mediterranean Sea. They are naturally exposed to fluctuating salinity due to seasonal sea-water intrusion and fresh-water run-off. In recent years there was increasing concern over the fate of petroleum hydrocarbons in marine ecosystems since several of these compounds are known to exhibit toxic, mutagenic or carcinogenic properties (5,6). We investigated the pollution in Wadi Gaza and carried out a screening experiments for biodegradation of petroleum model compounds by natural CBM.

Materials and methods

Cyanobacterial mats and freeze-dried sediments from Wadi Gaza were extracted with dichloromethane (DCM)-methanol-water 1:2:0.8 (v/v/v) and DCM, respectively. The sediment extracts were separated into aliphatic, aromatic and NSO fractions and analyzed by gas chromatography (GC) and GC-mass spectrometry. CBM from Wadi Gaza were inoculated into 100 ml autoclaved sea water with ammonium chloride (1 mM) and phosphate (8 μM). Pristane, *n*-octadecane, phenanthrene, and dibenzothiophene as petroleum model compounds (PMC) were added by means of organo-clay complexes (OCC; adsorbed on benzyl- trimethylammonium montmorillonite). 50 mg OCC containing 1.65 mg of each compound were added. The experiments were carried out in Erlenmeyer flasks incubated on a rotary shaker (70 rpm, 28°C) under 12 h light /12 h dark conditions. Uninoculated flasks containing medium and OCC served as controls to estimate PMC loss during the incubation period. PMC were extracted with DCM-methanol-water 1:2:0.8 (v/v/v) and quantified by GC.

Results and discussion

The analyses show that the sediments are contaminated with petroleum to variable levels. The aliphatic fractions are dominated by *n*-alkanes up to *n*-C_{35} (Figure 1). *n*-Alkane distributions with maxima between *n*-C_{19} and *n*-C_{21} are attributed to pollution by diesel oil. A predominance of *n*-C_{27}, *n*-C_{29} and *n*-C_{31} is due to the contribution of higher plants growing along the wadi. Elevated concentrations of the C_{17} *n*-alkane partly originate from cyanobacteria. The contribution of diesel oil or other petroleum derivatives is further indicated by the presence of fossil fuel biomarkers, *e.g.* pristane, phytane, and extended 17α,21β-hopanes in the aliphatic hydrocarbon fractions, and methyl- and ethylphenanthrenes and methyl- and ethyldibenzothiophenes in the aromatic hydrocarbon fractions. Increased pristane/C_{17} ratios show that slight biodegradation occurred. In a screening experiment the cyanobacterial mats from Wadi Gaza degraded the aromatic hydrocarbons within forty days. Also the aliphatic compounds were degraded to a large extent (Figure 2). This shows that natural cyanobacterial mats from polluted environments are well adapted to efficiently degrade pollutants. Biodegradation can be considered as potential tool for the cleaning of oil-contaminated marine and coastal environments. Further investigations will be carried out in the field to be relevant for oil spill incidents.

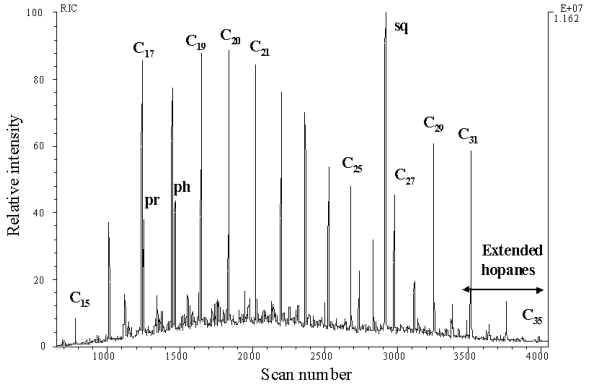

Figure 1. Representative gas chromatogram of an aliphatic hydrocarbon fraction of Wadi Gaza sediment polluted with diesel oil. Major peaks are n-alkanes (carbon numbers are indicated). Pr: pristane, ph: phytane, sq: squalane (internal standard).

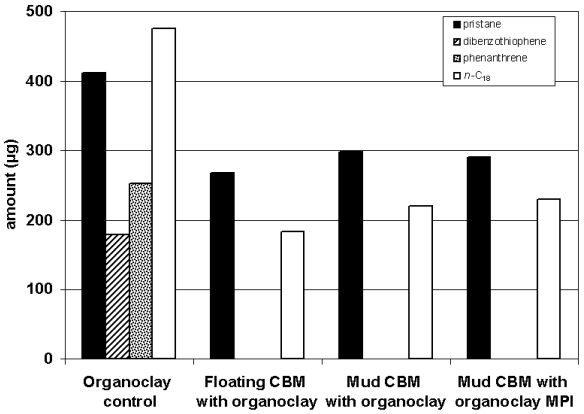

Figure 2. Biodegradation experiment with floating and benthic cyanobacterial mats from Wadi Gaza. Aromatic petroleum model compounds (added by means of organo-clay complexes) were degraded completely after 40 days.

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EFFECT OF TEMPERATURE ON THE RATE OF CONCENTRATION OF FAECAL COLIFORMS IN MUSSELS

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Abstract

The effects of different temperatures (12°C, 18°C, 24°C) on the rate of concentration of faecal coliforms (FC) in mussels were studied in experimental conditions at different concentrations of FC in seawater. At low initial concentrations of FC in mussels the rate of FC concentration increased with concentration of FC in seawater and with changes of temperature toward optimum. As concentration of FC in mussels increased, the rate of FC concentration decreased more rapidly as the concentration of FC in seawater increased and as the temperature was closer to optimum. Maximum concentrations of FC observed in mussels (level-off concentrations) were the highest at minimum temperature (at which rates of FC concentration were the lowest), whereas concentration of FC in seawater had no effect on level-off concentrations of FC in bivalves.

Key words: bacteria, bivalves, temperature

Introduction

The problem of faecal pollution in the coastal seawater, present in urban centers, has an effect on the sanitary quality of organisms living in such areas. Being sessile organisms the bivalves are permanently present in a certain area, and can not avoid stress situations by active moving. The rate of concentration of food particles in bivalves undoubtedly depends on the rate of filtration of seawater (1,2), which is determined by a number of factors such as food concentrations, flow rate, size of bivalves or life cycles of bivalves (3,4,5). However, one of the most important environmental factors which control filtration rate in bivalves is temperature (2,4). High filtration rate does not always mean high concentration of food particles in shellfish because of its low concentration in seawater. Similarly, high concentration of food particles in seawater does not always mean its higher concentration in shellfish, because at high food concentration decrease filtration rate as well as feeding efficiency (decrease retention rate and increase rate of pseudofaeces production occurs). From a practical point of view the most important question should be which concentrations of faecal pollution indicators in shellfish could be expected in particular conditions. In this paper, the effect of temperature on the rate of concentration of faecal coliforms (FC) in mussels as well as level-off concentration of FC in dependence on temperature and FC concentrations in seawater were studied.

Material and methods

Mussels (*Mytilus galloprovincialis*) were taken from the shellfish gardens near Split, and were held at ambient temperature in the laboratory until use. The experiments were carried out in 30 l fiberglass trays containing 15 l of seawater with bivalves of uniform size (4-5 cm). Each tray was aerated and termostated at experimental temperature. Ambient temperatures were changed to temperature of experiments at the rate of 0.5°C per day. After the experimental temperatures were reached, the bivalves were allowed to acclimate for at least two days. In the experiments, three temperatures and three concentrations of FC in trays were combined, and each experimental combination was carried out in several replications (3-6). The numbers of FC in bivalves were checked every hour until they reached plateau. Temperatures used in experiments were 12°C (mean winter temperature), 24°C (mean summer temperature), and 18°C (the temperature between these two extremes). Concentrations of FC in experimental trays were 10-10^3 FC L^{-1} ("unpolluted" seawater), 10^3-10^5 FC L^{-1} (moderately polluted seawater), and 10^5-10^7 FC L^{-1} (high polluted seawater). The beginning concentrations of FC (concentrations in the moment when experiments started) were low and varied between 0 and 13 FC per gram of flesh.

Results and discussion

In all experiments the rates of FC concentration in bivalves were high at the beginning of the experiments, when the initial concentrations of FC in bivalves were low, and decreased as the concentration in bivalves increased. Finally, at certain concentration of FC in bivalves (level-off concentration), bivalves ceased to concentrate FC (rate of concentration; k = 0) (Tab.1). Neither, the temperature nor concentration of FC in seawater changed this pattern, but both influenced the values of concentration rate as well as the slope of its decrease.At low initial concentrations of FC in mussels, the rate of concentration increased with the temperature. As concentration of FC in mussels increased, the rates of FC concentration decreased more rapidly at the higher temperature. As a result, at certain concentration ("turning-point concentration") of FC in mussels, or its narrow range, the rates of FC concentrations in mussels were similar at all temperatures (Tab.1). As the FC concentration in mussels kept on growing the rate of concentration became inversely proportional with temperature. As a consequence, the lower temperature, the higher was the level-off concentration (which is the maximal concentration of FC present in mussels), and more time was needed to reach that concentration (Tab.1). The concentration of FC in seawater (in experimental trays) had no effect on the pattern of temperature effect. However, the values of concentration rate, slope of its decrease and "turning point concentration" (concentration of FC in mussels at which positive correlation between concentration rate and temperature turns into negative correlation) varied in dependence on concentration of FC in seawater. At low initial concentration of FC in mussels, the rate of concentration of FC in bivalves increased with their concentration in seawater. As concentration of FC in mussels increased, the rates of concentration decreased more rapidly at higher concentrations of FC in seawater (Tab.1). Thus, mussels needed more time to reach the level-off concentration (maximal concentration of FC present in bivalves), at which mussels stopped concentrating FC (k = 0). Finally, the increase of FC number in seawater was also accompanied with the decrease of "turning point concentration". Contrary to temperature, which affected the values of maximal concentration of FC observed in mussels (inverse relationship was found), level-off concentration of FC in mussels did not significantly differed in dependence on concentration of FC in seawater. However, level-off concentrations were reached earlier as concentration of FC in seawater increased.

Tab. 1. The effect of temperature on the rate of concentration of faecal coliforms (FC) in mussels at different concentrations of FC in seawater

[Linear regression statistics: x = logarithm of concentration of FC in mussels, y = rate of concentration of FC in mussels (hours), y-int (intercept) = rate of concentration of FC at initial concentration of FC in mussels, r2 = coefficient of determination; Level-off concentration = maximal concentration of FC present in mussels at which concentration rate is zero (k = 0); Time = time needed for mussels to reach maximum concentration of FC in their bodies; "TP" ("turning-point concentration") = concentration of FC in mussels at which positive correlation between concentration rate and temperature turns into negative correlation.

Conc. of FC in seawater	Temp (°C)	Linear regression statistics			Level-off conc. (log FC g^{-1}	Time (h)	"TP" conc. (log FC g^{-1}	k (h) at "TP"
		y-int	slope	r^2				
Low	12	1.35	- 0.42	0.87	3.25	5.54		
10 - 10^3	18	1.90	- 0.68	0.95	2.75	3.33	2.13	0.48
FC 1^{-1}	24	3.12	- 1.25	0.88	2.50	1.85		
Moderate	12	3.35	- 0.94	0.81	3.56	2.45		
10^3 - 10^5	18	4.00	- 1.37	0.98	2.92	1.68	1.45	2.00
FC 1^{-1}	24	4.99	- 2.08	0.98	2.40	1.11		
High	12	5.17	- 1.52	0.91	3.40	1.51		
10^5 - 10^7	18	5.88	- 2.09	0.87	2.82	1.10	1.30	3.20
FC 1^{-1}	24	7.48	- 3.25	0.91	2.30	0.71		

Our study showed that higher concentration of food particles as well as change of temperature toward optimum, increased the rate of bacterial concentration in bivalves. At the same time, as concentration of bacteria in bivalves increases, the concentration rate decreases more rapidly as the concentration of bacteria in seawater increases and as the temperature is closer to optimum. Therefore, in conditions which are closer to optimal, bivalves need less time to reach level-off concentrations of bacteria and to become inefficient in feeding (decrease retention rate and increase the rate of pseudofaeces production). Finally, due to the fact that bacteria are not only, and very probably not the most important food for bivalves, the rates of FC concentration, as well as the values of level-off concentration are primarily determined by concentration of particulate organic matter, detritus and other particles suspended in the surrounding water. Thus, the results of this study could be interesting rather as qualitative than quantitative model.

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DISTRIBUTION OF HETEROTROPHIC MARINE BACTERIA IN THE ROMANIAN AREA OF THE BLACK SEA

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Abstract

During 2000 annual distribution of heterotrophic marine bacteria and seasonal characteristics were investigated in the water of the Romanian Black Sea coast. The heterotrophic marine bacteria density (CFU on agar plates) ranged from 5.4 x 10^2 to 2.8 x 10^5 CFU ml^{-1} with a maximum value in summer. As for the distribution of the physiological groups of bacteria (proteolytic, lipolytic, amylolytic), amylolytic bacteria were 80% of total heterotrophic marine bacteria during the investigation period.

Keywords : bacteria, coastal waters, Black Sea

Introduction

Microorganisms, especially bacteria, play an important role in the marine ecosystem, and number of heterotrophic bacteria serve as trophic level indicators. The coastal zone is an area where river and discharge receive great amounts of dissolved organic matter. Bacterioplankton can transform part of these substances to biomass supplying the grazing food chain in the ecosystem. In coastal areas distribution of bacterial numbers and activity is affected by fluctuations of some biotic and abiotic factors (1). The Black Sea is a semi-enclosed sea, constituting a *"unicum hydrobiologicum"* by virtue of its physical, chemical and biological conditions. During recent decades, the Black Sea has become seriously perturbed by anthropogenic forces, a large quantity of inorganic and organic compounds is introduced every year by rivers and by industrial and domestic discharges. The increasing nutrient inputs was reflected in changes in many abiotic and biotic factors with severe impacts on the entire marine ecosystem structure of the Black Sea (3). Therefore, it is necessary to understand function and structure of the ecosystem from eutrophied and polluted areas, in order to improve this ecosystem.

This paper reports the distribution and characteristics of heterotrophic marine bacteria in the coastal waters from the Mamaia Bay, Romania as affected by fluctuations of physico-chemical and biological factors during the 2000 year.

Material and Methods

Mamaia Bay (Fig.1) is an area from the Southern part of Romanian

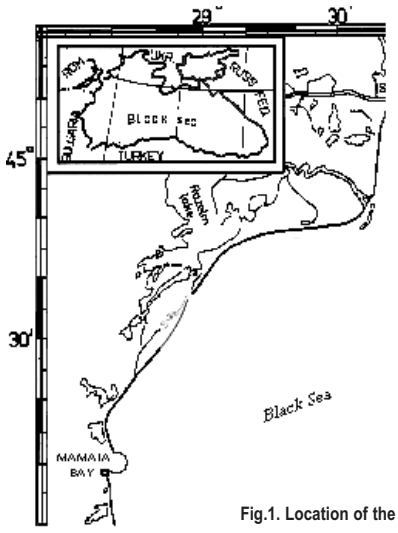

Fig.1. Location of the Mamaia Bay area

Black Sea coast in which there are many social and economic activities, especially touristic activities.

The water quality from this site is under the influence either directly or indirectly of sewage discharges into the sea at various points along the coast, which increase during summer owing to the increase of the population. Therefore, seawater in this area may become gradually contaminated with pathogens, organic and inorganic compounds

Seawater samples were collected from Mamaia Bay at bimonthly intervals between January to December 2000. Samples were taken aseptically from 0.3 - 0.5 m below the surface and processed within a few hours after collection. Water temperature and salinity were assessed during the study.

Spreading technique on solid ZoBell's medium was used for determination of heterotrophic bacteria measured duplicate (2). The number of heterotrophic bacteria was expressed as CFU ml^{-1} (colony forming units) after 7 days of incubation of 21° C. For the determination of physiological groups of bacteria, gelatin (0.4%) for proteolytic bacteria, Tween 80 (0.1%) for lipolytic bacteria, and soluble starch (0.2%) for amylolytic bacteria were added, respectively as the sole carbon source to the basal mediu (2) .

Results and discussion

Water temperature (Table 1) and salinity fluctuated between 3.2 – 23.8° C and 13.69 – 17.99% respectively. Total saprophytic bacteria numbers (Fig. 2) ranged within 5.4x 10^2- 2.8x 10^5 CFU / ml showed distinct seasonal fluctuations, with maxima in summer (June) and minima in winter (January).

Table 1. Seasonal fluctuation of heterotrophic bacteria (CFU / ml , 1*=Total saprophytes, 2*=proteolytic bacteria, 3*=lipolytic bacteria, 4*=amylolytic bacteria), temperature and salinity in seawater from Mamaia Bay in 2000.

Month	° C	%0	1	2*	3*	4*
Jan.	3.2	15.6	$5.42x10^2$	$3.48x10^2$	1.2x102	$0.4x10^2$
Feb.	4.8	16.84	$8.76x10^2$	$5.66x10^2$	2.8x102	$0.6x10^2$
Mar.	6.1	16.75	$1.94x10^3$	$8.9x10^2$	8.6x102	$0.9x10^2$
Apr.	10.4	14.67	$4x10^3$	$1.5x10^3$	2x103	$1.6x10^2$
May	15	13.69	$4.8x10^4$	$2.8x10^4$	1.8x104	$8.1x10^2$
Jun.	20	15	$2.88x10^5$	$6.8x10^4$	2.4x105	$1.8x10^5$
Jul.	18.5	17.99	$7.8x10^4$	$3.8x10^4$	5.6x104	$3.5x10^3$
Aug.	23.8	15.25	$2.1x10^4$	$1.2x10^4$	1.8x104	$2.1x10^3$
Sep.	19.4	15.83	$3x10^4$	$2.4x10^4$	9.8x104	$1.6x10^3$
Oct.	14.7	14.17	$6.7x10^4$	$2.6x10^4$	3.8x104	$1.6x10^4$
Nov.	12.9	16.41	$8.4x10^4$	$6x10^4$	3.4x104	$1.5x10^4$
Dec.	8.7	14.99	$2.2x10^4$	$1.6x10^4$	5.8x103	$2.6x10^4$

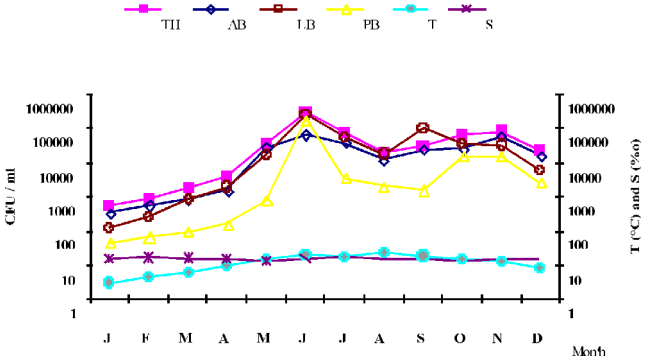

Fig. 2. Evolution of investigated bacteria and physico-chemical parameters according to seasons (TH= total heterotrophyc bacteria, PB= proteolytic bacteria, AB= amylolytic bacteria, LB= lipolityc bacteria, T= temperature, S= salinity)

The distribution of saprophyte numbers was strongly correlated with the water temperature and phytoplankton development (Fig. 2).

The specialized bacteria also showed a similar tendency. This may be related to a greater availability of easily degradable organic compounds and to higher temperatures. In fact, during the summer the alochtonous inputs of organic substrates must have increased owing to the phytoplankton blooms, and the substrates released by the macrophytes which are usually more readily available during this period. In addition, the sewage outflow increases during summer due to large number of tourists in the Mamaia Bay.

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LA CONTAMINATION BACTERIENNE DE LA MOULE *MYTILUS GALLOPROVINCIALIS* (LMK, 1829) DE LA BAIE D'ORAN

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Résumé

Notre étude a été réalisée en baie du port d'Oran, dans le but de comparer la contamination de l'eau et des moules (*Mytilus galloprovincialis*, lmk, 1829) du même site par le dénombrement des indicateurs usuels, Coliformes totaux, fécaux et Streptocoques fécaux, ainsi que la recherche de quelques germes pathogènes tels que les Salmonella, Vibrion cholérique, etc. La concentration par les bivalves est importante, mais diffère pour les trois indicateurs bactériens, les plus fortes abondances ont été rencontrés chez la moule, en période de chaleur qui correspondent à leur repos sexuel . L'efficacité des moules comme indicateur de contamination et comme matériel de recherche des bactéries pathogènes (Salmonella) a été confirmée.

L'urbanisation croissante dans les zones littorales entraîne une augmentation très importante des rejets polluants dans le milieu marin aux abords de grandes métropoles, comme Oran. En effet, outre la pollution due aux rejets domestiques, il existe dans ce secteur d'importantes unités industrielles ainsi que différentes activités particulièrement polluantes liées au port d'Oran. Cette pollution conduit à la contamination des fruits de mer dont la consommation peut engendrer des risques sanitaires. Les empoisonnements les plus sérieux sont dus aux Mollusques bivalves, principalement moules et huîtres qui, vu leurs capacités de filtrer de grands volumes d'eau, sont ainsi capables de concentrer un grand nombre de particules et bactéries. Dans ce travail, nous avons essayé, à travers l'impact des rejets polluants sur la qualité des eaux du littoral (i) d'apprécier la contamination en bactéries fécales, (ii) de faire une étude comparative entre les eaux de surface et des moules naturellement présentes dans la jetée du port d'Oran.

Matériel et méthodes

Analyses bactériologiques : dénombrer les coliformes totaux, fécaux et streptocoques fécaux dans du bouillon lactosé à 35°C, bouillon lactosé à 44.5°C et bouillon d'azide dextrose à 37°C, selon la méthode des tubes multiples. Recherche des Salmonella par un pré-enrichissement sur EPT, enrichissement sur le bouillon sélénite de Na, isolement sur les gélosse Hektoen, identification selon les critères biochimiques. Recherche du Vibrion cholérique par un pré-enrichissement sur EPA concentré 10 fois, un enrichissement sur EPA simple concentration, isolement sur gélose GNAB et identification par les épreuves d'agglutination.

Résultats et discussion

1. Etude comparée de la contamination de l'eau et des moules
2. Fréquences d'isolement des bactéries pathogènes : Enterobacter (31%), Citrobacter (25%), E.coli (27%), Proteus (15%), Salmonella et Leclercia adecarboxylata 2 fois/12 prélèvements, Aeromonas hydrophila 3 fois/12 prélèvements.
3. Variabilité des séries de dénombrement réalisées sur l'eau et les moules

L'examen des coefficients de variation obtenus pour chacun des prélèvements (eau de mer et moule) fait apparaître une variation sensiblement plus faible dans le cas des bivalves.

4. Relation entre la contamination de l'eau et des moules

On peut se demander si les variations observées sont indépendantes, ou si, au contraire, la contamination des moules est liée à celle de l'eau au même moment. Ces figures illustrent des droites de régression avec une pente positive, les corrélations sont hautement significatifs. Ceci signifie que la contamination chez la moule est donc en relation avec celle de l'eau prélevée au même moment. Il a été vérifié, par contre, qu'aucune liaison n'existe entre la contamination des moules et celle de l'eau prélevée 24 heures plus tôt. (1)

Conclusion

Notre étude a confirmé l'enrichissement effectif des bactéries dans les moules avec une sous estimation de leur nombre réel. Les techniques utilisées pour la numération des bactéries ne permettent pas le recouvrement total des bactéries entériques, stressées (2,3) L'eau de la jetée du port, contaminée par les Coliformes fécaux, enregistre un taux d'environ de 90% de dépassement par rapport aux valeurs guides. Quant aux moules, en période de chaleur, elles révèlent une plus forte contamination sur 12 prélèvements, on constate 12 dépassements aux nombres guides (soit 100 %). L'utilisation des bivalves comme «intégrateurs» de contamination bactérienne a été appliquée aussi à la détection des pathogènes. Dans le cas des Salmonella en particulier, nos résultats ont montré que la recherche sur la chair des moules conduit à une plus forte fréquence d'échantillons positifs par rapport à celle effectuée sur l'eau. Ceci vient confirmer les études démontrant la sensibilité des moules dans le piégeage des Salmonella (4).Nos résultats suggèrent que le milieu côtier est un écosystème dont les paramètres physico-chimiques (température, pH, pression osmotique, matière organique), sont tels que les bactéries qui s'y maintienne nt en survie, voire qui s'y développent, sont capables d'une grande adaptabilité physiologique ; croissance en présence de plusieurs polluants chimiques, en basses températures et en milieu hostile) et génétique.

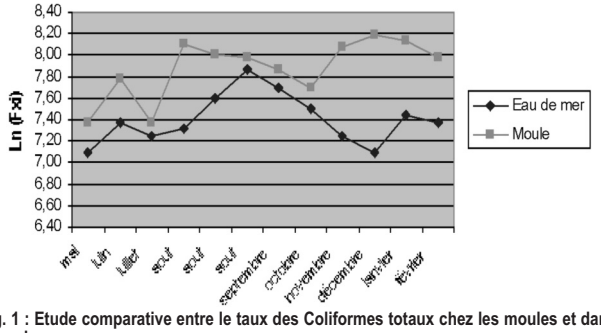

Fig. 1 : Etude comparative entre le taux des Coliformes totaux chez les moules et dans l'eau de mer.

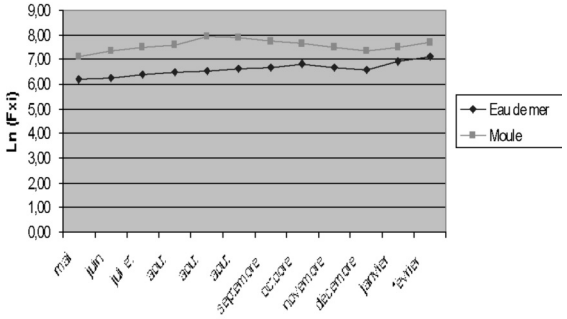

Fig. 2 : Etude comparative entre le taux des Coliformes thermotolérants chez les moules et dans l'eau de mer.

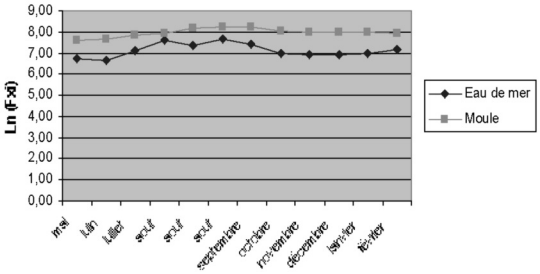

Fig. 3 : Etude comparative entre le taux des Streptocoques fécaux chez les moules et dans l'eau de mer.

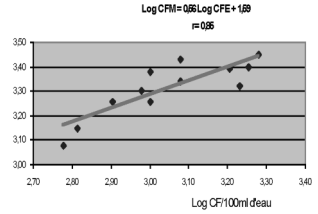

Fig.4 : Relation entre la contamination des moules et l'eau par les Coliformes fécaux.

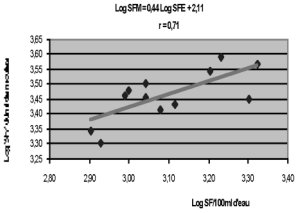

Fig.5 : Relation entre la contamination des moules et l'eau par les Streptocoques fécaux.

Tab 1. Coefficient de variation sur les dénombrements sur eau et moules.

	Moules			Eau de mer		
	X	d	V	X	d	V
Coliformes totaux	2725	663,50	24,35%	1683,33	415,24	24,66%
Coliformes fécaux	2112,50	497,32	23,54%	1200	449,75	37,48%
Streptocoques fécaux	2945,83	565,47	19,20%	1310,83	438,33	33,44%

X : Moyenne, d : Ecart type, V :Variabilité

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MIXED INDICATIONS OF MINERAL NUTRIENT LIMITATION IN A MICROCOSM EXPERIMENT USING EASTERN MEDITERRANEAN SURFACE WATER.

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Abstract

Microbial food web responses to additions of phosphate, nitrate, and glucose were investigated in a microcosm experiment using eastern Mediterranean surface water. Glucose alone gave no stimulation of bacteria, and there was free, bioavailable silicate. The food web thus appeared not to be constrained by carbon limitation of bacteria or by silicate limitation of diatoms. Adding phosphate alone led to an increase in both chlorophyll and primary production, suggesting the presence of a bioavailable N-reserve of ≈ 800 μmol-N m^{-3}. Turnover-time for orthophosphate, however, increased when phosphate doses > 10 μmol-P m^{-3} were added, and decreased when nitrate was added alone, resembling the pattern expected for N-limitation. Mixed indications as to whether the osmotroph organisms were phosphate or nitrogen-limited were thus found.

Keywords: Eastern Mediterranean, phosphorus, phytoplankton, bacteria

Deep water nitrate:phosphate ratios in the eastern Mediterranean basin have been shown to be well above Redfield (1) Combined with the observation that surface heterotrophic bacterial communities in the eastern basin (2), and phytoplankton as well as bacterial communities in the north-western Mediterranean (3) appear phosphate-limited, this has led to the suggestion that the Mediterranean surface ecosystem may be relatively simple in the sense that osmotrophs are limited by phosphate, rather than nitrogen, organic carbon, silicate, or combinations of these (4) (Fig. 1). As part of a more critical investigation of these suggested relationships, we here report results from a microcosm study designed primarily to test the response to phosphate addition of the microbial ecosystem in eastern Mediterranean surface water.

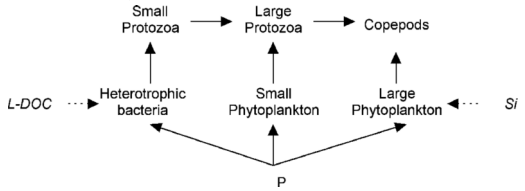

Fig. 1. Idealised model for the P-flow (adapted from Thingstad and Rassoulzadegan ,1999) proposing that, in the Mediterranean, the system is particularly simple with all osmotrophs (heterotrophic bacteria, small and large phytoplankton) are P-limited. If so, P-flow should not be constrained by labile DOC (L-DOC) limiting bacterial growth rate, silicate (Si) limiting diatom growth rate, or nitrogen limiting any of the three osmotroph groups.

Experimental design and rationale

Seawater pumped from 10m-depth 30 km west of Haifa during May 14 2000, was filtered on 125 μm mesh plankton nets to remove large grazers, and dispensed into 25L high-density polyethylene carboys that had been pre-treated with seawater, acid washed, and rinsed with seawater from the sampling station. The carboys were incubated in a circulating seawater (21°C) tank under subdued natural light conditions. Nutrient additions were made as single doses on Day 0 (May 15), according to the scheme in Table 1. Chl-a was determined by HPLC, primary production from ^{14}C-incorporation in light-dark bottles incubated at mid-day, and orthophosphate turnover-time from incorporation of ^{33}P after short-term incubation with $H_3{}^{33}PO_4$. Based on the hypothesis of a P-limited state of the food web, the four treatments with increasing phosphate dose (#2, #3 and #4) were expected to reveal an increasing response relative to the untreated control (#1). For a sufficiently large P-dose, the system was expected to be shifted into N-deficiency. In this case, continued growth was expected in the corresponding Treatments #6, #7, or #8, supplied with excess nitrate-N. Treatment #9 was given glucose as a negative control to confirm the expectation of no bacterial response to the addition of a degradable carbon source.

Results and discussion

No response could be found in bacterial biomass or activity to the addition of glucose alone (#9, data not shown. As evidenced by the diatom bloom induced, the free silicate in the collected water (1.1 mmol-Si m^{-3}) was bioavailable. Together, these observations support the hypothesis that the system was not constrained, neither by organic-carbon limitation of heterotrophic bacteria on the left, nor by silicate limitation of diatoms on the right side of Fig. 1. An increasing response to increasing phosphate-alone addition was found in both chlorophyll and in primary production (Fig.2). Saturation of the response occurred for additions around 50 μmol-P m^{-3}. Assuming a Redfield ratio of 16:1, this corresponds to the mobilisation of an N-reserve around 800 μmol-N m^{-3}. However, adding nitrate alone (#5) also had a stimulatory effect on both primary production and chl-a (Fig.2). Also, turnover-time of orthophosphate increased in carboys with phosphate added alone in doses >10 μmol-PO_4 m^{-3} (Fig. 3A), while adding nitrate alone (Fig. 3B) led to a decrease in turnover-time. Except for the absence of significant effects from adding 10 μmol-PO_4 m^{-3} alone (#2), the response-pattern seen in orthophosphate turnover-time (Fig.3) corresponds to what would be expected in a system with nitrogen-limited osmotrophs

Table 1. Nutrient additions to experimental carboys in µmol P, N or C m-3. Additions made as single additions of orthophosphate, nitrate or glucose on Day 0 to triplicate carboys.

P alone	#1:P:0	#2:P:10	#3:P:50	#4:P:500
Excess N	#5:P:0,N:1000	#6:P:10,N:1200	#7:P:50,N:2000	#8:P:500,N:1100
Glucose	#9:P:0,N:0,C:10000			

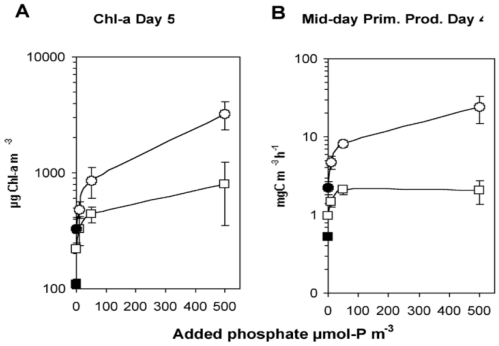

Fig. 2. (A) Chl-a on Day 5, and (B) mid-day primary production on Day 4 as functions of phosphate added (O)alone, or (O)in combination with excess nitrate. Nitrate alone (#5) indicated by filled circle and value on Day 0 by filled square. Error bars represent SE of mean of triplicate carboys. Note logarithmic scale on y-axes.

stimulated in their P-uptake by the added nitrate.

Conclusions

Our experiment supported the suggestion that neither organic-carbon limitation of bacteria nor silicate limitation of diatoms constrained the functioning of the photic zone microbial food web. As hypothesised, we also found a positive phytoplankton response from adding phosphate alone. Seen in isolation, these results suggest a P-limited system with a bioavailable N-reserve in the order of 800 μmol-N m^{-3}. This simple picture was however complicated by a response both in chl-a and in primary production to adding NO_3 alone (#5), an additional effect of nitrate in all treatments with NO_3 and PO_4 together (#6, #7 and #8), and a response pattern in orthophosphate turnover-time resembling that expected under N-limitation. The possible role of N as a co-limiting factor can thus not be ruled out. Interpretation was complicated by changes in the control treatment (#1, no additions). Sampling, prefiltration, and confinement, alone or in combination, may thus have disturbed the state of the food web present in the collected water. Two Lagrangian experiments are planned (May 2001, May 2002) that will be unaffected by these problems.

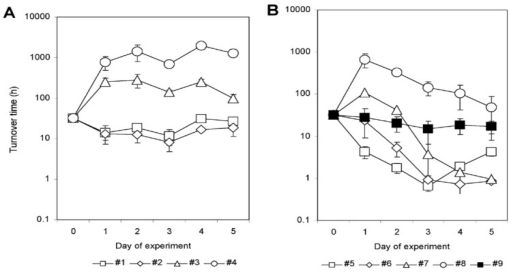

Fig. 3. Response in turnover-time for orthophosphate in (A) control (#1) and from adding phosphate alone (#2, #3 and #4), (B) nitrate alone (#5), phosphate in combination with excess nitrate (#6, #7, and #8), or glucose alone (#9). Error bars indicate SE of mean of triplicate carboys.

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LES PROTOZOAIRES CILIÉS DANS LA SALINE DE SFAX (TUNISIE) : IMPORTANCE DE LA BOUCLE MICROBIENNE DANS LES CHAÎNES TROPHIQUES DE CET ÉCOSYSTÈME.

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Résumé

En milieu aquatique pélagique, les travaux récents réalisés dans le domaine de l'écologie microbienne ont permis de montrer que les chaînes trophiques classiques: phytoplancton → zooplancton → poissons empruntent également la voie de la boucle microbienne. L'objet du présent travail est de montrer l'importance de la boucle microbienne (protozoaires ciliés et bactéries) dans les chaînes trophiques de l'écosystème de la saline de Sfax.

Mots clés: lagune - salinité - zooplancton - protozoaires ciliés .

La saline de Sfax, milieu lagunaire sursalé, se localise dans la région Sud Est de la Tunisie. Elle s'étend sur une zone côtière d'environ 1500 ha au sud de la ville. Suite à une étude biologique préliminaire (1), 8 stations de prélèvement ont été fixées (Fig. 1). Ces stations, qui s'étendent depuis l'eau de mer (station EM : salinité moyenne 42 g/l) jusqu'aux tables salantes (siège de précipitation de la halite : salinité moyenne 320 g/l), sont considérées comme représentatives pour

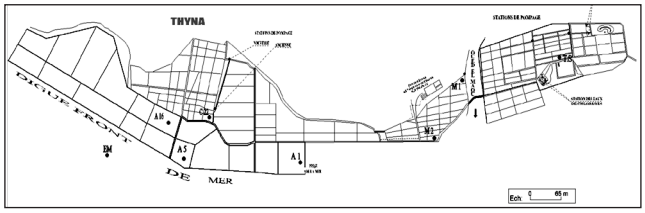

Fig. 1. localisation des sites de prélèvement dans la saline de Sfax.

l'ensemble de la saline.

Le zooplancton de ce biotope se compose des principaux groupes suivants: copépodes, rotifères, protozoaires ciliés et le crustacé *Artemia* (2). Le suivi spatio-temporel de la densité du zooplancton de la saline a montré que les protozoaires ciliés abondent le milieu durant toute l'année (Fig. 2), ils présentent l'écrasante majorité de la densité zooplanctonique au niveau des bassins sursalés de la saline. Durant la période printanière, la présence du crustacé *Artemia* dans le milieu fait régresser la densité des protozoaires ciliés. Cette densité des protozoaires ciliés, en dehors de la période printanière, est généralement très élevée (supérieure à 10^6 ind/m^3) dans les bassins sursalés de la saline, bassins (3).

La prolifération de ces protistes est généralement associée à une importante flore bactérienne qui se développe au détriment de la dégradation des organismes colonisant les premiers bassins de la saline. En effet la culture bactérienne a montré que la densité des bactéries hyperhalophiles peut atteindre 3.5 10^7 bactéries/ml au niveau de la station TS (salinité moyenne 320 g/l) (4). Dans nos échantillons de saumures, prélevés au niveau des stations sursalés M1, M2 et TS, nous avons noté la couleur rouge lie de vin due à l'abondance des bactéries hyperhalophiles notamment les deux genres *Halobacterium* et *Halococcus*.

Ainsi, l'étude microbiologique (4) entreprise sur ces bassins montre qu'outre les fortes densités des protozoaires ciliés rencontrés dans les bassins sursalés, la flore bactérienne représentée par les bactéries hyperhalophiles constitue la forme biologique caractérisant les saumures les plus concentrées de la saline. Cette pullulation microbienne (protozoaires ciliés et bactéries) montre l'importance de ce maillon dans les chaînes trophiques de cet écosystème.

Cette biomasse bactérienne pourrait être liée à la diminution de la pression de prédation dans la mesure où la plupart des prédateurs ne peuvent pas tolérer des salinités élevées, c'est ainsi que la densité bactérienne, dans ces milieux hypersalés, est généralement supérieure à celle des systèmes aquatiques de niveau trophique équivalent (5). L'omniprésence et le rôle clé de ces microorganismes dans le fonctionnement des systèmes écologiques, notamment aquatiques font de l'écologie microbienne une discipline essentielle (6).

La compréhension des mécanismes responsables de l'adaptation de ces microorganismes aux conditions fluctuantes du milieu constitue un enjeu majeur pour les études ultérieures. La modélisation mathématique de l'ensemble facteurs du milieu et abondance spécifique des groupes zoologiques caractéristiques de ce biotope devrait dans l'avenir fournir un cadre plus formalisé permettant une bonne compréhension et un outil de recherche et de gestion de cet écosystème.

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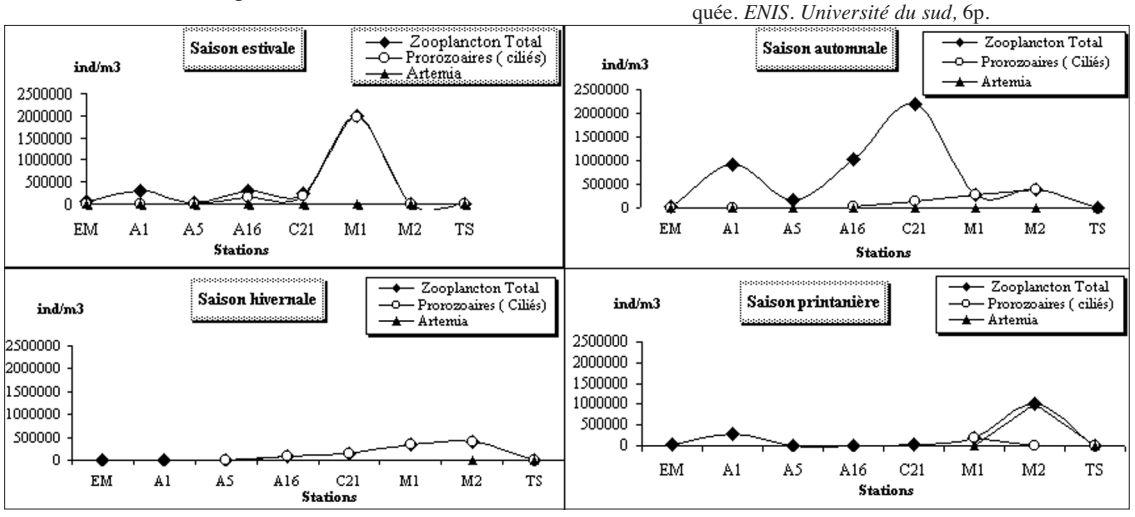

Fig. 2. Evolution spatio-temporelle de la densité des groupes Zooplanctoniques dans la saline de Sfax.

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CHEMICAL DEFENCE AND ANTIFOULING ACTIVITY OF SPONGES OF THE GENUS IRCINIA

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Abstract

The defense roles and the antifouling activity of the organic extracts and the major metabolites of the sponges I*rcinia pausifilamentosa*, *I. variabilis* and *I. spinosula* were investigated. The antifeedant activity was tested on the generalist predator fish *Thalassoma pavo*. The antifouling activity was tested against representatives of the three major groups of fouling organisms, marine bacteria and marine fungi, diatoms and the blue mussel. All extracts showed promising levels of activity.

Key Words : Porifera, Aegean Sea, Predation,

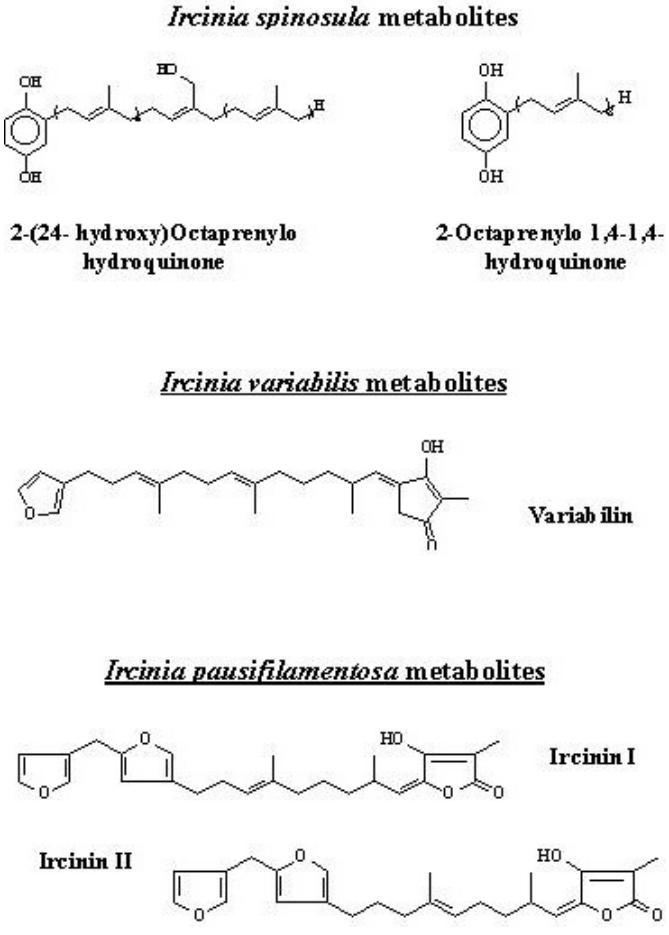
Introduction

Sponges are important members of the marine ecosystem. Because they are sessile and soft-bodied, they appear to be physically vulnerable. The lack of predation on sponges is thought to result from the elaboration of physical and chemical defenses.

A number of studies have shown that organic compounds extracted from a diversity of non-motile marine taxa, including sponges inhibit fouling in the laboratory or in the field. It has been stated (1) that these organisms secrete chemicals that prevent larvae of other marine organisms from settling and growing on them. The sponges of the genus *Ircinia* found in shallow Mediterranean marine ecosystems are most of the times free of epibionts and have at the same time proven to be rich sources of interesting metabolites.

Materials and Methods

Sponges were collected by SCUBA diving from the island of Melos and the island of Fleves. The preliminary palatability of the sponges was evaluated in laboratory aquaria with the generalist predator fish *Thalassoma pavo*. *Ircinia* extracts and pure metabolites were incorporated in food preparations following the methods described by Pawlik (2).



Major metabolites of the investigated *Ircinia* species.

Antibacterial testing of the extracts was performed by the disc diffusion technique in agar plated petri dishes (3). Five Gram-positive bacteria and five Gram-negative bacteria were chosen for this study. The activities of the sponges extracts and compounds towards marine fungi strains were performed using a modified well-agar diffusion method. Five marine fungi strains were obtained from the Culture Collection of the University of Portsmouth.

Inhibition of microalgae growth was tested on Diatomophyceae strains obtained directly from the Culture Collection of Algae of the University of Caen, including *Amphora coffeaformis*, *Phaeodactylum tricornutum*, *Cylindrotheca closterium*. The screening of activity was performed as previously described in Sawant & Garg (4). Antifouling tests were performed against three macroalgae namely *Enteromorpha intestinalis*, *Ulva lactuc*a and *Sargassum muticum*. Samples were collected in Concarneau Bay, France. Spores liberated from fronds after an incubation at 25°C during 20 min. were collected in a beaker and used for the experiments (4). The antifouling activities of the extract toward Mytilus edulis was measured by recording the activity of the phenoloxidase as previously described in Hellio *et al*. (4). Toxicity tests on oyster (*Crassostrea gigas*) and sea urchin larva (*Echinus esculentus*) were realised as previously described (4). The biocide TBTO (10 ppm) was used in all assays as a standard to check the sensitivity (4)

Results and Discussion

The defense mechanism of the sponges was found to rely on the presence of the major metabolites such as Ircinin I and II for *I. pausifilamentosa* and variabilin for *I. variabilis*. The extract of *I. spinosula* showed only moderate activity and that was traced to the prenylated hydroquinone constituents. The active factors of *I. pausifilamentosa* and *I. variabilis* were tested in natural concentrations and were inhibiting higher than 80% of the fish feeding.

Most of the extracts exhibited significant activity against fouling, with strong effect on the three major groups of fouling organisms (micro-organisms, algae and invertebrates). The dichloromethane extract of *I. spinolusa* and ethanol extract of *I. pausifilamentosa* were relatively broad spectrum, showing high to moderate level of activity in all assays. Since every antifouling coating must work against a range of fouling organisms, the above activities are promising.

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ORGANIC MATTER COMPOSITION, BACTERIA RESPONSE AND FUNCTIONING IN WELL ESTABLISHED FISH FARM SEDIMENTS OF THE LIGURIAN SEA (WESTERN MEDITERRANEAN)

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Abstract

The impact of a well established fish farm has been investigated in surface sediments of the Ligurian Sea in order to assess the biodeposition, bacteria response and functioning at a mature stage of organic enrichment. The biopolymeric fraction of organic matter showed very high values beneath the fish cages. Bacteria abundance was also very high and was positively correlated with OM values. Although enzymatic activity recorded high level in fish farm sediments, bacterial degradation rates showed a functional stress, thus representing a valuable environmental index to highlight the unbalance occurring between the supply and exploitation of OM in eutrophic environments.

Key-words: Bacteria; Organic matter; Aquaculture

The large diffusion of intensive fish-farm activities on the continental shelf of the Mediterranean Sea is causing increasing concern for the strong environmental impact. The most evident effects of the fish cages on bottom sediments are the accumulation of organic matter (OM) and the progressive transformation of the substrate into a flocculent anoxic environment (1). Previous studies have clearly demonstrated that disturbance induced by increasing organic loads in coastal areas might determine changes in the community structure and biodiversity of the benthic assemblages (2), and in some extreme cases might even result in azoic sediments (2). However little is known on the functioning and response of the benthic community and in particular to those compartments more directly affected by OM input such as bacteria (3).

We studied the impact of organic loads due to the biodeposition of a well established fish farm in a coastal area of the Ligurian Sea (Gulf of La Spezia, Western Mediterranean) in order to assess organic matter composition, bacterial response and functioning at a mature stage of organic enrichment.

Sediment chemistry and microbial parameters were investigated in June, July, September and October 2000 at two stations located along a transect crossing the farming area and directed from coast to the open sea (inshore and offshore) while a third station was investigated at about 200m distance and served as a control (Fig. 1).

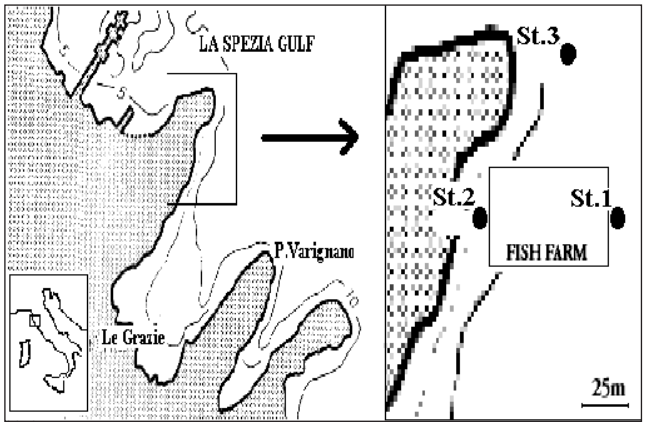

Fig. 1- Sampling area and stations locations (Gulf of La Spezia, Western Mediterranean)

Reducing conditions were recorded in the top sediment layer for stations located under the fish cages (Eh<-50mV). The accumulation of organic matter (in term of proteins, carbohydrates and lipids) were significant (Fig. 2a) and higher in June and October; moreover the highest OM concentrations were detected at the inshore station where water exchange was scarcer. Lipids and carbohydrates highlighted the most pronounced changes if compared to the control while proteins were the more conservative; lipids in particular showed very high values (up to 4973.2 μg g^{-1}) in relation to the feeding activity and could be identified as important biomarkers of organic loads in fish farm sediments.

Benthic bacteria appeared to be strictly related to organic enrichment as their abundance were three fold higher (up to 344.38 108cells g-1) in stations beneath the cages if compared to the control. The autofluorescent cells (AFC) accounted for less than 1.5% of total bacterial abundance (TBN). Furthermore the AFC to TBN ratio does not represent a useful tool in evaluating the impact of biodeposition displaying

(a)

Area	Depth (m)	Lipids ($\mu g g^{-1}$)	Proteins ($\mu g g^{-1}$)	Carbohydrates ($\mu g g^{-1}$)
Station 1	10	1706.851	1922.585	3469.949
Station 2	10	3979.704	2593.042	3719.307
Station 3	10	1115.259	2124.805	812.843

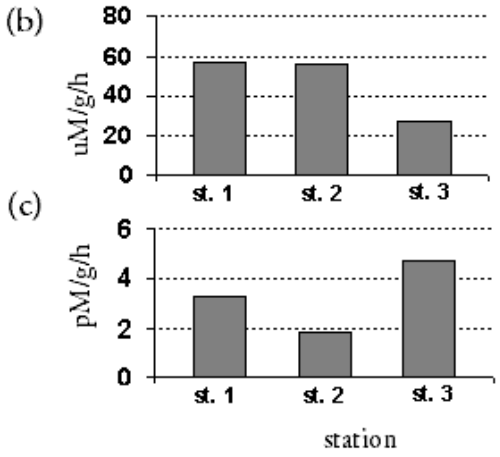

Fig. 2 – Four months average of (a) OM values, (b) aminopeptidase activity and (c) aminopeptidase activity per bacterial cell for the top 1 cm sediment layer in the three sampling stations.

similar values both in fish farm and control stations (3).

The dynamic of microbial community has been investigated by means of functional parameters such as the Frequency of Dividing Cells (FDC) and aminopeptidase enzymatic activity. Both FDC than aminopeptidase displayed higher absolute values in sediment beneath the cages; by contrast enzymatic activity per cell was lower (Fig 2b,c). According to what was observed in other eutrophic systems such as the Northern Adriatic Sea (4) we hypothesise that in conditions of strong and continuous organic enrichment the bacterial degradation rates may show a functional stress. This can be viewed as a valuable environmental index to highlight the unbalance occurring between the supply and exploitation of OM in eutrophic environments.

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Symposium

Mediterranean marine science: major issues for 21st century

"THALASSOGENIC DISEASE" - HUMAN DISEASE CAUSED BY WASTEWATER POLLUTION OF THE MARINE ENVIRONMENT WITH SPECIAL REFERENCE TO THE MEDITERRANEAN

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Society generally views recreation at the seashore and ocean bathing, called by some thalassotherapy, as a positive health experience. However, there has been some degree of historical awareness of the potential human health problems associated with bathing and harvesting shellfish, which are often eaten raw, in marine coastal waters contaminated by urban wastewater discharges. In the past such forms of thalassogenic disease have been perceived primarily as isolated local problems. The issue of marine biotoxin poisonings associated primarily with toxic algae blooms has also been of concern. However, the global disease impact and the associated economic implications of these human health problems is estimated for the first time in this study aimed at developing a preliminary quantitative estimate of the impact of these pathways of disease transmission (1). These findings have been underscored by other recent studies (2).

Any comparison of health impacts from various sources must start with a sense of scale of the health problems. Which health impact is more important in human disease and social terms or in financial terms, and by how much? In this preliminary study, each of three negative health impacts has been evaluated in terms of the concept of Global Burden of Disease (GBD). The GBD is measured in units of Disability-Adjusted Life Years (DALYs), a new concept recently developed by the World Health Organization (3) and the World Bank (4, 5). This new approach calculates a) losses from premature death, which is defined as the difference between the actual age of death and life expectancy at that age in a low-mortality population, and b) years of loss of healthy life resulting from disability. It is difficult to estimate the social and economic loss of one year of productive life resulting from premature death or disability (or one "DALY"). There are numerous approaches for making such economic estimates. For the purposes of this study I have estimated , in consultation with the WHO, the money value of the economic loss of one productive year of life, or one DALY, as being about $4,000. This figure approximates the global mean annual GDP per capita, but it is not necessarily based on that figure (6). (See Box on how DALY'S are calculated)

How are Disability-Adjusted Life Years- DALY's calculated?

As an example we shall present the sample calculation of DALY's for a hypothetical marine pollution associated Disease X that has caused 1,000,000 clinical cases of disease per year globally with 10 days of incapacitation per case, 5% or 50,000 cases of life long severe disability (say partial paralysis) and 1% or 10,000 cases of death. If we assume the average age of onset of the cases of disability and death is 20 then it assumed by a special actuarial and discounting method that the years of lost healthy life when discounted is 40. A factor of disability weight must be estimated for each disease for the degree of incapacitation during the acute stage of illness and the degree of disability in the case of longer term sequellae resulting from the disease. The factor of disability weight varies from 1 for total disability or death to 0.05 for very mild cases of disease. In the case of Disease X we shall assume a factor or 0.3 (or 30%) for the 10 days of incapacitation during the acute stage of the disease and a factor of 0.5 (or 50%) as the degree of incapacitation for the cases of lifelong partial paralysis

Thus the calculation of DALY's for Disease X would be as follows:

a) Acute cases: 1,000,000 cases x10 day/365 days per year x 0.3 (factor of disability weight) **= 8219 DALY's**
b) Life long disability: 50,000 cases of life long disability x 40 years of lost healthy life x 0.5 (factor of disability weight) = **1,000,000 DALY's**
c) Deaths: 10,000 cases of death x 40 years of lost healthy life x 1(factor of disability weight) = **400.000 DALY's**

Total for Disease X = **1.408,219 DALY's**
say **1.4 million DALY's**

From the above hypothetical example, it can be seen that the main weight factor in the calculation of the total number of DALY's results from the cases of disability for extended periods and/or cases of death. Only minor weight is given to the cases of acute disease with relatively short periods of incapacitation. This is logical for this particular new WHO/World Bank Global Disease Burden rating system since DALY is defined as- "Disability-Adjusted Life Years" which gives considerably greater weight to those diseases that cause greater long term (years) social and economic disruption and burden.

Thalassogenic Diseases Related to Bathing/Swimming in Marine Coastal Waters Contaminated by Wastewater Discharge

For the purposes of this paper we shall refer to all human diseases associated with sources of pollution –pathogenic microorganism and marine biotoxins, which are transported by marine waters or develop within marine organisms as 'Thallasogenic diseases" which in Latin means disease caused by the sea.

There is massive epidemiological evidence that enteric and respiratory diseases can be caused by bathing/swimming at marine coastal beaches contaminated with pathogenic micro-organisms, i.e., exposure to pollution from domestic wastewater sources (7,8,9). The evidence from 22 highly credible epidemiological studies clearly supports the conclusion that the rate of infections and disease among bathers increases steadily with increasing concentrations of indicator micro-organisms of fecal pollution in a dose-response relationship (9). These studies also support the conclusion that bathers face the risk of enteric and respiratory infection and disease even in lightly polluted coastal waters meeting current microbial standards of the EEC/European Union (10) and USEPA (11). Based on an extensive and careful evaluation of the available credible epidemiological evidence, WHO (7) estimated that bathing in what had previously been considered "acceptable" marine waters with a mean concentration of 50 faecal streptococci/100 ml will result in infection and illness in 5% of the healthy adult bathers after a single marine bathing exposure. In this study I have estimated a 50% higher risk-of-disease rates for: children who are known to be much more susceptible than adults; for adults visiting beach resorts in countries with high endemic disease rates in the local population; and for a certain percentage of highly contaminated beaches with microbial levels higher than is considered acceptable from a public health point of view.

Based on official reports from the World Tourism Organisation (12) and estimates from other sources, I have estimated that there are some 1-2 billion marine-exposure-days spent at beach resorts each year by local residents and foreign tourists. From these global figures, and based on the WHO risk estimates for gastroenteritis and respiratory infections at various levels of beach pollution, a highly tentative estimate has been made that some 250 million clinical cases of mild gastroenteritis and upper respiratory disease is caused every year by bathing in contaminated seawater. Calculated in terms of DALYs this results in some 400 thousand DALY units. The economic impact or financial loss resulting from this amount of disease has been estimated at some $1.6 billion/year.

Why has this situation gone unnoticed and unreported for so long? Epidemiological studies have revealed that minor cases of gastroenteritis are rarely seen by medical care professionals and even less frequently reported to health authorities. The ratio of actual clinical cases to reported cases of mild gastroenteritis can be 1000:1.

Thalassogenic Diseases Related to the Consumption of Seafood Harvested in Marine Coastal Waters Contaminated by Wastewater Discharge

Seafood, particularly molluscs normally eaten uncooked, is a commonly implicated vehicle for the transmission of infectious diseases caused by enteric micro-organisms (including bacteria and viruses) that enter the marine environment through the disposal of urban/domestic wastewater. Pathogenic bacteria can remain viable in the sea for days to weeks, and viruses can survive in the marine environment or in the tissues of fish and seafood for months (13).

Filter-feeding shellfish, whose breeding areas are often placed near sources of nutrients, such as wastewater outfall sewers or polluted

estuaries, are highly prone to concentrate high levels of pathogens. A series of studies involving the assay and detection of viruses in shellfish in the United States detected enteric viruses in 19% of 58 pooled samples taken from waters meeting current United States bacteriological standards for shellfish growing and harvesting. A mean virus concentration in the shellfish meat of 10 PFU (plaque forming units)/100 grams of shellfish meat was observed (14). One unpublished survey of enteric viruses in shellfish in a Paris market in 1978 indicated that 25% were contaminated with pathogenic enteroviruses. Infectious hepatitis A (HAV), a most serious and debilitating disease of the liver, is the most grave virus disease which is very frequently transmitted by shellfish.

Conventional depuration techniques are used to aid in cleaning shellfish harvested in contaminated waters. Shellfish are held in clean, disinfected water tanks for 36-48 hours of self cleansing, and this is partially effective in removing bacterial contamination. This is less effective for viruses, which are tightly adsorbed to the internal tissues of the molluscs (15). Thus, eating raw or lightly steamed shellfish harvested from such contaminated - but considered acceptable - marine waters can cause infection and disease in a significant percent of the exposed population. Several studies have indicated that so called light steaming of shellfish does not in most cases lead to the total inactivation of infectious viruses adsorbed onto the shellfish tissue.

There is firm epidemiological evidence for numerous sporadic cases of infectious hepatitis (IH) transmission by eating raw or lightly steamed shellfish not reported as part of epidemics. In the study by Koff *et al*. (1967) it was reported that some 25% of all the cases of IH during a non-epidemic period in Boston were apparently associated with the ingestion of raw or lightly steamed shellfish. Similar figures were found in England (16).

Rose and Sobsey (14) have written the seminal work on the development of the methodology for quantitative risk assessment associated with exposure to virus contamination in shellfish. They have estimated that the risk of infection for infectious hepatitis virus A (IHA) for individuals who consume one raw shellfish serving of 60 grams harvested from approved waters in the United State is about 1 per 100, or 1%. The risk from highly polluted waters is greater.

Based on reports from the FAO, it has been estimated that some 8 million tons of molluscs, including clams, oysters, mussels and cockles, are harvested and marketed globally each year. Assuming that one kilogram of gross shellfish, including shells, is required for each shellfish meal or serving, I have estimated that some 8 billion shellfish meals are consumed globally per year. Based on the assumption that some 90% of the shell fish are harvested in clean safe waters and/or are not eaten raw, and based on the risk of infection and disease drawn from the risk estimate study of Rose and Sobsey (1993), I have estimated that each year there are about 2.5 million clinical cases of infectious hepatitus globally, with some 25,000 fatalities and 25,000 cases of long term disabilities from liver damage caused by eating contaminated shellfish. This level of disease results in some 1.8 million DALYs with an estimated economic impact of $7.2 billion per year.

Thalassogenic Diseases Associated with Contamination of Shellfish and other Seafood with Toxins from Toxic Algae Blooms

Marine biotoxins apparently cause a large number of poisonings in humans annually, many with serious sequelae and frequent fatalities. While toxic algae blooms, often associated with marine pollution by urban wastewater, are the source of some of the marine biotoxins that cause human disease, there are other factors and sources. Most of these poisonings are in the subtropical/tropical circumglobal belt region bounded by Florida, the Mediterranean and Japan in the north and the northern edge of Australia, the southern tip of Africa and Chile in the South.

The human diseases most frequently associated with marine biotoxins are paralytic shellfish poisoning (PSP), ciguatera poisoning, and the more recently identified neurotoxic shellfish poisoning (NSP) and diarrheic shellfish poisoning (DSP) (3). Most of these diseases are apparently associated with fish and seafood that feed on toxic marine algae and toxic algae blooms such as red tides. PSP in particular can lead to severe neurotoxic effects, paralysis and death. The death rate for PSP and some of the other marine biotoxin diseases appears to be in the 10%-20% or greater range, while serious long-term sequels such as neurotoxic effects and paralysis are common.

At this time there is little data or agreement among experts on the true extend of the global impact of diseases associated with contamination of shellfish and other seafood with toxins from toxic algae blooms. I have based my tentative estimates of the global impact on data and estimates from various authoritative sources including World Health Organization studies, the opinions of scientists and some official governmental reports. There have been numerous local reports of outbreaks and high endemic incidence of ciguatera poisoning in small communities and islands in the Pacific, such as Tahiti, Hawaii, Samoa and New Guinea, where the incidence has been estimated to be about 500 per 100,000 population. A similar incidence was reported in Dade County, Florida (17). Higerd (18) estimated that 10,000-50,000 individuals are afflicted worldwide each year by ciguatera poisoning alone. Tu (1988) estimates that the true rate of ciguatera poisonings for the South Pacific is likely 2,500 per 100,000. The case fatality rate is low (about 0.1%). It is estimated that the total population in the circumglobal belt where the disease is endemic is about 400 million people, 10% of whom live near seacoasts and frequently eat locally caught fish and seafood. If the incidence rate of ciguatera poisonings in that limited exposed population alone is 500/100,000, then the global incidence might be 200,000 cases a year. If the rate is 2500/100,000 as estimated by Tu, then the global incidence might be 1,000,000 cases a year. In the latter situation, a case fatality rate of 0.1% would result in 1,000 fatalities per year.

In Canada, which has one of the best marine biotoxin monitoring and control programs, there are an estimated 1000 cases per year of illness caused by seafood toxins, with 150 cases per year of PSP and 350 cases of ciguatera poisoning (Ewen Todd, Canada, personal communication, 27 July, 1999). If the incidence for Canada of about 3.3 cases/100,000 of all marine biotoxin poisonings per year is representative of the temperate zones globally, then it might be possible to extrapolate the minimum global incidence for the world population of some 6 billion persons at about 200,000 cases per year, with some thousands of fatalities and thousands of cases with serious life long sequels. This would be a minimum since the rate for the tropical belt where these diseases are highly endemic would be expected to have a much higher rate.

It should be noted that while the death rate from ciguatera poisoning is only about 0.1% that of paralytic shellfish poisoning (PSP) is 10-20%.

In light of the above very scanty data on global incidence of marine biotoxins disease, I have been able to make only a very rough first approximation of the GDB. I have estimated that marine biotoxins associated primarily with toxic algae blooms cause some 100,000 to 200,000 serious cases of intoxications/year globally, and some 10,000 to 20,000 cases of death and a similar number of cases with very serious neurological sequels - paralysis, etc. More accurate or reliable global information is not available at this time. This crude first estimate of the GDB and the DALYs based on the above suggests that it might be as high as one million DALYs per year, with an estimated global economic impact of some four billion dollars.

Estimated Global Impact of Thalassogenic Disease

The total estimated impact of the illness associated with land based marine pollution may be about 3.2 million DALYs/year, with an estimated economic loss of some 13 billion dollars per year. Table 1. presents these estimates along with estimates for other known diseases of global public health importance for which DALYs have been calculated (4). Note that the loss of life years and their associated economic loss is very significant, with the impact being similar to that from upper respiratory tract infections and intestinal nematodes.

Since the Mediterranean plays such a very significant role in both world tourism and in particular recreation at marine coastal areas, including bathing and the consumption of seafood, particularly shellfish it would not be far fetched to estimate that a significant portion of the global burden of THALasSOGENIC disease associated with wastewater pollution of the marine environment occurs in Mediterranean countries. Possibly as much as one quarter of the world total of coastal/beach recreation tourism is in Mediterranean countries. No firm data is available on this point but it would not be incorrect to estimate that some billions of dollars of health damage occur yearly as a result of wastewater pollution along the Mediterranean shores.

It must be pointed out that the estimates above are at best only rough first approximations which must be taken with reservations and used with caution. They may serve as a basis for determining a rough

Table 1. Marine Contamination-Related Thalasogenic Diseases
Comparison of estimated Disability-Adjusted Life Years - DALYs - per year and their economic impact for marine contamination-related diseases and a number of other diseases on a global scale. A mean value to $4000 per DALY is used worldwide for the economic impact estimates. The potential impact of marine pollution-related diseases is quite apparent

Disease	Estimated DALYs per year (millions)	Estimated Economic Impact (billion dollars)
Diphtheria	0.36	1.4
Japanese Encephalitis	0.74	3.0
Dengue Fever	0.75	3.0
Trachoma	1.0	4.0
Upper Respiratory Tract Infections	1.3	5.2
Marine Contamination-Related Diseases	**3.2**	**13**
Bathing/Swimming-Wastewater Related	(0.4)	(1.6)
Seafood Consumption-Wastewater Related	(1.8)	(7.2)
Sea-food Consumption-Toxic Alga Blooms	(1.0)	(4.0)
Intestinal Nematodes (ascaris, etc.)	5.	20.
Stomach Cancer	7.7	31.
Trachea, Brachia and Lung Cancer	8.8	35.
Diabetes	11.	44.
Malaria	31.	124

order of magnitude of the global scope of the problem, which appears to be very much larger than previously estimated. The very provisional economic evaluation of this impact of marine pollution must be viewed with caution, since it is based on such a very preliminary and unconventional economic approach. However, it might suggest that we are dealing with a global problem with major economic implications in the multi-billion dollar range every year.

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ENRICHISSEMENT D'EAU DE MER PAR DES FERTILISANTS ORGANIQUES COMME ESSAIS SUR LA POLYCULTURE (MÉDITERRANÉE ORIENTALE)

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Résumé

Dans le but d'assurer l'enrichissement des bassins de culture, en utilisant les fumures respectives d'un herbivore comme les chèvres et d'un omnivore comme les poules, une expérience a été réalisée en période de production minimale des eaux côtières libanaises. Des paramètres hydrologiques, hydrobiologiques et biologiques ont été étudiés selon une certaine stratégie d'échantillonnage. En conclusion générale, et vue la densité cellulaire, le nombre d'espèces et le développement d'une espèce toxique *Amphidinium carterae*, l'enrichissement avec la fumure de chèvres s'est avéré meilleur que celui de la fumure de poules dans les conditions de l'expérience réalisée.

Moys-clés : Basin levantin, phytoplancton, biomasse, bloom toxique, aquaculture.

Introduction

Les études précédentes réalisées dans les eaux côtières libanaises ont montré que cette eau est riche en espèces mais à des densités relativement faibles (1 ; 2). L'enrichissement des bassins de pisciculture marine par l'ajout d'engrais organique peut être considéré comme une solution adéquate pour améliorer la production primaire sans augmentation du coût de production ; il peut favoriser le développement de la biomasse nécessaire à l'alimentation des larves de poissons. Les recherches sur l'usage des déchets d'animaux comme fertilisants en aquaculture ont été abordées (3, 4 , 5). L'une des méthodes d'enrichissement est la polyculture qui consiste à élever des volailles ou autres animaux autour du bassin d'élevage de façon que tous les excréments de ces animaux tombent dans l'eau. Il est plus conseillé de réaliser une telle expérience sur un modèle réduit. Le but de cette expérience était le choix et l'application de l'engrais organique dans l'aquaculture car il permet: une utilisation plus efficace de la surface d'élevage, de telle façon qu'un même endroit pourra servir à la fois pour l'élevage d'animaux et pour la culture des poissons, un enrichissement du milieu en matière organique et plus précisément en macro-éléments et micro-organismes, une réduction du coût de production, étant donné, que l'engrais organique est relativement à bon prix. En Extrême-Orient, où la fertilisation des bassins est utilisée avec succès, la variation locale des doses et des méthodes d'application est immense (6,).

Matériel et Méthodes

Des tests d'enrichissement ont été réalisés pour pouvoir déterminer la quantité optimale d'engrais à ajouter. Deux engrais ont été choisis: la fumure d'un herbivore (chèvre) et la fumure d'un omnivore (poule pondeuse). Une analyse préalable des engrais a été réalisée afin de connaître leur humidité, leur contenu en sels nutritifs et surtout en azote et phosphore.

Trois différents aquariums ont été placés à l'abri du soleil direct. L'eau de mer, prise, a été préfiltrée à 200μm pour faire déplacer le microzooplancton. Les dimensions des bassins sont les suivants : 31 x 25 x15 cm. Pour éviter la turbidité, les engrais ont été mis dans des tulles fermés et placés au milieu des aquariums. Le bassin I (B1) a été enrichi avec la fumure de poule à raison de 7kg/100m^2/semaine (5), le bassin II (B II) à raison de 10kg/100m^2/semaine de fumure de chèvre (7) et le bassin III (BIII), témoin, contient uniquement de l'eau de mer. L'expérience a commencé le 8/9/1997, considéré comme étant le jour zéro (J0). La fréquence des prélèvements, réalisés le matin à la même heure et dans 3 endroits différents, était journalière les 15 premiers jours pour déterminer la phase de latence, puis hebdomadaire jusqu'au 30/10/97 et après, mensuelle afin de suivre les variations quantitatives et qualitatives des populations qui se développent.

La température a été prise directement. La salinité a été mesurée par un salinomètre Beckman et le pH à l'aide d'un pHmètre modèle Mettler Delta 320. Les sels nutritifs ont été réalisés selon les méthodes classiques expliqués par (8) La biomasse phytoplanctonique a été estimée d'après les numérations cellulaires effectuées selon la méthode (9). Selon la densité des cellules, un certain volume d'eau allant de 1cc jusqu'à 100cc a été sédimenté.

Résultats et discussion

Les variations de la température dans les trois bassins ont présenté toutes à peu près la même allure et les températures ont varié entre 17°C et 24°C. Etant donné que l'expérience a été réalisée dans des bassins en verre à volumes limités, il est normal que les conditions météorologiques influencent le milieu. L'eau des bassins, prise directement de l'eau de mer, avait le jour zéro (J0) une salinité de 39‰. Au cours de l'expérience il y a eu une augmentation progressive de la salinité atteignant 51,277 ‰ due sûrement à l'évaporation après plusieurs jours d'ensoleillement, bien que la quantité d'eau prélevée pour l'échantillonnage ait été remplacée par l'eau de mer. Les valeurs du pH ont varié entre 7,91 et 9,43 dans B I à la fin de l'expérience. Au B III, le pH a augmenté durant la période de pluie. Le B I a présenté une variation du pH à peu près linéaire. Les concentrations des orthophosphates étaient de loin supérieures dans les deux bassins enrichis et atteignaient des valeurs de l'ordre de 56,25 μatg/l au J6 dans le B II. Au B III, les valeurs ont diminué pour atteindre des valeurs zéros à partir du J31. Les concentrations des nitrites étaient relativement faibles aux trois basins (entre 0 et 0.714μatg/L). L'ajout d'engrais dans B I et B II n'a pas assuré un apport suffisant de nitrates (maximum 1.57 μatg/L au B II le J31).

D'après les résultats obtenus du plancton, les remarques suivantes peuvent être avancées :

1- Le développement cellulaire a été rapide dans les deux premiers bassins (moins de 24h) et a atteint des valeurs relativement supérieures à celles observées dans le B III. 2) le bassin témoin a présenté une diversité spécifique très marquée (29 espèces contre 8). Il y a eu apparition, développement et dominance de certaines espèces différentes parfois dans chacun des 3 bassins. Il y a eu succession des populations commencant par des nanophycées petits (max. 10^8 et 10^{10} cell./L dans BI et BII), puis nanophycées grands (max.11 x 10^6, puis des diatomées, petites (absentes dans B III) puis grandes, pour finir presque avec les mêmes espèces dans les trois bassins. 3- Certaines espèces sont apparues seulement dans les bassins enrichis : *Cerataulina* sp. (max.61 x10^6 à J12 à I), Oxyrrhis marina (max. 19.5 x10^6 au J24 à I) et les ciliés de différentes tailles (max. 6 X10^6 à J5). 4- Certaines espèces ont abondées seulement au bassin témoin où il n'y a pas eu d'enrichissement : *Pseudonitzschia pseudodelicatissima* (max. 5 x10^6 cell./L), *Chaetoceros curvisetus, Ch. sociale, Leptocylindrus danicus, , Rhizosolenia delicatula, Gonyaulax hyalina*. 5-Certaines espèces sont apparues dans les trois bassins comme *Cylindrotheca closterium*, le chrysophycée *Mallomonas* sp. surtout au B III. *C. closterium* est présente durant toute l'année sur la côte libanaise, surtout en novembre et décembre sans former de grandes densités (1). 6-Une espèce toxique, le dinoflagellé *Amphidinium cartarae*, présente dans nos eaux (10), a fait une prolifération importante dans le bassin enrichi de fumure de poule (max. 28 x 10^6 à J18). D'autres dinoflagellés comme *Protoperidinium* sp et *Heterocapsa niei* ont fait leur apparition dans le bassin enrichi de fumure de chèvre. L'espèce *Amphora* sp. s'est développée dans le bassin enrichi de fumure de chèvre et B III. 7-Les dinoflagellés sont omniprésents dans les 3 bassins tout au long de l'expérience avec des valeurs de l'ordre 10^{10}, 10^8 et 10^6 successivement. 8- Certaines espèces, notées rarement dans le milieu naturel, ont présenté une prolifération importante comme le tribophycée *Rhizochloris* sp, trouvée dans les deux bassins enrichis et le chrysophycée *Meringosphera* sp, observé seulement dans le B III, entre J6 et J31 (maximum 205820 cellules/l). 9- Il faut signaler la présence de cyanophycées : *Nostoc spumigena* et *Spirulina subselsa*. Pour cette dernière, nous avons remarqué que les spirales sont devenues de plus en plus nouées avec l'augmentation de la salinité.

En conclusion générale, et vue la densité cellulaire, le nombre d'espèces et le développement d'une espèce toxique *Amphidinium carterae* (max.28 x10^6 cell.L au J18), l'enrichissement avec la fumure de chèvres s'est avéré meilleur que celui de la fumure de poules dans les conditions de l'expérience réalisée.

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DETERMINATION OF EFFECTIVE FISHING EFFORT IN A MEDITERRANEAN TRAWL FISHERY

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Abstract

The use of fishing effort limitations as a management tool should be based on a precise knowledge of their effects on fishing mortalities. The aim of this study was to develop an approach to analyse this relationship for Mediterranean hake and striped red mullet trawl fisheries. Thus, estimates of fishing effort directed to these species, by "métier", were obtained from a data base including disaggregated data on daily catches by boat covering a nine years period. They were related to fishing mortality values derived from VPA, showing significant correlations, which permitted to calculate for the first time in the area, catchability coefficients for both species.

Keywords: Fishing effort, trawl fisheries, Balearic islands

Material and methods

Fishing effort

One of the components of the fishing effort, the fleet capacity, was calculated from official fleet census. The second component, the fleet activity, was analysed by means of a relational database containing detailed information on weight and specific composition of daily landings by boat for the period 1983-1991. This database, built up from the receipts of daily sales realised in the central auction wharf of Palma, contains information on 40522 trips, divided over 294511 records including each one data on species name, vessel code, day of capture and landed weight. From the database was calculated the actual number of fishing days of all the fleet by year, which permitted to obtain realistic values of total nominal fishing effort (GRT*fishing days or HP*fishing days). Moreover, analysing the specific catch composition of each trip, it was possible to estimate the number of fishing days in which each considered species, hake or striped red mullet, were the target species. It was found that only the trips where the hake landings were >10Kg could be considered to be directed to hake, because lower values corresponded to hauls performed on slope grounds targeting red shrimp or on shallow shelf areas targeting red mullet. In the case of striped red mullet, due to its more restricted bathymetric distribution, it was considered that the presence in the landings of this species indicated that at least part of the effort was directed to this species. Data on vessels characteristics and the relative specific composition of their landings were analysed using clustering techniques (UPGA algorithm and Euclidean distances were considered), which permitted to split the fleet in three different "métiers". The weight of discards of commercial demersal species are negligible in this fishery, so landings data can be considered as representative of total catches and, subsequently, a good indicator of the exploited biocenosis.

Fishing mortalities

The fishing mortalities in the period 1980-1991 were estimated from VPA by using COHORT software programme ANACO (1). Partial fishing mortalities by "métier" were calculated as:

$F_{partial} = F_{total}\ C_{fleet}/C_{total}$; where F is total fishing mortality by year, C_{fleet} is the catch in weight by a "métier" and C_{total} is the total catch in weight

From the fishing mortalities and the catch number by age, a weighted global fishing mortality by year was calculated (2).

Results and conclusions

In general, no relationships were found between fishing mortality rates and fishing effort when effort was measured as total number of fishing days of the fleet, standardised either by vessel tonnage or HP. This was not a surprising result since most of Mediterranean trawl fleets are heterogeneous and they exploit several fishing grounds and target different species. So the total effort can be only considered as a nominal effort and not an effective effort measure, relevant in terms of fishing mortality rates of a single species. On the other hand, when the estimates of effort directed to each target species were used significant correlations between f and F were found.

For hake the best correlation (r^2=0,84) was obtained when estimates of fishing days targeting this species were standardised by the GRT of the fleet (Figure 1).

For striped red mullet the best estimate of effective effort was merely the number of trips targeting this species (Figure 2), with r^2=0,90. Including a dependency on either the tonnage or the HP gives a worse fit (r^2=0,84). This is due to the fact that smaller vessels use a type of gear which permits them to fish on hard bottom grounds where this species is mainly distributed, thus increasing their efficiency.

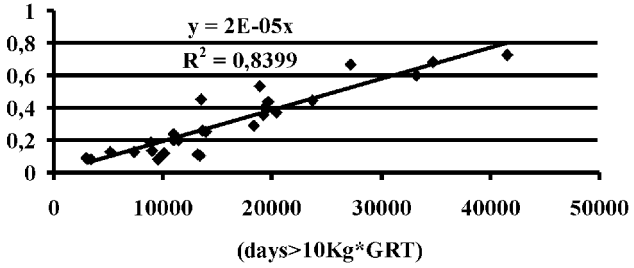

Figure 1.

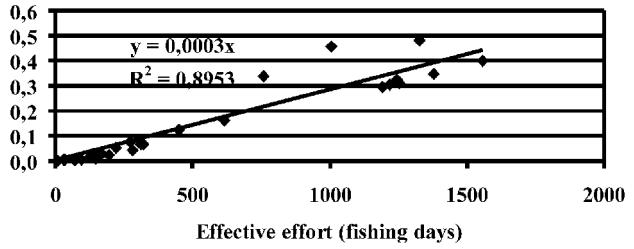

Figure 2.

The estimated catchability values for both species were 0,0003 for striped red mullet and 0,00002 for hake as can be seen in figures 1 and 2.

The main conclusion is that in the Mediterranean trawl fisheries, due to their multiespecific nature, management measures limiting the total effort of the fleets can fail in their objective of reducing fishing mortalities in single stocks. Thus, methods to identify the fleet components that really contribute to the effective effort exerted on each stock would be required.

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CYCLE SEXUEL DE *MYTILUS GALLOPROVINCIALIS* (MOLLUSQUE, BIVALVE) À LA LIMITE MÉRIDIONALE DE SON AIRE DE RÉPARTITION EN MÉDITERRANÉE

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Résumé

Le cycle sexuel de *Mytilus galloprovincialis* est étudié dans le lac de Bizerte (Tunisie) où la population se trouve à la limite méridionale de la répartition de l'espèce en Méditerranée. Il est caractérisé par une activité quasi-continue au cours de l'année, le repos sexuel étant limité aux mois de juillet et août. L'émission gamétique principale, enregistrée en décembre, est suivie par des restaurations gonadiques induisant des émissions gamétiques accessoires jusqu'à mai ou juin. Les conditions thermiques et nutritives du milieu favorisent l'activité sexuelle d'où l'expansion de l'espèce dans le Lac de Bizerte au-delà duquel les populations se raréfient pour disparaître totalement à environ 150 km, à la pointe du Cap Bon.

Mots-clés : Mollusca, Bivalves, Reproduction.

Au cours de la dernière décennie, le cycle sexuel de *M. galloprovincialis*, qui montre une très grande variabilité en fonction de la position géographique des populations, n'a été que peu étudié. Sur les côtes africaines, ces études ont concerné pour l'essentiel l'Afrique du sud (1) et l'Algérie (2, 3). En Tunisie, l'espèce se trouve sur les côtes nord et nord-est avec une densité maximale dans le lac de Bizerte. Bien que le cycle sexuel de cette dernière population ait été analysé par Lubet et *al*. (4), compte tenu de l'importance aquacole de ce Mytilidé et de sa situation en limite est de son aire de répartition naturelle, il nous a semblé intéressant de le réétudier. En effet, le développement important de l'urbanisation et de l'industrialisation dans la région et par conséquent les fluctuations de certains paramètres environnementaux sont susceptibles de modifier l'activité reproductrice de cette population soumise par exemple aux polluants métalliques venant des chantiers de construction navale et de la surcharge en matière organique provenant des principales agglomérations.

Matériel et méthodes

L'étude histologique a été réalisée mensuellement d'octobre 1994 à septembre 1996, sur un lot d'une trentaine d'individus, en provenance chacun de 3 stations différentes, et deux fois par mois durant les périodes de forte activité gonadique. Les techniques histologiques utilisées sont celles de Martoja (5). La richesse du milieu en nutriments, évaluée par la teneur en chlorophylle *a* (6) et la température, prise *in situ*, sont mesurées tous les 15 jours.

Résultats

Le cycle sexuel est caractérisé selon l'échelle proposée par Lubet (7) (tab.1). Il se déroule de manière similaire dans chaque station. L'activité gonadique débute en septembre et prend fin vers juin. Une émission gamétique principale est enregistrée en décembre. Les restaurations gonadiques qui la suivent sont d'amplitude plus ou moins grande et donnent lieu à de faibles émissions gamétiques. Le repos sexuel est limité, pour la majorité des individus, aux mois de juillet et août, et ne concerne pas toute la population (environ 5% des individus ne vident pas complètement leur gonade). Des différences entre les deux cycles sont observées mais n'affectent pas le modèle général de reproduction. On note une précocité de l'activité sexuelle la première année pour les stades I, II, III, IIIA1 et IIIA2. Le décalage par rapport au second cycle est plus réduit, en particulier pour les mâles, à partir du stade IIIB. L'écart devient moins important au stade IIIC mais conduit à la fin de l'activité, dès le mois de mai pour certains individus, caractérisant ainsi la seconde période par une précocité et un rallongement du stade de repos sexuel.

Tableau 1 : Succession des stades gonadiques au cours du cycle sexuel de *M. galloprovincialis* dans le lac de Bizerte durant les deux périodes d'étude.

Stade gonadique	1ère période (oct.1994-sep.95)	2ème période (oct.1995-sep.96)
Stade 0 : repos sexuel	A partir de début juin; juillet et août (majorité des individus)	de mai à fin août
Stade I : reprise de l'activité sexuelle	début à mi-septembre	fin septembre
Stade II : progression de la gamétogenèse	fin septembre	octobre
Stade III : période de reproduction		
IIIA1 : gamètes prématures	octobre	octobre à novembre
IIIA2 : gamètes matures	novembre à mi-décembre	novembre à décembre
B : émission des gamètes	de mi- à fin décembre	de fin décembre à janvier (mâles), février(femelles)
C : phase de restauration	de janvier à avril	de janvier à mars
D : fin du cycle annuel	mai	avril

Discussion

Seed and Suchanek (8) mettent en évidence la remarquable plasticité du genre *Mytilus* à ajuster sa stratégie de reproduction en fonction des conditions de l'environnement. Cependant, nous observons que les variations des paramètres physico-chimiques n'influencent pas au cours d'une même année, la succession des différents stades sexuels dans les 3 stations. L'action des facteurs du milieu s'effectuerait à plus grande échelle, par suite de variations importantes touchant une même population ou suivant la latitude. Le premier argument peut être conforté par la comparaison de nos résultats avec ceux de Lubet *et al*. (4). Ces travaux mettent en évidence une durée de repos sexuel de 3 mois (juillet, août et septembre), alors que la reprise de l'activité sexuelle (stade I) est enregistrée dans notre cas, dès septembre. Le décalage entre les études se maintient au cours des stades IIIA1, IIIA2 et IIIB. Il est réduit durant les stades IIIC et IIIA2. Les périodes de déroulement du stade IIID sont similaires avec les nôtres aux cours du 1er cycle (mi-mai à fin mai) mais ce stade est plus précoce durant le 2ème cycle (fin mars à fin avril). La température de l'eau, dans les 3 stations, varie entre 11,1°C et 28,2°C. Le pic d'émission gamétique observé au mois de décembre, correspond à une période au cours de laquelle la température enregistrée est de l'ordre de 15 °C. Les températures relevées atteignent, pendant la période d'activité sexuelle, les valeurs maximales de 21°C à 21,1°C en mai 1996 permettant de maintenir une activité gonadique bien qu'elles se situent en dehors de la limite supérieure de la zone thermique sensible de gamétogenèse (18-20 °C) définie par Lubet et Aloui (9). Ces fortes températures dépassant les limites thermiques supérieures dès mai, alors que celles-ci ne sont normalement atteintes qu'en juin durant la première période, expliquent la précocité du repos sexuel au cours de la deuxième période d'étude. Les températures élevées du lac de Bizerte sont favorables au déroulement des processus de gamétogenèse. Le fait que les limites inférieures de température (5,5 à 8°C) ne soient jamais atteintes, expliquerait non seulement le maintien sur plusieurs mois de l'activité sexuelle mais aussi l'importance des phases de rematuration. Parmi les facteurs influençant la reproduction, la disponibilité des nutriments joue, selon de nombreux auteurs (6, 10) un rôle important du fait qu'il existe chez les Mytilidés une corrélation significative entre le développement du tissu de réserve, sa richesse en glycogène et l'intensité de l'effort de reproduction. A ce propos, Lorenzen (6) note chez *M. edulis* des émissions gamétiques répétées sur plusieurs mois dans les zones à haute productivité primaire. Les eaux du lac sont caractérisées par une teneur relativement élevée de chlorophylle *a* durant toute l'année. Les moyennes enregistrées sur les deux périodes d'étude montrent une teneur significativement plus importante dans certains sites : 1,14 mg/ m^3 ± 0,57, par rapport à d'autres : 0,73 mg/m^3 ± 0,34. Même si Lubet *et al*. (4) ne font pas état de la teneur en chlorophylle a du milieu, il est certain que la pollution d'origine industrielle et urbaine s'est accentuée ces dernières années et a eu pour conséquence l'enrichissement du milieu en matières organiques, ce qui pourrait expliquer les variations du cycle sexuel depuis leurs travaux. Les moules du lac de Bizerte trouvent la quantité de nourriture et la température nécessaires au maintien de l'activité sexuelle durant presque toute l'année. De plus, les températures élevées de ces eaux stimuleraient la reminéralisation des matières organiques et favoriseraient la production primaire disponible pour les bivalves. Les Mytilidés possèdent une grande aptitude à adapter leur cycle reproducteur aux fluctuations des conditions externes (7). Les différences que nous observons d'une part, entre les 2 périodes étudiées et, d'autre part, par rapport aux résultats de Lubet at al. (4) montrent que *M. galloprovincialis* est en mesure d'ajuster ses besoins physiologiques aux fluctuations environnementales à l'échelle annuelle, au sein d'une même population, et à long terme, par suite de variations importantes des conditions du milieu et en particulier l'enrichissement du milieu en nutriments. Ces apports d'origine anthropique pourraient, jusqu'à un certain seuil, améliorer les conditions physiologiques des moules et compenser l'action du stress imposé par les variations des conditions du milieu (11). Cette compensation ne se fait que dans certaines limites de température et dans des conditions trophiques particulières telles que celles qui prévalent dans le lac de Bizerte. *M. galloprovincialis* s'adapte aux conditions du milieu et maintient l'effort de reproduction malgré des températures supérieures à 19°C sur plus de la moitié de l'année, alors que celles-ci constituent des facteurs limitants de l'extension de l'espèce vers le sud (12). L'intense activité sexuelle et l'importance des émissions gamétiques est une stratégie offrant la possibilité aux larves de trouver des conditions favorables à leur survie sur une période très étendue. Par ailleurs, les conditions moins favorables de teneurs de milieux en matières nutritives, notamment en mer ouverte, en dehors du Lac de Bizerte, ainsi que l'augmentation de la température plus au sud de la Tunisie semblent constituer des limites à l'expansion de l'espèce au-delà du Cap Bon.

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PROTECTION OF THE MEDITERRANEAN MONK SEAL (*MONACHUS MONACHUS*) AND ITS HABITATS

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Abstract

The Mediterranean Monk Seal (*Monachus monachus*, Hermann 1779) is one of the world's most endangered mammals. Our research was aimed at: obtaining information from the local fishermen in the Croatian and Albanian part of the Adriatic Sea and of the Ionic Sea on sightings of the Mediterranean monk seal, and investigating its habitats in these areas. We have investigated 19 habitats in the Reza e Kanalit area of the Ionic Sea and 18 habitats in the Vis archipelago in the Adriatic Sea. Legislative measures for the protection of the Mediterranean monk seal were not adequately effective to enable preservation of this species in the Adriatic and Ionian sea .

Keywords: Adriatic Sea, Ionian Sea, islands

Introduction

The Mediterranean monk seal (*Monachus monachus* Hermann, 1779) used to be wide spread throughout the Adriatic Sea but today is very rare in this area (1). It is presumed that 350 specimens are present in the Mediterranean area. Only a few individual specimens were observed recently, passing by the outermost Croatian islands. Biology and population ecology of this endangered marine mammal in the Croatian part of the Adriatic Sea have not been extensively studied (2).

The aim of this study was to investigate habitats known to have been visited by the Mediterranean monk seal in the Adriatic and Ionian Sea. The local fishermen are an important source of information on the presence of the monk seal and its habitats. This study includes important data for evaluation of habitats in natural caves and beaches which might be used by the Mediterranean monk seal. We expect that this investigation will contribute to the protection of the Mediterranean monk seal and its habitats, increase of awareness of the importance of this action and provide general knowledge on this topic.

Materials and methods

Two approaches were used in this investigation. The first was interview with the local fishermen and the second included examination and measurements of the monk seal habitats. It was necessary to conduct a carefully planed interview according to a specific questionnaire with the local fishermen, 40 or more years of age, in selected areas of the Adriatic and Ionian sea. The interview was aimed at obtaining reliable information on sightings of the monk seal, number of specimens observed, number of fishermen involved on that occasion, behaviour of the monk seal, extent of damage on the fishing gear caused by the monk seal, and fishermen's attitude toward the monk seal. The interviewing comprised 44 fishermen from Komiza, island of Vis.

The interview provided also information on known habitats of the monk seal in these areas. These sites were visited and examined in the Vis archipelago and Ionian Sea, Rreza E Kanaliti, in the period 1994 -1999.

Some of the habitats i.e. caves had entrances below sea level which required diving. Measurements were taken and maps of caves created according to speleological methods. The caves were also photographed, and entrance exposure determined by compass.

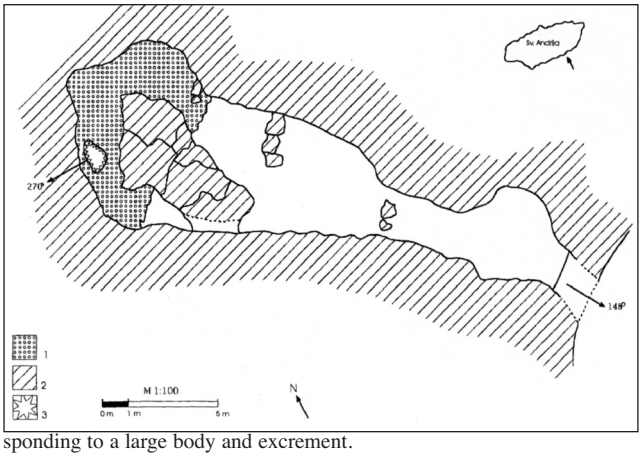
Caves were inspected for signs of monk seal's presence e.g. impressions of a large body in sand, smell of urine and findings of faeces which could originate from the monk seal.

Results and discussion

According to the reports on sightings received and interviews with the fishermen the Mediterranean monk seal is only rarely present in the Vis archipelago in the last two decades. Conditions were not always in favour of the Mediterranean monk seal and its habitation requirements. The island population and its dependence upon fishing has decreased, but the marine traffic has intensified. Major obstacles for the return of the Mediterranean monk seal are not only reduction in the amount of fish but rather lack of ecological consciousness, public awareness and most of all very intensive marine traffic.

This study comprised examination of 18 caves and 2 shingle beaches in the Vis archipelago in the Adriatic and 19 caves in the Reza E Kanalit region in the Ionian Sea. The habitats indicated by the fishermen during the interviews are mostly secluded flat rocks or shingle beaches surround by steep rocks. Most of these caves were formed in dolomite and limestone during Flandrian transgression, partly flooded by sea, and shaped by collapsing and sea erosion (Fig 1).

The entrances to the caves were from land, at or below the sea level, depending on the location. Caves in the Reza E Kanaliti region mostly have entrances at sea level or from beaches. The entrances are mostly protected from direct sunlight and wind, with south-west, south-east and northern exposure. The air temperature was similar in all caves at that time of the year and with abundant light. Clear evidence of the presence of the monk seal was found in some caves i.e. impressions in the sand corresponding to a large body and excrement.



Map of the cave Tovorski bod, island of Sveti Andrija in the Vis archipelago (ground plan *- a, cross-section - b). The legend indicates: 1 = shingle beach, 2 = limestone flat rock, 3 = entrance from land.*

No human settlements were located in the vicinity of the investigated caves and can thus be considered as possible habitats for the return of the monk seal. None of the habitats investigated have been changed due to human activity or earthquake. The shingle beaches are less suitable due to increased marine traffic, and would need to be protected as marine parks.

Conclusions

The investigated areas of the Vis archipelago and Reza E Kanaliti have well preserved former habitats of the monk seal. There is also evidence of its presence in the past and occasional sightings recently in this area. This points to favourable environmental conditions for the return and repopulating of the Mediterranean monk seal in this region.

Nevertheless, measures for protection of the monk seal and its habitats need to be more closely conducted and controlled, including continuous efforts oriented towards education of the local population on the problem of this endangered species.

Acknowledgement

This research would not be possible without the support and full collaboration of the local fishermen.The authors gratefully acknowledge the assistance of Vlado Antolovic for help during field research.

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VARIABILITE STRUCTURALE DE LA RATE CHEZ LE MULET (*MUGIL CEPHALUS*) DU LAC ICHKEUL

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Résumé

L'étude histologique de la rate chez 88 individus de mulet (*Mugil cephalus*) prélevés au lac Ichkeul pendant une période de 2 ans a permis pour la première fois de classer en trois groupes les poissons en fonction du nombre d'agrégats de mélanomacrophages. Le groupe qui contient le plus d'agrégats correspond aux poissons de taille supérieure à 40cm. Par ailleurs, cette étude a montré que le nombre d'agrégats de mélanomacrophages n'est pas associé aux variations saisonnières de la température et de la salinité de l'eau, à la période de reproduction et au sexe du mulet.

Mots clés: Physiology, Bio-indicators

Introduction

L'étude histologique des organes lymphoïdes est une approche fréquemment utilisée chez les poissons pour étudier les effets des facteurs immuno-modulateurs notamment des xénobiotiques sur les réponses immunes non spécifiques (1).

Dans ce travail, nous avons abordé l'étude des variations saisonnières de la température et de la salinité de l'eau sur la structure de la rate. En particulier de vérifier le nombre de centres ou d'agrégats de mélanomacrophages chez chaque individu de poisson. Par ailleurs, nous avons analysé les résultats en fonction de la taille, de la période de reproduction et du sexe des mulets.

L'étude a duré deux ans (de Mai 1997 à Juin 1999) et a concerné une espèce de mulet (*Mugil cephalus*) qui vit en abondance dans le lac Ichkeul au nord de la Tunisie. Ce milieu lagunaire très fragile, est très sensible aux variations des conditions climatiques (2) ce qui justifie le choix de la température et de la salinité dans notre étude.

Matériel et méthodes

L'échantillonnage des poissons a été le plus souvent mensuel. A chaque campagne, nous avons prélevé du lac Ichkeul quatre mulets (*Mugil cephalus*). Sur chaque individu, nous avons déterminé la longueur totale , le sexe et nous avons prélevé la rate pour effectuer une étude histologique. Nous avons utilisé le liquide de Bouin pour fixer les organes et les coupes histologiques ont été colorées à l'Hémalun Eosine (3). Enfin, nous avons également mesuré la température et la salinité de l'eau dans le lac.

Résultats et conclusions

L'examen des coupes histologiques au microscope nous a permis pour la première fois de classer les individus de l'échantillon en trois groupes:

- groupe d'individus présentant un nombre relativement important de petits centre mélanomacrophages (entre 20 et 30 par surface de coupe). Ce groupe représente 28% de l'échantillon.

- groupe d'individus ayant un nombre relativement moyen de petits centres mélanomacrophages (entre 6 et 19 par surface de coupe). Il représente 37% de l'échantillon.

- groupe d'individus possédant un nombre relativement faible de petits centres mélanomacrophages (2 à 5 par surface de coupe) et correspond à 35% de l'échantillon.

Des travaux antérieurs ont mis en évidence un rapport entre le nombre d'agrégats de mélanomacrophages et d'autres facteurs. Ainsi, il a été constaté (4, 5, 6) que le nombre d'agrégats augmente avec l'âge, la taille et l'état de santé des poissons. De même , il a été montré (7) que l'immunisation du poisson rouge augmente la taille et le nombre d'agrégats de mélanomacrophages. D'autres travaux ont prouvé que les polluants interviennent aussi mais leurs effets sont variables. Ainsi, selon leur nature il y a soit une augmentation soit une diminution du nombre d'agrégats de mélanomacrophages (8, 9, 1).

En analysant les résultats de notre étude, nous constatons que le facteur saison avec toutes ses caractéristiques de température et de salinité n' a pas d'effets sur le nombre d'agrégats de mélanomacrophages chez *Mugil cephalus*. En effet, à chaque saison on retrouve pratiquement les trois groupes d'individus avec des proportions équivalentes ce qui signifie que le nombre d'agrégats de mélanomacrophages ne constitue pas un indicateur immunologique pour les variations de température et de salinité. Cependant, nous avons remarqué que tous les individus qui présentent un nombre élevé de petits agrégats de mélanomacrophages ont une taille supérieure à 40 cm à l'exception de l'individu n°1 de la campagne du 2/6/99 (tableau 1). Ce résultat concorde avec les données bibliographiques mentionnées plus haut. Concernant les deux autres groupes d'individus, la taille est très fluctuante et n'est pas liée au nombre d'agrégats ce qui suppose l'intervention d'autres facteurs. Par ailleurs, d'autres travaux (6) ont aussi montré que pendant la période de frai, le nombre d'agrégats de mélanomacrophages augmente dans la rate. Dans le cas de notre étude, nous n'avons pas remarqué une telle relation chez le mulet. En effet, le nombre d'agrégats ne corrèle ni avec la période de reproduction (de juillet à octobre) ni avec le sexe de ce poisson.

Tableau 1 - Taille et sexe des individus présentant un nombre important de petits agrégats de mélanomacrophages.

Date de prélèvement	N° des individus	Taille des individus (cm)	ntervalle l de taille (cm)	Taille moyenne (cm)	Sexe (m ou f)
28/5/97	10	40	34 - 46	41,11 ± 2,10	f
26/6/97	8	43,5	34 - 46	41,46 ± 1,92	f
28/7/97	1 ; 8 ; 11	42 ;41,5 ;44,5	41,5 – 46,5	43,46 ± 0,89	m; m;m
28/8/97	1	46,5	33,5 – 46,5	42,33 ± 2,09	f
24/9/97	5	42,5	34 - 49	41,93 ± 2,63	m
13/1/98	2	43,5	30 - 48	37,72 ± 4,57	f
2/9/98	1	44,5	39 - 49	43,36 ± 1,93	m
2/5/99	6	40	32 - 57	45,14 ± 7,55	f
2/6/99	1	27	27 - 58	46,80 ± 5,1	f

m : mâle ; f : femelle

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FLUCTUATIONS IN SPACE AND TIME OF PELAGIC POPULATIONS IN THE NORTH ADRIATIC SEA FROM 1976 TO 1998

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Abstract
The intent of this paper is to discuss some problems that have arisen from the spatial and temporal variability of small pelagic fish in the North Adriatic Sea during the period 1976-1998. This variability can be attributed to variations in physical factors (in this paper surface temperature is considered) acting on these resources in many compound ways, to fishery, and to the internal complexity of the pelagic system.

Keywords: Acoustics, Adriatic Sea, Biomass, Pelagic, Temperature

Introduction
With an acoustic methodology and technology it's possible to examine the trend of the pelagic density through the years and its spatial structure relative to the period of the echo-survey. It may be of extreme importance for fishery to know if biomass fluctuations are periodical and related to its spatial structure. The data of surface temperature can be used together with the biomass' data to see if this physical factor can influence the fish distribution.

Material and methods
The data on the biomass of small pelagic fish and its spatial distribution were collected with acoustic methodologies and technologies. Biological data (fish demography) were acquired from net samplings. Surface temperature data (SST) were obtained from satellite [1]. All data were processed using the GFRDBS (Geographical Fishery Resources Data Base System) SW package designed by the IRPEM acoustic team [2]. GFRDBS processes the data in a geographical context, converting Lat&Lon into X&Y coordinates. The Elementary Sampling Distance Unit (ESDU) of the X, Y map is one nautical mile.

The object of this study is the North Adriatic Sea, which extends from Trieste to S. Benedetto del Tronto, from the Italian coast to the Mid-Line. It has been investigated annually, in summer-autumn, since 1976 [3][4].

Results and discussion
One basic issue is the stability of the pelagic biomass and of its species composition. Figure 1a shows the trend from 1976 to 1998 of the biomass of pelagic populations as a whole.

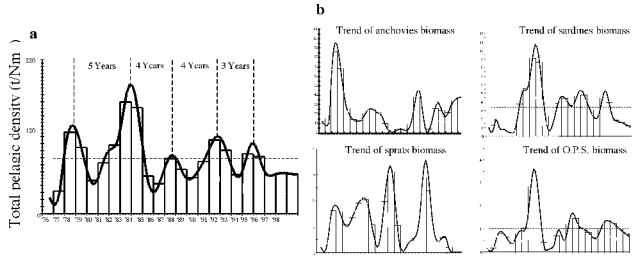


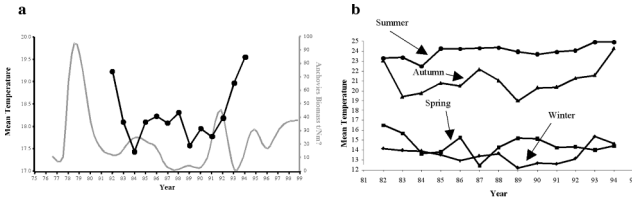
Fig. 1. a. Fluctuation of pelagic biomass as a whole in the North Adriatic Sea. b. Trend of pelagic populations in the North Adriaric Sea

Data indicate that the total pelagic biomass fluctuated in a nearly periodic way. The highest peaks (130 and 190 t/nm^2, observed in 1978 and 1983, respectively) and the longest periods of fluctuation (around 5 years) occurred before 1985. After 1985 the peaks become smaller (85, 110 and 100 t/nm^2) and, accordingly, the fluctuation periods seem to shorten (1987; 1991; 1994). The mean ratio of the maximum level to the minimum one is around 4. Mean biomass density from 1976 to 1998 in the North Adriatic was estimated to be 78 t/nm^2 (i.e. 25%). In Figure 1b the total biomass was divided into four groups: Anchovies, Sardines; Sprats and Other Pelagic Populations (mainly *Scomber scomber, Trachurus trachurus*).

The biomass changes of single populations were not regular. In particular, the anchovy stock reached the maximum peak in 1978-79, it collapsed in 1987-89 and ten years later (1996) began to recover. The ratio between the maximum and minimum level was around 20. Mean density of the anchovy stock was estimated as 23.5 t/Nm^2. By contrast, the sardine stock showed a minimum around 1978, and the highest peak in 1982-83 followed by a period of stability (1985-1996). The ratio between the maximum and minimum level was very similar to that of Anchovy (25). Mean density was calculated as 33.4 t/Nm^2. The other species (sprats, mean density 12.6 t/Nm^2; other pelagic species, mean density 9.8 t/Nm^2) showed very irregular changes. It could therefore be concluded that the pelagic biomass as a whole fluctuates almost regularly, whereas its composition is affected by drastic and unpredictable changes. Moreover, there is evidence of possible interactions between species such as anchovies-sardines and sprats-anchovies.

A second basic question about pelagic resources is their spatial structure and distribution, which for fisheries management may be more important than the simple measurement of total biomass.

Generally, the basic spatial structure of pelagic populations is patchiness, irrespective of the abundance of biomass. However, the surveys indicate a contraction of the patches towards the coast in the period when the anchovy stock collapsed (1986-90) and their expansion towards the open sea when the stock recovered (from 1994). In the period 1992-1994, a movement of the anchovy stock from the North to the South Adriatic was observed. Unusual migrations of sprat from North to Middle Adriatic (1987 and 1993) and as far as to the South Adriatic (1994) were also detected. Figure 2a shows the trend of mean annual surface temperature (SST) over the whole Adriatic Sea and Figure 2b the seasonal trend of the same parameter in the period 1982-1996 [5].



Although there does not appear to be any direct, clear-cut relationship between biomass and climate variations, one observation can be made. The minimum values recorded in spring (1987), summer (1984), autumn and winter (1989) temperatures as well as the fall of annual mean temperature all coincided with the collapse of the anchovy stock (1986-1990). These two phenomena might thus be related in some way.

Conclusion
The central result of this study, relevant also to management, is the temporal and spatial changes of the pelagic biomass as a whole and per species. The fluctuations in time of the pelagic biomass as a whole seem fairly regular and pretty limited; in regard to the single species there is a range of variation much larger and strongly irregular both in time and in space. The fluctuation in space seem to be related, beside to alterations in migration habit, to the biomass abundance. The fluctuations in time have been dramatic for Anchovy (collapse of 1987), and very large for the other species under examination. As an initial simplification the fall of Anchovy stock in the period 1986-1990 have been attributed to the decrease of the surface temperature that could have affected the recruitment. However the appropriate management of these resources requires greater knowledge of how and to what extent the variations in space and time of the single populations can be affected by internal factors (interactions between species), external conditions (climatic variations), predation and fisheries management.

Acknowledgements.
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BIOMASS ESTIMATES OF THE TRANSPARENT GOBY STOCK IN THE NORTHERN TYRRHENIAN SEA

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Abstract

The transparent goby is fished in Italy by nearby 400 boats with trawl or purse seine nets and can produce an annual yields over 70 tons. It is one of the most valuable target species of the artisanal fishery in wintertime. In Tuscany 50 boats operates in wintertime with the purse seine on this species and daily catch and effort data are available for the last 10 years. Depletion models suggest that, even if stock abundance is fairly stable, catches can fluctuate because of changes in recruitment timing.

Keywords : stock assessment, biomass, fisheries, models, Tyrrhenian Sea

Introduction

The transparent goby *Aphia minuta* is fished with an artisanal gear and represents a typical single-species fishery. This small fish, less than 6 cm long, is traded similarly to the frylings of anchovies and sardines, but while the catches of these small pelagics came out from stocks which are mainly exploited later on in the adult stages, the goby lives only one year and it can be fished only in the 0+ age class.

Because of the relevant economic value of the Italian production (more than 1.5 million EURO's a year), several research programs have been carried out in the recent years (1,2,3,4).

A. minuta is strictly coastal and lives spottily on sandy-muddy bottoms mainly at depths less than 20-30 m. After the hatching of benthic eggs, planktonic larvae attain in few months the size of 15-20 mm and recruits near the bottom. In this stadium, up to 35 mm, they concentate in abundant and relatively compact shoals, which can be detected with the echo-sounder and captured with the purse seine. From 35 to 50 mm, when gonads maturate, the transparent goby moves closer to the bottom, and became vulnerable to the trawl net. By the end of this period, immediately after the reproduction, they die, and hence the whole life cycle of the species doesn't last more than one year. The recruitment of *A. minuta* can extend from the spring to the autumn, but with extremely varying intensity, sometimes concentrated in spring and in other years with summer-autumn peaks (5).

In Tuscany, the transparent goby fishery with the purse seine is relevant for about 50 boats with an average GRT of 6.5 tons and power of 68 kW.

Materials and methods

When a fish stock (in closed zones such as lakes or rivers) is intensely fished, in a relatively short period of time and with a noticeable decrease of its abundance, the classical depletion method of Leslie - De Lury (6) can be applied. This is a simple regression of CPUE (i.e. kg/day/boat) and the cumulative catch (kg): the intercept on the X axis represents the stock size at the beginning of the fishing period. This approach was also used in open sea, mainly for short living species such as cephalopods and the same *A. minuta* (7,8). Since in Tuscany the licenses are linked to the compilation of recording sheets by the fishermen, the daily catch for each boat of the fleet was recorded since 1989.

Results and discussion

The legal fishing season begins in November and concludes in April: operative boats can vary from 20 to 45 each month. The yearly fishing effort of the whole fleet is however fairly constant (around 1000 daily trips) but catch rates are highly variable (from a couple of kilograms up to half a ton/day/boat) and globally they can vary between 29 tons/year (in 1992-93 season) and 9 tons/year (in 1994-95).

The depletion model applied to the Tuscany area suggest for each year the presence of a fairly stable stock, between 40 and 60 tons. The higher CPUE (at the beginning of the fishing season) can range from around 40 kg/boat/day (Fig.1) down to 10-20 kg/boat/day (Fig.2), but such noticeable fluctuations in the catch time series have also been reported from other authors (7).

In order to link the annual steady standing stock with the variable catches, the structure of the Tuscany transparent goby stock was implemented into a dynamic model which simulates the population growth and exploitation through the year (5). When the recruitment is concentrated during the spring, in autumn most of the population has already gone beyond the vulnerable size for the purse seine and the commercial catches will be very low. Massive recruitment in the summer-autumn period is instead most profitable for the commercial fishing, whereas in the fishing season the gobies reach the size of 20-35 mm, for which the seine catches are elevated. Nevertheless the stock size can be assessed every year around 50 tons, even if more precise estimates of the effort are needed (e.g. taking into account engine power, net size, boat efficiency, etc).

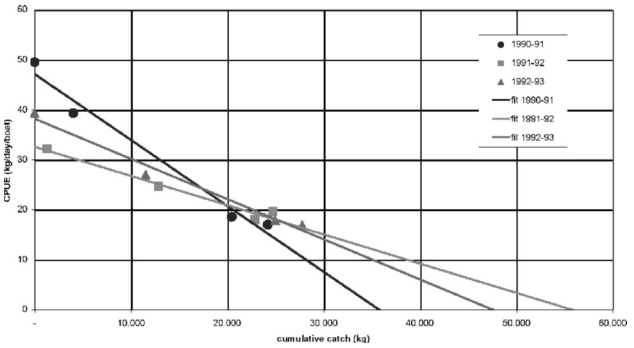

Fig. 1 - Depletion models from 1990 to 1993

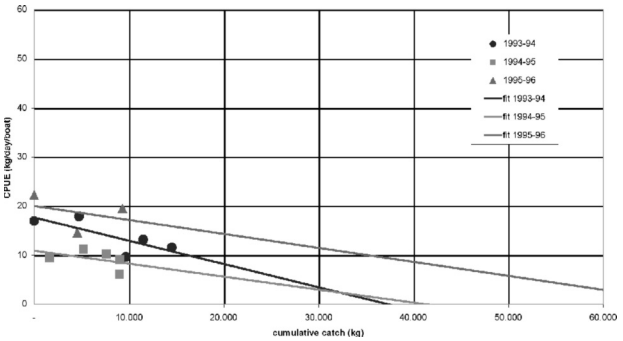

Fig. 2 - Depletion models from 1993 to 1996

In conclusion this single-gear and single-species fishing activity in Tuscany indicates that commercial yield is lower than half of the standing stock in the sea, and so a policy of licenses regulation to the actual number seems a enough to assure the fishery sustainability.

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CATCH COMPOSITION AND ABUNDANCE OF ELASMOBRANCHS BASED ON THE MEDITS PROGRAM

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Abstract

Species composition and distribution from international trawl surveys are analysed in relation to geographical areas and depth. Data were gathered in six campaigns carried out in 1994-99 along the whole European Mediterranean coasts with standardised gear and methodology. Depths from 10 to 800 m were explored. For fortyfive species, the biomass indexes, standing stocks and frequencies of occurrence are reported.

Keywords : elasmobranchii, trawl surveys, demersal, stock assessment, biomass

Sharks and rays occupy, an high level in the trophic webs and are characterised by a K strategy (1). This determines an high sensibility to even relatively low fishing pressure (2), but in the Mediterranean very few assessments and standardised data are available (3,4).

Material and methods

Six bottom trawl surveys, from Alboran to Aegean Sea, were carried out between April and June (1994–99) within the MEDITS International program (5). Biomass indices (BI; kg/km^2) and standing stocks (swept area method assuming a full catchability) were estimated from the database produced by IFREMER. The BI were referred to 4 arbitrary geographical areas identified by using a land-oriented criterion: *Western* (*WA*; Morocco, Spain and France coasts), *Western Central* (*WCA*; Tyrrhenian, Corsica, Sardinia and Sicily coasts), *Eastern Central* (*ECA*; Adriatic, Ionian and Albanian), and *Eastern* (*EA*; Aegean Sea). The BI by dept strata were pooled in 4 levels (– = less than 0.1, + = between 0.1 and1, o = between 1 and 10, O = more than 10 kg/km^2).

Results and discussion

Overall, 6336 tows were performed and 45 species of elasmobranchs identified (Tab.1) : 18 sharks, 2 angelsharks, 4 stingrays, 3 skates, 14 rays, 3 electric rays and 1 rabbitfish. Single or sporadic captures were recorded e.g. for *Dasyatis violacea, Hexanchus griseus, Mustelus asterias, Raja batis*. For some species, these figures reflect a true rarity (*Rhinoptera marginata*) or population reduction (*Squatina spp*.), but in other cases (*Galeus atlanticus*) some misclassification problem cannot be excluded.

Scyliorhinus canicula, Raja clavata, Galeus melastomus and *Squalus acanthias* showed both high occurrence (>5% of the hauls) and abundance (> 10 kg/km^2 or > 10% of relative biomass). Three faunistic groups can be identified in regard to depth distribution : *a)* well represented on all depths such as *R. clavata* and *S. canicula*; *b)* with preference for the shelf such as *Dasyatis pastinaca* and *M. mustelus* and *c)* for the slope such as *C. granulosus* and *Etmopterus spinax*. Only an handful of species have abundance levels of practical interest and just some are actually commercialised, but the large-sized species (*Mustelus* and *Squalus spp*.) show signs of depletion although it were evidenced zones of relatively high density (likely dangerous hauls usually not explored by fishermen). From the geographical point of view, some species are abundant in all areas (*S. canicula, R. clavata, Torpedo marmorata, R. asterias, C. monstrosa*), while others are most common in the west (*T. nobiliana, R. alba, Oxynotus centrina*) or in the east (*S. acantias, R. radula, R. naevus, R. brachiura*); some species are localised into restricted areas (*Hexachus griseus* and *Raja miraletus* in the Tyrrhenian, *M. mustelus* in the Adriatic Sea, or *R. brachiura* and *R. undulata* in the Aegean Sea). Globally speaking the eastern basins (Adriatic and Aegean Seas) show higher standing stocks, mainly due to the wider continental shelf. The good catches of *R. clavata*, the most abundant ray in the Mediterranean, seems to reflect mainly an higher ecological performance than a true resilience to exploitation; in fact, concentrations (up to 100 kg/km^2) likely closer to the "virgin" conditions are found only locally in the Gulf of Lion, Corsica, Sardinia and Greece waters. It is worth noting that up 64% of the total biomass is located in the Aegean Sea, where trawling deeper than 400 m is practically absent. These preliminary results are only a first step toward a future assessment aimed at the management of the elasmobranchs stocks. Nevertheless, also the analysis of MEDITS data evidences clear signs of sufferance for most of sharks and rays and the risks of local extinction for some once common species (*Squatina spp*.).

Tab.1 – List of the elasmobranchs species caught in the MEDITS surveys, their occurrence, biomass, depth distribution and densities.

Species	Frequency of occurence		Standing stock biomass positive		Depth distribution (m)					biomass index by geographical area (kg/km^2)				
	hauls	%	tons	%	0-50	50-100	100-200	200-500	500-800	WA	WCA	ECA	EA	Overall
Centrophorus granulosus	116	2%	1528	3%		-		o	O	2,7	5,5	0,1	3,1	**2,9**
Centrophorus uyato	19	0%	318	1%		-		+	o	1,0	1,7			**0,6**
Chimaera monstrosa	524	8%	2056	4%			-	o	O	8,5	3,3	1,4	4,5	**4,0**
Dalatias licha	152	2%	780	1%				+	o	3,3	2,8	0,8	0,2	**1,5**
Dasyatis centroura	1	0%	6	0%	+							0,0		**0,0**
Dasyatis pastinaca	49	1%	778	1%	o	o	+			0,1	2,9	0,2	1,9	**1,5**
Dasyatis tortonesi	2	0%	24	0%		+	+						0,1	**0,0**
Dasyatis violacea	2	0%	5	0%	+	-				0,0	0,0			**0,0**
Etmopterus spinax	1173	19%	2248	4%			+	o	o	9,2	6,5	0,9	3,1	**4,3**
Galeorhinus galeus	5	0%	126	0%	+	-		+	+	0,1	0,2	0,1	0,4	**0,2**
Galeus atlanticus	1	0%	1	0%					-	0,0				**0,0**
Galeus melastomus	1702	27%	6891	12%			+	O	O	48,5	16,7	3,0	3,3	**13,3**
Heptranchias perlo	12	0%	723	1%			+	o	o	0,7	3,9		0,7	**1,4**
Hexanchus griseus	12	0%	440	1%		-		+	o	0,0	3,1			**0,8**
Hexanchus vitulus	1	0%	49	0%				+					0,3	**0,1**
Mustelus asterias	5	0%	87	0%	+	+						0,7		**0,2**
Mustelus mustelus	111	2%	2645	5%	O	o	+	+	+	0,1	1,1	18,7	0,3	**5,1**
Mustelus punctulatus	1	0%	2	0%		-						0,0		**0,0**
Myliobatis aquila	37	1%	626	1%	o	+					0,3	4,3	0,1	**1,2**
Oxynotus centrina	36	1%	380	1%		+	o	+	+	0,6	1,9		0,4	**0,7**
Raja alba	9	0%	125	0%	-		o	-	-		0,8		0,0	**0,2**
Raja asterias	252	4%	1575	3%	o	o	o	o	+	2,2	3,5	1,3	4,4	**3,0**
Raja batis	2	0%	14	0%		+			-	0,2	0,0			**0,0**
Raja brachyura	21	0%	532	1%	+	+	o	o	-		0,4		2,8	**1,0**
Raja circularis	12	0%	29	0%		-		-	+	0,2	0,0	0,1		**0,1**
Raja clavata	1000	16%	8151	15%	o	O	O	O	o	4,6	14,9	7,9	27,0	**15,7**
Raja fullonica	7	0%	3	0%				-	-		0,0	0,0	0,0	**0,0**
Raja melitensis	20	0%	705	1%		+	+	o	o		4,9		0,0	**1,4**
Raja miraletus	422	7%	1729	3%	o	o	o	o	-	1,3	6,4	2,0	2,7	**3,3**
Raja montagui	107	2%	882	2%	+	+	o	o	-	0,9	2,4	0,1	2,7	**1,7**
Raja naevus	42	1%	348	1%	+	+	o	+		0,3	0,0	0,1	1,8	**0,7**
Raja oxyrinchus	301	5%	1899	3%		+	o	O	o	1,0	8,1	0,3	3,7	**3,7**
Raja polystigma	171	3%	568	1%	o	o	o	o		2,4	2,6	0,0	0,2	**1,1**
Raja radula	21	0%	181	0%	o	+	+				0,0	0,2	0,9	**0,3**
Raja undulata	6	0%	13	0%	+	-	-						0,1	**0,0**
Rhinoptera marginata	2	0%	1	0%		-						0,0		**0,0**
Scyliorhinus canicula	1761	28%	8396	15%	o	O	O	O	o	19,3	14,4	11,8	19,8	**16,2**
Scyliorhinus stellaris	34	1%	301	1%	+	o	+	+	+		0,7	1,2	0,2	**0,6**
Squalus acanthias	327	5%	6682	12%	O	o	o	O	o	0,3	1,2	31,3	14,1	**12,9**
Squalus blainvillei	196	3%	1490	3%	+	+	o	o	+		6,6	1,3	2,1	**2,9**
Squatina aculeata	1	0%	0,3	0%				-					0,0	**0,0**
Squatina squatina	2	0%	14	0%		+		-			0,1			**0,0**
Torpedo marmorata	317	5%	1239	2%	o	o	o	o	-	4,3	3,3	0,9	1,9	**2,4**
Torpedo nobiliana	73	1%	531	1%	+	+	+	o	+	2,1	2,1	0,0	0,5	**1,0**
Torpedo torpedo	28	0%	38	0%	+	-	+	-		0,0	0,2	0,0	0,0	**0,1**
TOTALS	6336		55158							114	122	89	103	106

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CATCH OF THE SPECIES *HOLOTHURIA TUBULOSA* GMELIN, 1788 ON CONTINENTAL SHELF IN THE ADRIATIC SEA

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Abstract
This paper presents data about catches of the species *Holothuria tubulosa* Gmelin during PIPETA expedition (1985-1994) on 10 profiles or 50 stations on continental shelf in the Adriatic Sea. 496 bottom trawl hauls are elaborated. The greatest amount of the catch on all profiles was at stations that are situated in the north Adriatic on "relict" sand and clayey "relict" sand at depths to 50 m.

Keywords: Holothuria tubulosa, catch, Adriatic Sea

Introduction

Expedition HVAR reports present data about non edible bycath on each investigated stations (1). Only genus *Holothuria* can be found on the list, so we don't have any data about species *Holothuria tubulosa*. During PIPETA expedition for the first time non edible trawl bycatch is completely analysed in the Adriatic Sea. Catch of the species *H. tubulosa* based on PIPETA expedition (1985-1994) results is presented in this paper. Some results about non edible bycatch during this expedition are already presented (2, 3, 4).

Material and methods

Italian trawler PIPETA at 10 profiles (A – L) or 50 stations collected biological material during 11 cruises. Station planning was systematic with additional stratification (sediment, depth). The weight of the bycatch was measured by filling up a plastic box of 50x32x10.5 cm by the random sample method with epifaunal material collected by the trawl. The weight of each species was multiplied with the total number of boxes with epifauna collected during a single bottom trawl haul and the value was expressed in kg h^{-1}. Standard Italian bottom trawl was used (5).

Results and discussion

On continental shelf species *H. tubulosa* is the most abundant on "relict" sand (6). The species lives on depths to 100 m (7). The greatest presence of the species is on depths from 10 to 50 m (6). During PIPETA expedition the stations of the investigated profiles are situated at different depths and sediment types. 496 bottom trawl hauls are elaborated.

Profiles "A", "B" and "C" are situated in the north Adriatic at few different sediment types and depths to 50 m. Thus, the catch from the stations on these profiles depends on sediment type. The greatest catch was on profile "C" (Table 1). That is because more than half of the stations on this profile are on "relict" sand. This is the only profile where the species is caught on clayey silt and silty clay. Considerable catch was on profile "A" and this is the only profile where the species was caught on sand-silt-clay sediment. Negligible catch was on profile "B". It's due to fact that almost all stations are on sediments that contain silt and clay. All stations, except one, on profile "D" are situated at depths from 50 m to 70 m. Value for the average catch on this profile is similar to value for the average catch on profile "A". Considerably smaller catch was on profiles "E", "F" and "G". On profile "F" the species was noted only at two stations on "relict" sand and depths to 100 m. The species was not caught on profiles "H", "I" and "L". Almost all stations on these profiles are on depths more than 100 m and on clayey silt and silty clay sediment. Stations on these profiles that are on depth to 100 m are on sediments that are not suitable substrates for *H. tubulosa* species. The greatest amount of the catch on all profiles was at stations that are situated on "relict" sand and clayey "relict" sand. On all profiles there were hauls without this species. Standard deviations show that the species is unevenly distributed on the investigated profiles (Table 1). ANOVA-test shows that difference in catch among profiles is significant ($p<0.01$). Tukey-test shows that difference in catches between profile "C" and all other profiles is significant ($p<0.01$).

The greatest catches were at stations in the north Adriatic. The greatest value for the catch during one haul was at station "C6" (116.25 kg h-1). Average values above 10 kg h-1 were at following stations: "C5", "C6", "C7", "D7", "E6" and "E7" (Figure 1).

Table 1. Catch of the species *H. tubulosa* on profiles during PIPETA expedition.

PIPETA		Catch (kg h^{-1})				
		n	min	max	x	s
Profile	A	54	0	19.20	2.34	4.06
	B	44	0	0.08	0.00	0.0
	C	65	0	116.25	9.15	18.19
	D	62	0	22.50	2.49	4.95
	E	55	0	12.00	0.53	2.23
	F	54	0	1.17	0.02	0.16
	G	50	0	1.01	0.02	0.15
	H	33	0	0	0	0
	I	40	0	0	0	0
	L	39	0	0	0	0

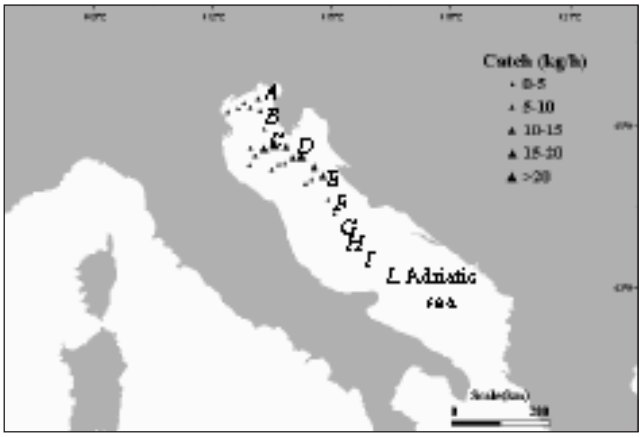

Figure 1. Catch of the species *H. tubulosa* at PIPETA expedition stations.

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ANNUAL VARIABILITY OF THECOSOME PTEROPOD POPULATION DENSITIES IN THE SOUTH ADRIATIC

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Abstract

The composition and abundance of thecosome pteropods were investigated by taking weekly samplings at the station near Dubrovnik during 1996. Twelve species were identified. *Desmopterus papilio* was registered for the first time in the Adriatic. The highest density of pteropods (1171 ind./10m^3) was recorded in mid-August, while the lowest density (1 ind./10m^3) occurred in mid-January. *Limacina inflata*, *Creseis virgula* and *C. acicula* accounting more than 85% of the overall pteropod counts. Intensive reproduction occurred in the summer-autumn period for all three species.

Keywords: Zooplankton, Pteropod, Adriatic Sea.

Introduction

Existing data on thecosome pteropod in the Adriatic Sea are scarce. The available literature regards mostly species composition and horizontal distribution (1,2). This paper presents the composition and weekly variation in abundance of thecosome pteropods over a one year period in the coastal waters of Dubrovnik.

Material and methods

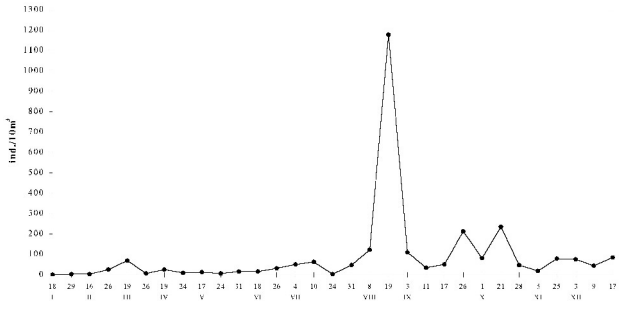
The plankton samples were collected at a station located 1/2 Nm southwest of the island Lokrum near Dubrovnik in time intervals of 1-3 weeks during 1996. Samples were taken by vertical hauls at depth of 75-0 m, using a Nansen net with a 200 μm mesh size. The planktonic material was preserved with a 2.5 % formaldehyde solution.

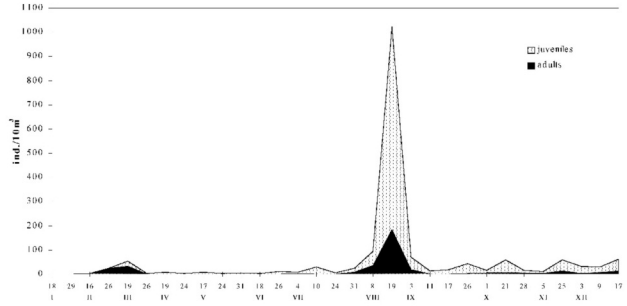
Results and discussion

At the Lokrum station 12 species of thecosome pteropods were identified. *Limacina inflata, L. trochiformis, L. bulimoides, Styliola subula, Creseis virgula, C. acicula, Hyalocylix striata, Clio pyramidata, Cavolinia inflexa, Peracilis reticulata i Cymbulia peroni* have been reported previously (1, 2) while Desmopterus papilio has been registered for the first time in the Adriatic. This species is common in tropical areas of the Atlantic and in the Indian Ocean (1). Contrarily, it is rare in the Mediterranean and has been registered only in the western basin (3, 4), which indicates its probable immigration to the Adriatic by way of the Red Sea.

The total number of thecosome pteropods were higher in the latter half of the year (Fig. 1) that coincidence with earlier research (2). A marked increase in numbers (1171 ind./10m^3) was recorded in mid-August, then decrease rapidly at the beginning of September. *Limacina inflata* made 87% of total thecosome pteropods count (Fig. 2). On the contrary, in the Mediterranean, this species has its lowest density during summer, and its maximum mainly from autumn to spring (1). Except *L. inflata*, the most numerous species were *Creseis virgula* and *C. acicula*. The highest numbers of *C. virgula* (136 ind./10m^3) were recorded at the end of October, and for *C. acicula* (62 ind./10m^3) at the end of September (Fig. 3, Fig. 4). In the Mediterranean Sea *C. virgula* is numerous, but the seasonal distribution in density varies in certain areas (1,5). Also, the density and frequency of the *C. acicula* are irregular and coherent ecological rules are difficult to determine (1).

All three species reproduce intensely during the summer-autumn period, according to the distribution of juvenile specimens throughout the year (Fig. 2, Fig. 3, Fig. 4). In the Mediterranean Sea *L. inflata* reproduce intensely from autumn to spring, the *C. virgula* from autumn to winter, and there is no rules for the *C. acicula* (1).





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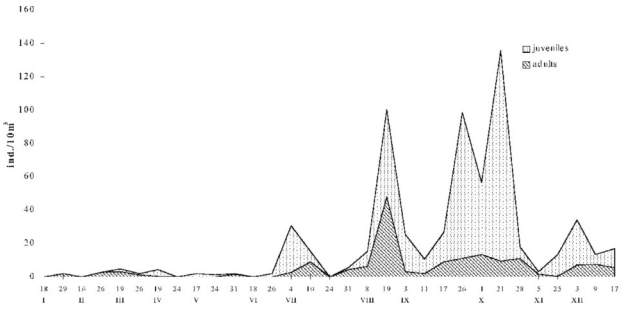

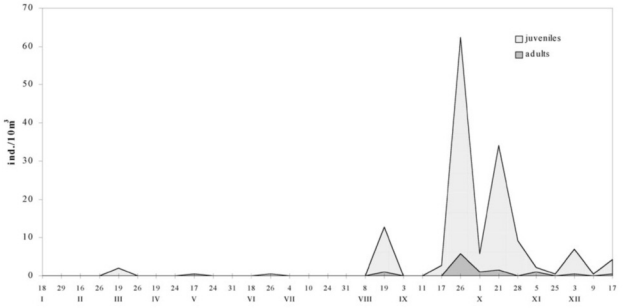

Fig. 1. Abundance of total thecosome pteropods at the station Lokrum during

L'EXEMPLE DU RORQUAL COMMUN EN MÉDITERRANÉE NORD-OCCIDENTALE EN PÉRIODE ESTIVALE : UN PAS VERS UN NOUVEL ATLAS DE DISTRIBUTION ?

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Résumé

L'application simplifiée de la technique du Transect de Ligne, selon des modalités adoptées par le Groupe de Travail "Mammifères Marins" de la CIESM, permet d'améliorer substantiellement nos connaissances sur les fluctuations de la distribution spatiale des Cétacés. La mise en place du programme "Indices relatifs d'abondance", illustrée ici par l'exemple du Rorqual commun en Méditerranée nord-occidentale, devrait permettre d'envisager un nouveau type d'Atlas, à l'échelle des bassins ou à un niveau régional. Une telle entreprise relève de l'implication de chacun.

Mots clés : Cetacea, Distribution coefficient, Mapping.

Les observations aléatoires de cétacés vivants faites en mer, rassemblées et gérées par le GT "Mammifères Marins" de la CIESM depuis plus de vingt ans, avaient permis d'éditer en 1995 (1) un *Atlas préliminaire* de distribution des espèces dans les bassins de Méditerranée et de Mer Noire. Cet ouvrage collectif dressait le point de la situation, et mettait en exergue de nombreuses lacunes sur l'état de nos connaissances des espèces.

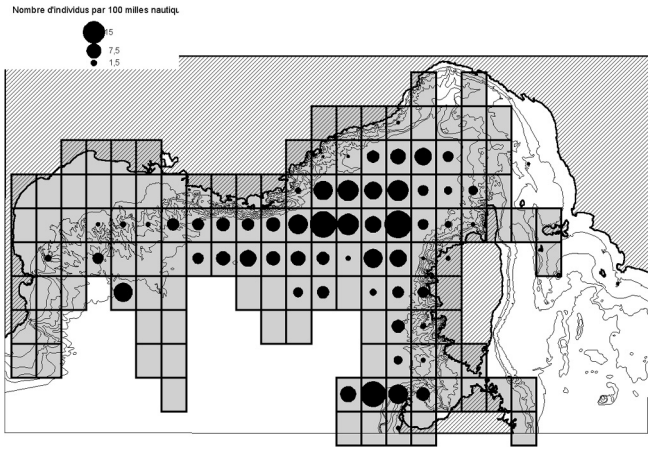
La nécessité était en particulier ressentie d'orienter dorénavant les travaux sur une approche plus méthodique de la récolte des informations sur le terrain, avec pour objectif de mieux cerner les fluctuations des effectifs ou des abondances spatiales et saisonnières des animaux. Les termes de référence des protocoles à appliquer dans ce but ont été définis lors d'une réunion du GT (janvier 1996), et ont insisté sur le lien indispensable qui devait dès lors rattacher les observations de cétacés aux efforts effectués en prospection.

Méthode préconisée

Le principe de la méthodologie retenue est délibérément simple, pour bénéficier du maximum d'opportunités d'embarquements dans les deux bassins. Il préconise qu'un observateur (au moins) spécialement affecté à cette tâche effectue, en ligne droite, une veille continue entre deux points de coordonnées connues (principe du Transect de Ligne), par état de la mer ≤ 3 Beaufort, sur n'importe quel type de bateau dont la vitesse est ≥ 4 noeuds. Les bordereaux d'informations regroupent l'heure et la position de début et de fin des observations, de même que celles des points de virement sur la route; apparaissent aussi heure, position et effectif de toute espèce de cétacé rencontrée.

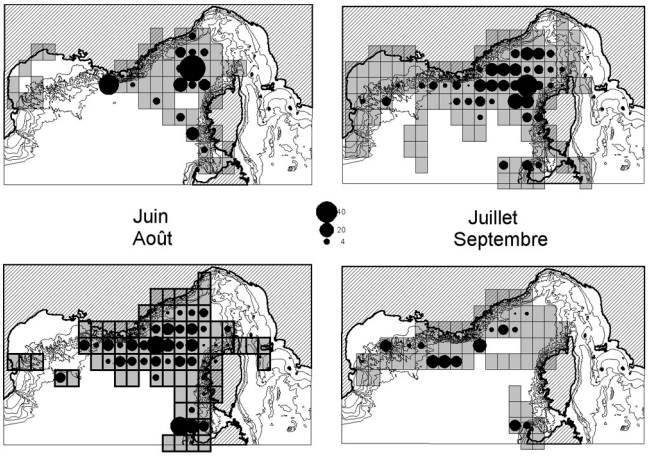
Exemple de résultat

L'exemple donné ici de l'application de cette procédure concerne, sur la base des mois de juin à septembre, la distribution des indices d'abondance relatifs du Rorqual commun (*Balaenoptera physalus*) en Méditerranée nord-occidentale. Les cartes 1 et 2 présentent, selon un carroyage de 20x20 milles nautiques, les indices moyens calculés sur une période de quatre années (1995-1998). L'opération, initiée et coordonnée par les équipes de l'E.P.H.E (France) et de l'Institut Tethys



(Italie), a vu se joindre progressivement plusieurs autres partenaires.

Carte 1: Distribution estivale des indices relatifs d'abondance du rorqual commun en Méditerranée nord-occidentale (moyennes de juin à septembre, et de 1995 à 1998)



Carte 2 : Distribution mensuelle des indices relatifs d'abondance du rorqual commun en Méditerranée nord-occidentale (moyennes de 1995 à 1998)

La carte 1 montre que, en été, les Rorquals fréquentent essentiellement les profondeurs supérieures à 2000 m, et sont particulièrement abondants dans le secteur Corso-Liguro-Provençal. Les évolutions mensuelles (carte 2) indiquent que les Rorquals sont faiblement représentés en juin, arrivent massivement en juillet, période où ils sont plus fréquents au nord-ouest de la Corse. En août ils se déplacent vers les côtes continentales, et beaucoup d'entre eux sont repartis en septembre. Une Anova sur mesures répétées (test d'appariement significatif p=0.0228, Anova significative : F=3.552, p=0.0328) confirme ces variations mensuelles d'abondances, le test des contrastes opposant le mois de juillet à juin et septembre.

Perspectives

Le cas du Rorqual choisi ici n'est qu'un exemple puisque les mêmes cartes existent pour toutes les espèces rencontrées en Méditerranée nord-occidentale. Répondant à l'appel lancé en 1996 par le GT de la CIESM, plusieurs équipes se sont déjà investies dans ce type de travail et transmettent régulièrement leurs observations au Secrétariat du Fichier. Nous citerons en particulier celles prospectant la Mer d'Alboran et le détroit de Gibraltar ou, en Mer Noire, comme la Bulgarie ou l'Ukraine. Il est certain que plusieurs autres ont entamé de telles approches dans leurs régions, et il serait bon qu'elles s'identifient auprès du Secrétariat pour examiner comment envisager un nouveau genre d'Atlas, à l'échelle des bassins ou à des niveaux régionaux.

L'identification des Indices d'abondance relatifs traduit l'hétérogénéité spatiale de la distribution d'une espèce. Cette étape de connaissance de la répartition des animaux est nécessaire à franchir puisqu'elle permet de mieux affiner la planification des prospections indispensables aux recensements ultérieurs des effectifs des populations.

Remerciements

Collaborations de : E.P.H.E. Montpellier, Tethys Research Institute, ASMS, Céta-squale, Delphinia S.C., GREC, R. Zotier, Ministère français de l'Environnement, Nature et Découvertes, WWF-France, Europe Conservation, Amitié sans Frontières.

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SPATIAL DISTRIBUTION AND SEASONAL CONCENTRATION OF EUROPEAN HAKE'S JUVENILES, *MERLUCCIUS MERLUCCIUS* (L. 1758), IN THE NORTH TYRRHENIAN SEA

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Abstract

Data on abundance and size frequency distribution of European hake, *Merluccius merluccius*, collected in the northern Tyrrhenian Sea during trawl surveys carried out from 1985 to 1998, were analysed using the Geographical Information System. The areas of concentration of individuals smaller than 12.5 cm of Total Length were identified; charts of bimonthly distribution of the juveniles were produced.

Keywords : Fisheries, demersal, population dynamics, Tyrrhenian Sea, Teleostei.

Introduction

The European hake, *Merluccius merluccius*, is one of the most important species exploited by the Mediterranean demersal fisheries. Trawl catches are characterised by a high percentage of small specimens; thus, for a better management of this species is important to improve the knowledge of this phase of life. The purpose of the present study is to provide additional data on the spatial distribution and seasonal concentration of the specimens in the first year of life (0 group, individuals smaller than 12.5 cm of Total Length, TL), i.e. to localising the nursery area.

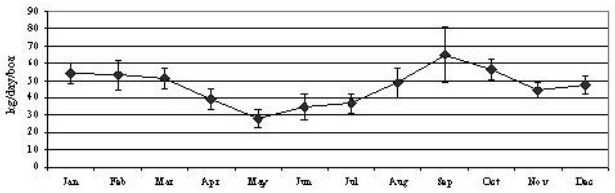
Material and methods

The investigated area was the northern Tyrrhenian Sea, where the juveniles of European hake are exploited by the bottom trawlers. Data on size composition and abundance of juveniles were gathered by means of several trawl surveys, funded by the Italian Government, carried out from 1985 to 1998, during spring, summer and autumn, generally following a stratified random design (1, 2). Abundance data were standardised to number of specimens per surface unit (km^2), using the swept area method. Data were converted in an ARCHVIEW compatible format and interpolated by means of kriging (linear function) in order to produce maps of bimonthly abundance of juveniles (3). Further monthly data (from 1991 to 1998) on hake of Porto Santo Stefano, the most important landing place of this area, were collected.

Results

The size frequency distributions of the catches of the trawl surveys were characterised, in all the considered periods, by a high percentage of small specimens, particularly in September – October where the individuals measuring less than 12.5 cm TL represented about 85% of the total abundance. Juveniles were mostly distributed from 100 to 200 m depth and concentrated in areas around the Giglio Island and between Elba and Montecristo Isles (Fig. 2,3,4,5).

The landing of hake is commercialised in three different categories, according to the size of the specimens: the juveniles belong to the third category (individuals smaller than 15 cm TL). The monthly landing per unit effort of small specimens of *M. merluccius* in Porto Santo Stefano (Fig.1) confirmed the seasonal trend in the abundance of juveniles observed



through the experimental surveys: highest values were found in the period late summer – early autumn, with a maximum in September.

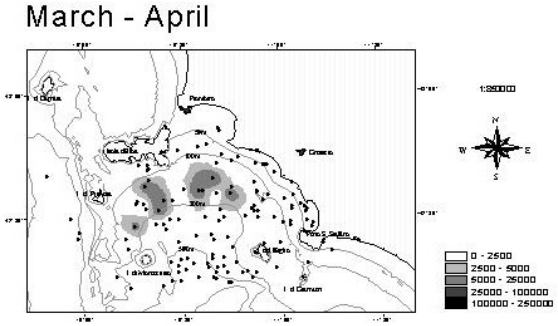


Figure 1. Mean monthly landing per unit effort (kg/day/boat) of small hakes (< 15 cm TL) in Porto Santo Stefano 1991-1998.

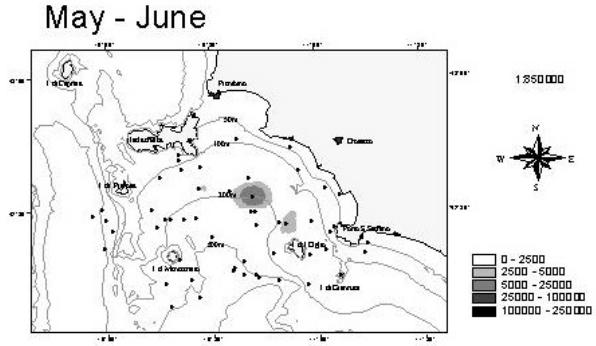


Figure 2. Spatial distribution of juveniles (specimens<12.5 cm TL per km^2) in the period March-April.

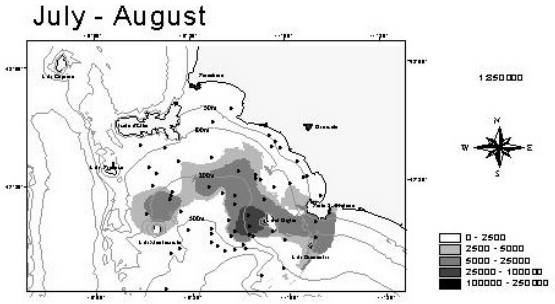


Figure 3.Spatial distribution of juveniles (specimens<12.5 cm TL per km^2) in the period May-June.

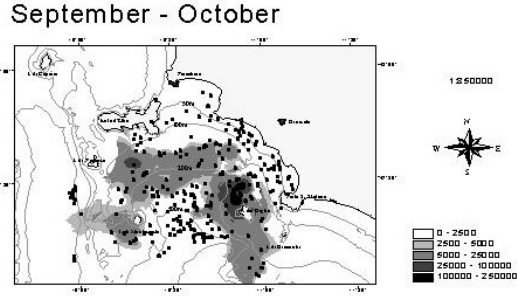


Figure 4. Spatial distribution of juveniles (specimens<12.5 cm TL per km^2) in the period July-August.
Figure 5. Spatial distribution of juveniles (specimens<12.5 cm TL per km^2) in the period September-October.

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CROISSANCE, MORTALITÉS ET ANALYSE DE L'ÉTAT DU STOCK EXPLOITÉ PAR VPA DE L'ESPADON *XIPHIAS GLADIUS* (L, 1758) PÊCHÉ PAR LES PETITS MÉTIERS À BÉNI SAF

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Résumé

Le stock de l'espadon, exploité de manière traditionnelle dans la région de Béni Saf (Ouest algérien), présente une tendance de surexploitation (E=0,79). Sa biomasse totale équilibrée est de l'ordre de 273,5 tonnes. L'âge et longueur moyens des captures atteignent respectivement 1,81 an et 88 cm alors que l'âge et la longueur critique du stock sont 2,49 ans et 115 cm.

Mots-clés : growth, mortality, biomass, analytical methods

Introduction

La pêche de l'espadon *Xiphias gladius* (L, 1758), sur la côte algérienne, se pratique essentiellement à la palangre et au filet maillant dérivant. Dans la région de Béni Saf (35°23'N-1°14'E), l'espadon est quasiment pêché par les petits métiers dont les débarquements représentent plus de 95,7 % des captures. Les prises des chalutiers sont accessoires, celles des senneurs accidentelles. L'importance et la valeur économique de cette espèce ont induit des investissements étatiques et privés afin d'augmenter les captures. C'est dans ce contexte qu'une étude analytique de l'état du stock exploité a été réalisé.

Matériel et méthode

L'échantillonnage a été effectué sur les lieux des débarquements et au niveau de la poissonnerie. L'opération a concerné la mesure de la longueur sans rostre (L_{JFL}) de 666 individus (tab. 1) dont 54 d'entre eux ont été pesés (poid éviscéré = W_e) pour déterminer la relation d'allométrie. La gamme des couples taille-poids varient de 77 à 193 cm pour les taille et des poids de 3 à 70 Kg . Les poissons étant éviscérés en mer , l'échantillon n'a pas été divisé selon le sexe. Les données disponibles, sur la maturité sexuelle par classes de taille, donnent un L_{50} de 140 cm (1) en Méditerranée Occidentale (données prises en compte pour la VPA) et de 179 cm (2) dans l'Atlantique nord-ouest.

CC (cm)	(N)	CC (cm)	(N)	CC (cm)	(N)	CC (cm)	(N)
45	1	85	105	125	53	165	20
55	4	95	117	135	57	175	7
65	3	105	95	145	14	185	12
75	42	115	118	155	15	195	3

Tableau 1 : Répartition des effectifs d'espadon par classe de taille

Cette étude a été menée à partir de trois softwares : Fishparm pour la croissance (3), Fisat pour les mortalités (4) et Vit (5) pour la VPA (en pseudo-cohorte). La méthode de Bhattacharya (4) a été appliquée pur la séparation des cohortes. La mortalité totale Z a été estimée par la méthode de la courbe des captures (4) et la mortalité naturelle M à partir de l'équation de Pauly (4). Le taux d'exploitation e a été déduit des mortalités totale z et par pêche F (E = F/Z).

Résultats et discussion

Cinq cohortes (tab. 2) ont été identifiées. l'équation de croissance ($L_t = 291.2*(1-e^{-0.191(t+0.145)})$), semble fournir une longueur asymptotique surestimée ($L_\infty = 291.2$ cm), en raison de l'absence des individus de tailles supérieures à 195cm dans l'échantillonnage.

Tableau 2 : Décomposition des cohortes d'espadon pêché dans la région de Béni Saf

Groupe d'âge	Moyenne (cm)	N	S^2	S. I.
1	58.3	8	7.73	-
2	94.9	358	13.28	3.48
3	131.5	113	7.81	3.48
4	162.4	41	8.50	3.77
5	180.0	14	8.66	2.05

La légère allométrie majorante de relation taille-poids ($W_t(E) = 0.004432*L_t^{3.18}$), n'a pas été confirmée statistiquement, il s'agit donc une isométrie.

Les valeurs de Z et M sont respectivement 1.14 et 0.24 an^{-1}, fournissent une mortalité par pêche F = 0.9 an^{-1}. Ces valeurs concordent avec des estimations antérieures dans la même région (Z=1.13 an^{-1} et M = 0.33 an^{-1} ; Z = 1.58 an^{-1} et M = 0.2 an^{-1}).

L'application de la VPA a montré que les captures d'espadon présentent un âge moyen de 1.81 ans pour une longueur moyenne de 88 cm alors que l'âge et longueur critiques du stock exploitable (277.66 tonne) sont respectivement 2.49 ans et 115 cm. La biomasse totale équilibrée est de l'ordre de 273.5 tonnes. Les gains, pour cette biomasse, sont engendrés par le recrutement (5.2% : 14.2 tonnes) et la croissance (94.8% : 259.3 tonnes). Les pertes dues à M et F sont respectivement de l'ordre de 66.64 tonnes (24.4 %) et 206.9 tonnes (75.6%). La relation le stock exploitable et biomasse totale équilibrée montre un déficit dans le taux de renouvellement du stock (Turnover = 98.5 %) de l'ordre de 1.5% représentant 4.16 tonnes. Le vecteur des mortalités par pêche, par classe de taille, présente des variations dont le maximum (1.29 an^{-1}) agit sur la taille 115 cm (taille critique du stock) alors que F moyen est de l'ordre de 0.77 an^{-1} et F terminal préconisé est de l'ordre de 0.4 an^{-1}. Cette dernière est beaucoup plus proche de F induisant un rendement par recrue optimum (F = 0.5 an^{-1}, Y/R= 13160 g).

Le taux d'exploitation E = 0.79 indique une surexploitation.

Conclusion

Le stock présente des signes de surexploitation (E > 0,5); il est préférable de ce fait de diminuer l'effort de pêche ou étendre la zone exploitée . Néanmoins, le caractère migratoire de l'espadon impose une approche régionale, spécifique aux stocks chevauchants.

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BIOLOGICAL AND "ECONOMIC" VIRTUAL POPULATION ANALYSIS OF THE RED SHRIMP (*ARISTAEOMORPHA FOLIACEA*) STOCK OF THE STRAIT OF SICILY.

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Abstract
The virtual population of the red shrimp (*Aristaeomorpha foliacea*) stock of the Strait of Sicily has been reconstructed, both in terms of biomass and of economic value, running the package VIT on experimental data "mimicking" the commercial catch. The most productive class is the 2-year old (55% in weight); about 2/3 of the loss is due to the fishing mortality; the turnover rate is 140-150% for the biomass, and 160% for the value. The actual critical age is around 1.4 years, while it is 2.5 years for the virgin stock. Results indicate a slight overexploitation, similar to that estimated for the companion shrimp *A. antennatus*, but a lower turnover rate.

Keywords : Decapoda, Fisheries, Population dynamics, Sicilian Channel

Aristaemorpha foliacea is a deep-water demerso-pelagic shrimp, distributed in the Mediterranean, Eastern Atlantic, Western and Central Pacific; in Sicily, annual landings exceed 1000 tons, worth over 10 million US$. A series of trawl experiments, carried out in 93-94 and aimed at selectivity studies, were used to reconstruct the life history of the stock [1].

The virtual population can be reconstructed by means of standard VPA or thru cohort analysis [2]; the first generally used for data structured in age-classes, the second for data both in age- or length-classes. Both approaches are implemented in the package VIT [3], which has been used in this study.

For VPA reconstruction, female shrimps (≈80,000 animals) were arranged by 1-mm carapace length classes. The input parameters [4] were L_∞= 70 mm, K= 0.6 /y, t0= 0, a= 0.0013, b= 2.642, M= 0.5, F_{term}= 0.5 (constant), proportion factor= 624 (to reach a catch of 1050 tons), maturation starting at 26 mm and always mature at 39 mm CL. In the analysis by ages, the terminal fishing mortality was adjusted to F_{term}= 0.04, and so was the maturation which is nil at age 1, 94% at age 2, and always present from age 3 on, up to the last class (age 8).

When the length-weight algorithm is replaced by a length-value (potential) relationship, the output may be considered as an "economic" virtual population [4]. For the "economic" VPA, the same above parameters were used, but with the following differences : a′= 0.00042, b′= 3.708, proportion factor= 772 (a multiplier used to reach a total value of the catch of 25 billion Italian liras).

The virtual population calculated from age-restructured data has a mean age of 0.8 y, and a mean CL of 23.6 mm, while the classes most represented (in weight) are those of age 2 and age 1 (521 tons and 198 tons, respectively); the average weight of the virtual population is 944 tons. The critical age is 1.0 y for the actual stock (corresponding to a critical length of 31.6 mm), and 2.54 y for the virgin stock (critical length 54.8 mm). On a total biomass balance of D= 1375 tons, the input is totally assigned to growth, while the output is 34.3% for the natural deaths, and 65.7% for the catch; the turnover is 145.6%. There is almost no difference in the two options, standard or pseudo-cohort analysis, since the two sets of results disagree for less than 0.5%, at least with the present data.

In contrast, the VPA performed on the length classes has a mean age of 1.02 y, a mean CL of 30.0 mm and mean fishing mortality of F= 0.46, while the classes most represented (in weight) are those between 31 and 49 mm CL; the average weight of the virtual population is 1066 tons. The critical age is 1.36 y for the actual stock (corresponding to 39.0 mm), while it remains at 2.54 y for the virgin stock (54.8 mm). On a total biomass balance (D) of 1583 tons, the input is split 1:20 between recruitment and growth, while the output is 1/3 for the natural deaths, and 2/3 for the catch. The turnover is 148.5%. A few compact elements of the VPA, useful for comparisons in time or space, are presented in Table I.

Table I - "Compact" results of the VPA of *Aristaeomorpha foliacea*; data classified by CL size or restructured by age.
R/B_{mean}, ratio of recruits to mean standing biomass; B_{max}/B_{mean}, ratio of critical class to mean standing biomass; D/B_{mean}, turnover, i.e. ratio of annual biomass balance to mean standing biomass; B_{max}/D, ratio of critical class to annual biomass balance.

	R/B_{mean}	B_{max}/B_{mean}	D/B_{mean}	B_{max}/D
from age (%)	0	54.1	145.6	37.2
from length (%)	7.0	69.7	148.5	46.9

The "economic" virtual population calculated from age-restructured data has an average value of 19.5 billion liras. On a total value balance of D= 31.3 billion liras, the input is totally assigned to growth, while the output is 31.3% for the natural deaths, and 68.7% for the catch; the turnover is 160.0%. In contrast, the average value of the virtual population is 22.0 billion liras when calculated for length-structured data. The critical age for value is 1.41 y for the actual stock (corresponding to 40.0 mm), and 2.54 y for the virgin stock (54.8 mm). On a total value balance of D= 36.0 billion liras, the input is split 1:99 between recruitment and growth, while the output is 30.5% for the natural deaths, and 69.5% for the catch. The turnover is 163.9%. A few compact elements of the economic VPA are presented in Table II.

Table II - "Compact" results of the economic VPA of *Aristaeomorpha foliacea*.
data by CL size or restructured by age. $\$R/\$_{mean}$, recruits to mean standing value; $\$_{max}/\$_{mean}$, critical class to mean standing value; $\$D/\$_{mean}$, turnover; $\$_{max}/\$D$, critical class to annual value balance.

	$\$R/\$_{mean}$	$\$_{max}/\$_{mean}$	$\$D/\$_{mean}$	$\$_{max}/\$D$
value (age)	0	56.2	160.0	35.1
value (length)	1.9	68.4	163.9	41.8

The VPA is based on the assumption that the length-frequency data that are used are representative of the commercial landings; thus, results should be taken with precaution, since the data set comes from experimental hauls, and is therefore only an approximation of the population structure of the actual landings, and since the steady-state assumptions might not be fulfilled; in any case, real commercial data are not available at present for this population. In spite of these limitations, present results indicate a status of slight overexploitation, similarly to that estimated using an analogous methodology for the companion shrimp *A. antennatus* [5], but with a lower turnover rate.

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SEASONAL DISTRIBUTION OF THE CILIATED PROTOZOA AND MICROMETAZOA IN THE NERETVA CHANNEL (SOUTH ADRIATIC)

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Abstract:
Annual distribution of the microzooplankton density was investigated in Neretva Channel from November 1998 to October 1999.

Keywords: zooplankton, Adriatic Sea

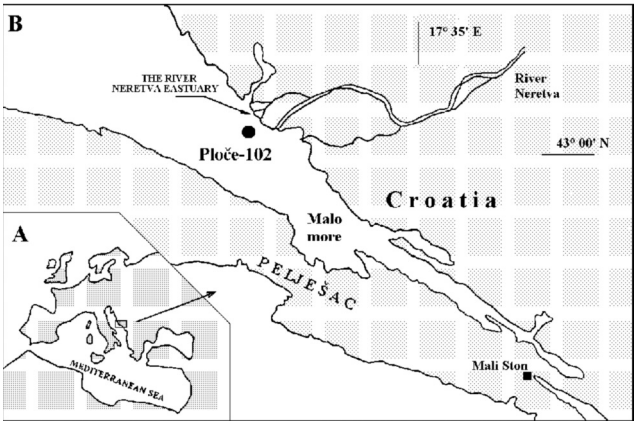
Introduction:

Preliminary investigations of microzooplankton in Mali Ston Bay during the 1973 showed that the smallest zooplankton organisms are of importance in the Adriatic Sea [1]. During the next decade, the investigations became more intensive in the inner part of the Bay and tintinnines became one of the most studied microzooplankton groups [2]. Species composition, density and vertical distribution of tintinnines were observed. However, the data of seasonal distribution of nonloricates, nauplii, copepodites, adult small copepods and other micrometazoans are scarce and refer to research carried out during the 1979/80 [3].

Material and methods

Microzooplankton was studied at station in the Neretva Channel (43° 1.5' N and 17° 24.8' E) between November 1998 and October 1999 (Figure 1). Samples were taken at 0, 5, 10 and 18 m depth using Niskin bottles (5 l volume). The material was preserved in 2.5% neutralised formaldehyde. In the laboratory the volume of samples were reduced to a few millilitres after 72 hours by using the sedimentation and decantation methods [1]. The organisms were counted using the inverted microscope "Olympus" IMT-2, under 100x magnification.

Seawater temperature and salinity were measured with IDRO-



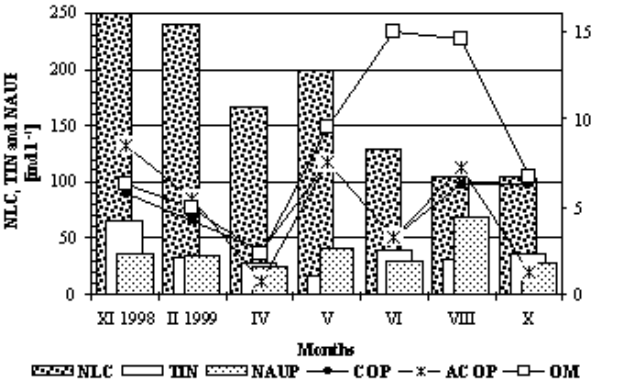
NAUT 316 CTD Multi-parameter Probe.

Figure 1. Study area (Neretva Channel) with the sampling station - Ploce-102

Results and discussion

Seasonal distribution of nonloricates was distinguished by two peaks, the first in the autumn-winter period and the second in the spring with the mean values higher then 200 ind.l^{-1}. The maximum, 496 ind.l^{-1} was obtained in May at the surface when were recorded the intensive inflow of fresh water (Figure 2). Throughout the year, 63% of nonloricates were in the upper 5 m from the surface. They accounted an average of 83% of the total ciliated protozoan density.

Tintinnines were more abundant only in November with the mean density of 66±15 ind.l-1 and were represented with 21% of total ciliated protozoans. Until spring organisms were retained in deeper layers. From May on tintinnines come closer the surface and the maximum of 84 ind.l-1 in August was found at the surface. At the investigated station a total of 33 tintinnine species were found. Qualitatively the most important ones were Salpingella rotundata and Stenosemella nivalis which account 41% of tintinnine count. The first one prevailed in the plankton during the summer-autumn period and the second one during the autumn-winter period. That seasonal pattern of ciliated distribution is comparable to investigations in other temperate waters [4, 5]. Their distribution could be influenced by abiotic factors and metazoan grazing what confirm the significant correlations between nonlor-



icates and salinity, and tintinnines and micrometazoans.

Figure 2. Seasonal fluctuations in the abundance of nonloricates (NLC), tintinines (TIN), copepod nauplii (NAUP), copepodites (COP), adult small copepods (ACOP) and other micrometazoans (OM)

Copepod nauplii were qualitatively the most important micrometazoans especially in August with the average density of 68±50 ind.l^{-1} and the share in total micrometazoans of 71% (Figure 2). During the summer stratification of the water column, nauplii retained in the surface layers, with the highest density (132 ind.l^{-1}) at the surface.

Copepodites and adult small copepods were of less importance at this station and their shares in total of micrometazoans were the highest in October of 14% and 16%, respectively. Other micrometazoans comprise of following groups: Cladocera, Pteropoda, the small larvae of benthos organisms and planktonic tunicata. They contribute to the total of micrometazoans the most in June (29%).

The smalest average densities of microzooplankton related to number in other Adriatic bays [6, 7] point at their limited role as a conduit for carbon flow to higher trophic level.

This paper gives some new data about the microzooplankton distribution and contribute to the knowledge of their ecology in coastal waters.

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BIODIVERSITY OF DEMERSAL FISH IN THE SOUTHERN TYRRHENIAN SEA (WESTERN MEDITERRANEAN)

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Abstract
The biodiversity of demersal ichthyofauna was analysed using the ecological indices of Shannon-Weaver (H') and Pielou's (E). The data comes from seven Medits trawl surveys carried out from 1994 to 2000 in the Southern Tyrrhenian Sea. A total of 88 demersal fish species was collected. Demersal fish diversity is strictly correlated with the depth.

Keywords: Biodiversity, demersal fish, Tyrrhenian Sea

Introduction

Studies on diversity in biological communities has been carried out over the last twenty years by ecologists and applied to different ecosystems. In particular, demersal fish biodiversity studies have been carried out in different Italian seas, the North Tyrrhenian (1), the South Adriatic (2) and the Ionian seas (3). The demersal fish biodiversity in an area of the South Tyrrhenian Sea was analysed using the Shannon-Weaver diversity index (H') and Pielou's evenness index (E).

Materials and methods

The data reported here was gathered during seven trawl surveys carried out, from 1994 to 2000, during the Medits project (International bottom trawl survey in the Mediterranean Sea) funded by the European Community.

They were conducted every year between the end of spring and the middle of summer. The study area was situated between Suvero Cape (the Calabrian coast) and S. Vito Cape (the Sicilian coast) (Fig. 1). The gear used had a small codend (20 mm, stretched mesh) and 2-2.5 m of vertical opening (4). A total of 194 hauls were carried out randomly allocated into 5 depth strata (A: 10-50 m; B: 51-100 m; C: 101-200 m; D: 201-500 m; E: 501-800 m). All fish were identified and counted (N/h), the mean number (1994-2000) of each stratum was calculated. Pelagic species, occasionally collected by gear, were excluded for this study, as well as the individuals with N/h values less than 4. For each stratum and year the Shannon-Weaver (H') and Pielou (E) indices were calculated. Because the annual variations of both indices E and H' were not significant, the mean index, calculated over the seven years, has used (Tab. 1).

Fig. 1 - Study area From Suvero Cape (Calabria) do S. Vito Cape (Sicily)

Results and discussion

A total of 88 demersal fish species with 265.720 specimens were collected in the study area. The diversity and evenness indices mean values in five strata are reported in table 1. Generally the diversity and evenness values showed a similar trend in accordance to the depth. The H' and E indices showed the highest values in the B stratum with 2,96 and 0,7 respectively. In this stratum a mean of 23 species was recorded with 8507 specimens. For the A stratum the diversity value is also high (2,83) and the evenness index shows a value of 0,64. 20 species (mean value) were in this stratum found with a number of specimens totalling 4384. The most abundant species in the first two strata are *Trachurus trachurus* (n° specimens totalling 11014), *Mullus barbatus* (n° specimens totalling 10944), *Pagellus acarne* (n° specimens totalling 10840), *Spicara flexuosa* (n° specimens totalling 8898) and *Lepidotrigla cavillone* (n° specimens totalling 6050). On the contrary the D stratum showed the lowest H' (2,12) and E values (0,47). The most abundant species is *Clorophtalmus agassizi* (n° specimens totalling 44334).

Tab.1 - Shannon-Weaver diversity index (H) and Pielou's (E) values

strata	n of hauls	H'mean	s.d.	H'min	H'max	Emean	s.d.	Emin	Emax
A	27	2.83	0.6	1.94	3.34	0.64	0.12	0.45	0.76
B	27	2.96	0.6	1.64	3.31	0.7	0.14	0.33	0.72
C	42	2.55	0.5	1.88	3.27	0.54	0.10	0.39	0.7
D	49	2.12	0.5	1.18	2.42	0.47	0.12	0.24	0.62
E	49	2.46	0.8	1.51	3.82	0.6	0.17	0.39	0.88

(mean. s.d., min., max).

For the C stratum the diversity value is 2.55 and the evenness index shows a value of 0,54. Finally in stratum E both H' (2,46) and E (0,60) values were quite high.

Analysing the data here reported, it is clear that demersal fish diversity is strictly correlated with the depth. The lowest strata (10-50 m and 51-100 m) showed the highest biodiversity, but the stocks have a low homogenity structure dued to many dominant species. The D stratum (201-500 m) showed the lowest diversity because of the heavier dominance of some species (*C. agassizi, A. sphyraena, G. argenteus*) which often reach a number of specimens higher than the other species that characterize the other bathymetric strata. On the contrary, in the deepest stratum (501-800 m), although both the ecological indices showed low values, the diversity is quite high because the species are represented by homogeneus individual numbers. In particular, during 2000 this stratum registered the highest H' values (3,82) compared to all other strata and years.

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SUR L'ESTIMATION DE L'ÉTAT D'EXPLOITATION DU MERLU *MERLUCCIUS MERLUCCIUS* (LINAEUS, 1847) DE LA RÉGION CENTRE DE LA CÔTE ALGÉRIENNE

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Résumé
L'estimation de la biomasse totale équilibrée du stock de merlu dans la région centre de la côte algérienne est de l'ordre de 1070 tonnes dont les gains sont représentés, en partie, par un recrutement de 2.8% ne contribuant ainsi que très peu dans la reconstitution du stock. Cette situation alarmante est due à l'exploitation massive des jeunes immatures, vu que la taille moyenne de capture englobe 99% de femelles et 40% de mâles n'ayant pas encore atteint leur première taille de maturité sexuelle. L'état d'exploitation actuel coïncide avec la situation optimale.

Mots-clés : Fishes, demersal biomass, Algerian basin

Introduction

Dans la région centre de la côte algérienne allant de Tamenfoust (3°10E) au mont Chenoua (2°20E), la production du merlu a été estimée à 600 tonnes en 1999 (1). Afin d'estimer l'état d'exploitation de cette espèce, et si possible d'indiquer les mesures indispensables à l'amélioration du rendement de cette espèce, il convient d'entreprendre l'étude de son état de stock par l'analyse virtuelle des populations (2).

Matériel et méthodes

Les données d'"Input" nécessaires pour l'analyse virtuelle de la population de merlu de la région centre de la côte algérienne, par analyse des fréquences de tailles, sont dressées dans la table 1.

Table 1 : paramètres utilisés dans l'analyse virtuelle de la population du merlu.

C.C. (cm)	N	C.C. (cm)	N	C.C. (cm)	N
7.5	52	27.5	222	47.5	17
9.5	69	29.5	191	49.5	11
11.5	463	31.5	168	51.5	19
13.5	691	33.5	95	53.5	9
15.5	730	35.5	62	55.5	4
17.5	643	37.5	65	57.5	5
19.5	402	39.5	48	59.5	3
21.5	308	41.5	21	61.5	2
23.5	372	43.5	27	63.5	1
25.5	264	45.5	14	65.5	2

Age (an) (3)	1	2	3	4	5	6	7	8	9
Taille (cm) (4)	15.8	23.1	33.8	36.7	43	47.1	51.7	57.1	57.7
H/S ≤ 2.2	1.08	1.13	0.96	0.95	1.52	1.36	1.26	1.29	0.92

$L_t = 77.71\ e^{-0.146(t+0.549)}$ (5), $(W_{ev})_t = 0.0057L^{3.038}$ (5), M = 0.27 an^{-1} (6), Z = 0.78 an^{-1} (7), F=0.51 an^{-1}, Taille à la première maturité sexuelle TPMS (femelles) : L_{50} = 30.5 cm (8)

Résultats et discussion

Age et longueur (moyen et critique) du stock

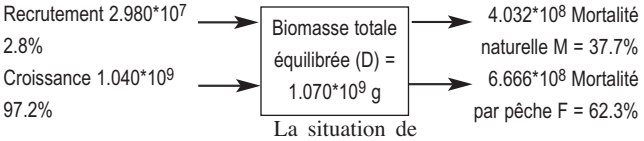
L'analyse de la taille moyenne de capture (table 2) montre que 99% des femelles et 40% des mâles n'ont pas encore atteint la taille à la première maturité sexuelle (8), ceci dit que l'exploitation du stock du merlu cible la biomasse des immatures, responsables de la pérennité du stock. Cette situation serait due au fait que la pêche se concentre essentiellement sur les petits fonds, n'excédant pas 200 m de fond, peuplés par les jeunes immatures (9).

En tenant compte de la taille critique du stock du merlu (27.5 cm), taille à laquelle le stock demeure très vulnérable vu que 77% des femelles capturées sont toujours immatures (8), il serait souhaitable de déplacer l'effort de pêche soit vers les grands fonds quasiment inexploités, soit vers d'autres fonds chalutables vierges.

Age moyen (T) et taille moyenne l_t de capture	T = 1.74 ans,	l_t = 21.34 cm
Age moyen et taille moyenne du stock	T = 1.47 ans,	lt = 18.76 cm
Age et taille critique du stock	T = 2.44 ans,	lt = 27.50 cm

Table 2 : âge et taille (moyen et critique) du stock.

Biomasse et état d'exploitation



La situation de la biomasse du stock de merlu de la région centre de la côte algérienne est consignée dans le diagramme ci-joint :

Ces résultats permettent d'estimer la biomasse totale équilibrée exploitable du stock de merlu à 1070 tonnes dont les gains sont représentés d'une part par le recrutement (2.8%) qui ne contribue que très peu dans la reconstitution du stock et ce suite à l'exploitation des jeunes immatures ne leur laissant ainsi aucune chance de se reproduire, d'autre part ce déficit est compensé par la stimulation du taux de croissance (97.2%).

Pour ce qui est des pertes, elles sont représentées en grande partie par la mortalité par pêche (62.3%). Il est intéressant de signaler que le turnover, qui traduit l'importance du renouvellement annuel de la biomasse, est de l'ordre de 71.6%. Enfin, l'état d'exploitation actuel coïncide avec la situation optimale présentant un rendement par recrue optimal (Y/R) qui est de l'ordre de 70.61 g pour F égale à 0.5 an^{-1} (2).

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SUR L'ESTIMATION DE L'ÉTAT D'EXPLOITATION DE LA SARDINELLE (*SARDINELLA AURITA*, VALENCIENNES, 1847) DE LA RÉGION CENTRE DE LA CÔTE ALGÉRIENNE

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Résumé
L'analyse virtuelle de la population de la sardinelle de région centre de la côte algérienne par analyse de fréquences de tailles, a montré que l'âge moyen et la taille moyenne des captures sont inférieurs respectivement à l'âge critique et à la taille critique qui à son tour demeure supérieure à la taille de la première maturité sexuelle des femelles. Cependant, l'état d'exploitation actuel dépasse largement le rendement par recrue optimal, reflétant ainsi un état de surexploitation.

Mots-clés : Fishes, pelagic, biomass, algerian basin

Introduction

La production de la sardinelle, en 1999, a été estimée à 29693 tonnes (1), soit 40% des débarquements de la pêcherie sardinière opérant dans la région centre de la côte algérienne comprise entre Tamenfoust à l'Est d'Alger (3°10'E) et le mont Chenoua à l'Ouest de la capitale (2°20'E). Afin de connaître l'état de stock de cette espèce, l'étude de son exploitation a été entreprise par l'analyse virtuelle des populations (2).

Matériel et méthodes

A raison de deux prélèvements par mois, 5467 individus de tailles comprises entre 6.5 et 25.5 cm, regroupés en classe de taille de 1 cm, ont été échantillonnés entre janvier 1995 et décembre 1996. Les données nécessaires pour le calcul de la VPA de la sardinelle, par analyse des fréquences de tailles, sont consignées dans la table 1.

Table 1 : Paramètres utilisés dans l'analyse virtuelle de la population de la sardinelle.

C.C. (cm)	N	C.C. (cm)	N	C.C. (cm)	N	C.C. (cm)	N
6.5	01	11.5	629	16.5	485	21.5	99
7.5	14	12.5	522	17.5	461	22.5	47
8.5	155	13.5	425	18.5	381	23.5	26
9.5	417	14.5	380	19.5	284	24.5	12
10.5	557	15.5	438	20.5	132	25.5	02
Age (an) (3)		1 (4)		2		3	4
Taille (cm)		11.6		16.5		20.4	22.4
h/S ≤ 2.2		0.75		0.43		0.68	0.83
$L_t = 34.96\ e^{-0.236(t+0.707)}$ (5), $W(ev)_t = 0.0036L_t^{3.006}$ (5), M = 0.54 an^{-1} (6), Z = 2.22 an^{-1} (7), F=1.68 an^{-1}, taille à la première maturité sexuelle TPMS (femelles) : L_{50} = 14.1 cm (com. Pers.)							

Résultats et discussion

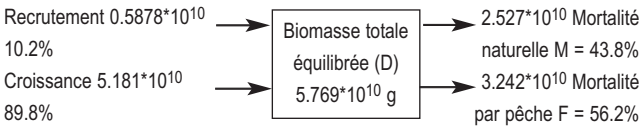
Age et longueur (moyen et critique) du stock

Le temps critique, représenté par une longueur critique et un âge critique, est le temps équivalent à la biomasse du stock (8).

L'âge moyen (1.02 ans) et la taille moyenne (11.39 cm), du stock exploité de la sardinelle de la région centre de la côte algérienne, sont inférieurs à ceux des captures (âge moyen = 1.70 ans, taille moyenne = 14.80 cm), qui à leur tour dépassent l'âge critique (1.56 ans) et la taille critique du stock (14.50 cm : valeur inférieure à la taille de la première maturité sexuelle L_{50} des femelles, qui est de l'ordre de 14.1cm). Néanmoins, l'âge et la taille des captures demeurent inférieurs à ceux du stock vierge (âge critique = 2.84 cm, taille critique = 19.83 cm).

Biomasse et état d'exploitation

La situation de la biomasse du stock de la sardinelle de la région centre de la côte algérienne se résume comme suit :



Les gains que connaît le stock sont dus principalement au taux de croissance élevé (89.8%) devant recrutement qui est de l'ordre de 10.2%. Pour ce qui est des pertes, le taux le plus important est représenté par la mortalité par pêche (56.2%) devant une mortalité naturelle qui est de 43.8%. En outre, la biomasse de la sardinelle se caractérise par un taux de renouvellement annuel (turnover) oscillant autour de 123.3%.

L'état du stock actuel (Y/R= 5.052 pour F=1.68 an^{-1}) de la sardinelle de la région centre de la côte algérienne, exploité par la pêcherie sardinière, révèle d'après l'évolution du rendement par recrue en fonction de la mortalité par pêche (2) un état de surexploitation du fait que le rendement par recrue optimal (Y/R) est de l'ordre de 5.67 g pour F = 0.65 an^{-1} .

Suite à des résultats il serait souhaitable de déplacer une partie de l'effort de pêche en dehors des baies (9) afin d'éviter, outre l'effondrement du stock, la crise socio-économique de la population côtière qui dépend étroitement de la pêche.

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DIVERSITÉ DU PEUPLEMENT ICHTYQUE DES CÔTES TUNISIENNES

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Résumé

Nous avons inventorié pour le moment 319 espèces de poissons valides. Par rapport à la dernière liste établie par (1), nous avons enregistré 58 nouvelles signalisations sur les côtes tunisiennes dont 14 sont mentionnées pour la première fois dans ce travail.

Du point de vue biogéographique, l'essentiel de la faune ichtyologique tunisienne est atlanto-méditerranéenne, cet élément représente en effet 86,5 %. L'endémisme représente 7,21 %.

L'essentiel de la faune ichtyologique tunisienne est à affinité chaude, se rattachant assez étroitement à la faune subtropicale voire saharienne de l'océan Atlantique. Toutefois, ce phénomène est plus remarquable dans la région du golfe de Gabès

Keywords : Biodiversity, Biogeography, Elasmobranchii, Gulf of Gabes, Teleostei

Introduction

Les données générales sur la faune ichtyologique de la Tunisie sont succinctes. Selon des travaux relativement plus récents, 267 espèces de poissons sont signalées en Tunisie (1). Depuis, plusieurs mentions de nouvelles espèces ont succédé avec le temps. Dans ce travail, nous essayons de compiler toutes ces données en ajoutant nos propres nouvelles observations à fin d'inventorier toutes les espèces de poissons des côtes tunisiennes et faire par ailleurs des réflexions concernant la diversité ichtyques de ces côtes.

Matériel et méthodes

Les poissons inventoriés sont classés selon leur distribution géographique actuelle. Nous avons retenu quatre groupes selon les définitions données par (2) : (1) espèces cosmopolites (et sub-cosmopolites) (2) espèces atlanto-méditerranéennes (3) espèces endémiques à la Méditerranée (4) espèces indo-pacifiques ou lessepsiennes.

Les différentes espèces sont par ailleurs, rangées selon leur thermophilie:(2) :

• les espèces à affinité froide : poissons atteignant sur les côtes est-atlantiques au moins la Manche et ne dépassant pas au Sud le Cap Juby ;

• les espèces à affinité chaude : poissons dont l'aire de distribution dépasse largement le Sud du Cap Juby et dont la limite nord est située vers le Cap Finistère.

Résultats :

En Tunisie, à ce jour, 325 espèces de poissons ont été signalées dans la littérature ou pour la première fois dans ce travail. Pour les espèces citées dans la littérature, nous avons éliminé, après une révision critique, six espèces que nous avons jugé non valides. Les espèces retenues sont donc au nombre de 319 (1 petromyzontidé, 1 holocéphale, 61 élasmobranches, 1 chondrostéen et 255 téléostéens). Elles sont réparties entre 209 genres , 109 familles et 30 ordres.

Durant ces derniers 27 ans, on a enregistré 58 observations de nouvelles espèces en Tunisie soit en moyenne deux espèces par an ce qui représente une augmentation d'environ 19,48 % de la richesse spécifique par rapport à notre recensement. Sur ces 58 observations, nous avons contribué par 14 nouvelles mentions soient 24,14 %.

Secteurs biogéographiques des côtes tunisiennes

Sur les 319 espèces recensées 134 ont été signalées sur tout le littoral, 265 dans la région nord et 244 dans le Sud tunisien. 52 espèces sont rencontrées uniquement dans la région nord et 43 que dans le golfe de Gabès.

Nous mentionnons pour la première fois dans la région du golfe de Gabès la présence de 16 espèces connues auparavant dans les eaux du Nord et/ou du Centre. Par rapport au recensement de (1), nous notons un enrichissement spécifique de la région du golfe de Gabès. Ce phénomène a été constaté par ailleurs dans tous le bassin oriental de la Méditerranée ce qui est dû principalement à un effort de prospection accrue et à l'incursion d'espèces de la mer rouge et de l'Atlantique dites exotiques.

Biogéographie

Les caractéristiques biogéographiques de la faune ichtyologique tunisienne sont données dans le tableau 1.

Affinités

L'essentiel de la faune ichtyologique tunisienne est à affinité chaude, elle se rattache assez étroitement à la faune subtropicale voire saharienne de l'océan Atlantique comme c'est le cas d'ailleurs pour toute la faune ichtyologique méditerranéenne (2). Toutefois, ce phénomène est plus accentué dans la région du golfe de Gabès.

Tableau 1 : Caractéristiques biogéographiques de la faune ichtyologique tunisienne

Biogéographie	Tunisie	Golfe Gabès	Méditerranée
Cosmopolites	5,02 %	4,13 %	-
Atlanto-medit.	86,5 %	86,7 %	56 %
Endémiques	7,21 %	7,85 %	18 %
Indo-pacifiques	1,25 %	1,25 %	6,79 %

Nos résultats confirment bien l'affinité de la faune ichtyologique du golfe de Gabès avec les provinces tropicales et tempérées chaudes (3, 1 et 4). Ce phénomène se confirme davantage par l'abondance relative de certaines espèces entre le nord et le sud. Il est à signaler par ailleurs que toutes les espèces nouvelles pour la région du golfe de Gabès sont à affinité chaude.

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AGE ET CROISSANCE DU SPARAILLON *DIPLODUS ANNULARIS* (TELEOSTEI, SPARIDAE) DU GOLFE DE GABES

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Résumé

Dans cette note, nous donnons les résultats relatifs à l'étude de l'âge et de la croissance du sparaillon *Diplodus annularis* dans la région du golfe de Gabès (Tunisie) par la méthode de rétrocalcul en utilisant les écailles.

Mots-clés : Teleostei, growth, Gulf of Gabes

Le sparaillon *Diplodus annularis* poisson téléostéen appartenant à la famille des Sparidae est très fréquent dans le golfe de Gabès et débarqué aussi bien par les chalutiers que par les barques côtières dans les ports de la région.

Dans ce travail, nous étudions l'âge et la croissance en longueur et en masse de cette espèce à partir des écailles.

Matériel et méthodes

Nous avons mesuré le rayon total (R) de l'écaille, du focus au bord antérieur, ainsi que les rayons R1, R2, ..., Rn relatifs aux différentes stries d'arrêt de croissance. Nous avons supposé que l'apparition de la première strie d'arrêt de croissance se situe à un âge de 12 mois. Par la suite, nous avons ajusté les équations exponentielles reliant la longueur totale (LT) du poisson au rayon total (R) de l'écaille.

A partir de ces équations, 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 Bertallanfy aux données de longueur par âge dont l'équation s'écrit de la façon suivante : $\mathbf{Lt = L\infty\ (1- e^{-K(t-t0)})}$.

Lt : Longueur du poisson à l'instant t ; L∞ : Longueur asymptotique correspondant à un taux de croissance nul ; K : Constante de vitesse de la croissance ; t_0: Age théorique auquel la longueur est nulle. 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.

La relation taille-masse a été également déterminée, elle est de la forme : M = a Lb. a et b sont deux constantes. La croissance massique absolue est décrite également par l'équation de Von Bertalanffy : $\mathbf{Mt = M\infty\ (1- e^{-K(t-t0)})\ b}$

Résultats

Les équations exponentielles liant la longueur totale (LT) aux rayons des écailles (R) pour les sexes séparés et confondus nous ont permis de calculer rétrospectivement les longueurs totales moyennes par âge (Tableau 1).

Tableau 1. Longueurs totales moyennes par âge calculées rétrospectivement pour les femelles (F), les mâles et les deux sexes confondus (M + F) de *D. annularis*

Age	1	2	3	4	5	6
F	88,274	120,50	128,35	138,02	148,2	165,01
M	77,72	121,35	120,84	129,62	136,34	
M + F	84,47	120,17	126,59	136,64	147,22	161,33

Les valeurs des paramètres de l'équation de Von Bertalanffy, décrivant la croissance en longueur de cette espèce, sont obtenues par ajustement de ce modèle aux données observées. Elles sont consignés dans le tableau 2.

Tableau 2. Paramètres de l'équation de Von Bertalanffy estimés pour le sparaillon *Diplodus annularis* du golfe de Gabès.

Paramètres	Femelles	Globale
L∞ (mm) Ic	221,8 33,4	226,4 48,4
K Ic	0,164 0,066	0,160 0,086
t_0 Ic	-2,083 0,075	-2,00 0,09

Ic: Intervalle de confiance

Les valeurs des longueurs totales théoriques en fonction de l 'âge sont très proches de celles déterminées par le rétrocalcul (Tabl. 3). Nous pouvons donc déduire que le modèle de Von Bertalanffy s'applique bien à l'étude de la croissance en longueur de ce sparidé.

Tableau 3.: Comparaison de la taille (Lt en cm) estimée par le modèle de Von Bertalanffy (A) et celle déterminée par le calcul rétrospectif (B) pour les sexes confondus.

	1	2	3	4	5	6
A	8,8	11,2	12,9	14,1	15,0	15,7
B	8,4	12,01	12,66	13,66	14,7	16,1

Les coefficients a et b des relations taille-masse de l'animal éviscéré et entier ont été calculés en considérant les mâles, les femelles et les deux sexes confondus. Les valeurs de ces deux coefficients ainsi que celles de W∞ se trouvent dans le tableau 4.

Tableau 4. Coefficients des relations taille-masse et W_∞ de *D. annularis*.

Coefficients		Mâles	Femelles	Globale
Poisson éviscéré	a	0,014	0,015	0,014
	b	3,053-	3,032	3,044
	W∞	–	180,75	186,37
Poisson entier	a	0,014	0,015	0,014
	b	3,092	3,078	3,094
	W∞	–	208,43	217,83

Tableau 5. Les paramètres de l'équation de Von Bertalanffy relative à la croissance massique de *D. annularis*, bp et be : pentes des relations logarithmiques taiile-masse (poisson entier et poisson éviscéré)

	Mp∞(g)	Me∞(g)	K	t0 (ans)	bp	be
Femelles (F)	208,43	180,75	0,164	-2,083	3,078	3,032
M + F	217,83	186,37	0,160	-2,000	3,094	3,044

Conclusion

Cette étude a montré que la croissance du sparaillon de la région du golfe de Gabès s'avère très modérée. Ce phénomène a été également constaté pour d'autres espèces telles que les rascasses (1) et le pageot commun (2).

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ANNUAL DISTRIBUTION OF CLADOCERANS IN THE OPEN SEA NEAR DUBROVNIK (SOUTH ADRIATIC)

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Abstract

The quantitative and qualitative composition and annual changes of abundance of cladocerans have been investigated. A weekly samplings were taken at the station one mile southwest from the island of Lokrum (sea depth 100 m) from 16 May 1995 till 9 December 1996. Five cladoceran species were found. A maximum density of 845 ind/m^3 was recorded on 26 September 1996 with *Penilia avirostris* accounting for 97.6% of the total number. *P. avirostris* and *Evadne tergestina* display similar seasonal fluctuations in abundance.

Keywords : Adriatic Sea, plankton, open sea, population dynamics

Introduction

Researches about Adriatic cladocerans (the Gulf of Trieste) date back to 1876 (1) and many studies have been carried out in this area (2, 3) and in the open Adriatic Sea (4). On the contrary, seasonal variations of cladoceran populations densities in the eastern part of Adriatic are mostly unknown (2). Particular investigations were performed in Rijeka Bay (5), in Mali Ston Bay (6, 7) and in the coastal region of the south Adriatic (8).

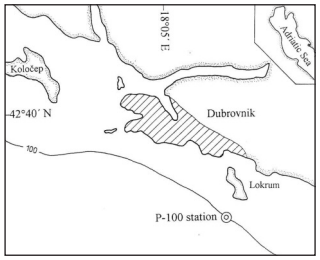

Fig. 1. Location de P-100 station

Study area

Station P-100 (fig.1.) is positioned extend from the coast, above isobaths of 100 m, directly exposed to the incoming open sea current. This is the zone of the lowest production in the Adriatic Sea on the base of concentrations of nutrition (<0.2 µmol l^{-1} PO_4 and <3μmol l^{-1} NO_3), primary production, abundance of populations and phytoplankton volumes, and bacterioplankton population densities (9, 10).

Material and methods

Material was collected at P-100 station during 44 cruises from 16 May 1995 till 9 December 1996. Samples were taken with 200 μm Nansen net, 255 cm in length, 54 cm in diameter, by hauling speed of 0.5 ms^{-1}, in the depth layer 0-75m. All samples were preserved in 2.5% formaldehyde, neutralized with a calcium carbonate buffer.

Results and discussion

At P-100 station a regular seasons successions of cladoceran species was noted. *Penilia avirostris* Dana 1849 was dominant species (fig. 2.) with portion of 97% in whole number of cladocerans with the maximum number of 827 ind.m^{-3}, found on 26 September 1996. *P. avirostris* always dominated during the summer (2, 4, 6). *Evadne spinifera* P. E. Müller 1868 was the second quantity important cladocera at this station. It is the most common open water species with optimal salinity values of 38.1 psu that clearly indicates the influence of open sea waters and stability of environment (11, 4). Maximum 31 ind./m^3 was found on 4 July 1996. (fig. 4.). *Evadne tergestina* Claus 1862 was noted from the beginning of July till the end of October with maximum 7.6 ind./m^3 on 26 September. It was not found during the winter (fig. 3.). *E. tergestina* shows similar seasonal fluctuations in abundance as *P. avirostris*. *Evadne nordmanni* Loven 1836 is rare species at the investigated station. It is found in only 16% samples (fig. 3.), particularly represented in the winter period from 26 February till 17 May 1996. Maximum number of *Podon intermedius* Lilljeborg 1901 (fig. 4.) 37 ind./m^3 was found on 23 May 1995. On the contrary, one year later, on 24 May 1996 only one specimen was found. Adriatic cladoceran species *P. polyphemoides* was not found because it preferes low salinity coastal waters. It is numerous in pollution harbor areas (12) as it is in Marseilles Bay (13, 14). The observed changes show progressive influence of open sea waters at P-100 station, despite of small vicinity of the investigated station from the coast.

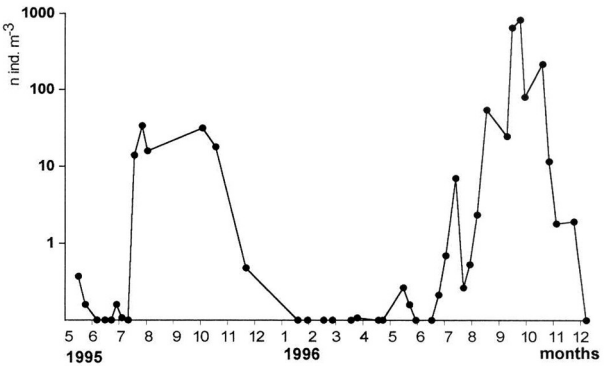

Fig. 2. Number of individuals of species *Penilia avirostris*

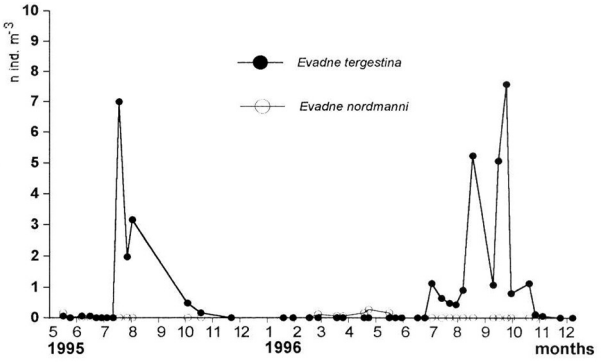

Fig. 3. Number of individuals of species *Evadne tergestina* and *Evadne nordmanni*

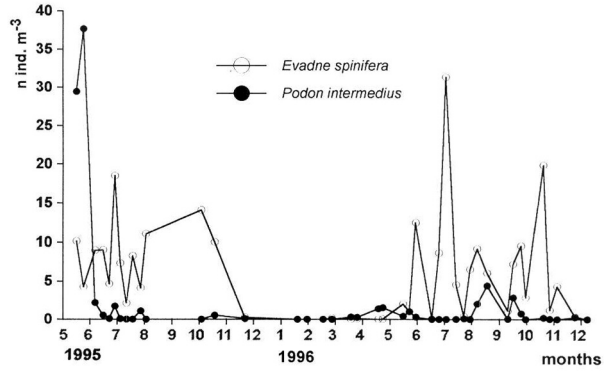

Fig. 4. Number of individuals of species *Podon intermedius* and *Evadne spinifera*

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MARINE TURTLES, MAMMALS AND SEA BIRDS CAPTURED INCIDENTALLY BY THE SPANISH SURFACE LONGLINE FISHERIES IN THE MEDITERRANEAN SEA

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Abstract

The Spanish surface longline fishery in the Mediterranean target swordfish, bluefin tuna and albacore using appropriate gears according the target species and year period. In 1999 and 2000 a total of 798 fishing operations of drifting longline fisheries were controlled by an onboard observers program. 2127 specimens of two species of marine turtles (*Caretta caretta* and *Dermochelys coriacea*), three species of marine mammals (*Stenella coeruleoalba, Grampus griseus* and *Ziphiidae* sp.) and four sea bird species (*Calinectris diomedea, Larus cachinans, L. fuscus* and *Morus bassanus*) were captured during fishing operations. Loggerhead turtle (*Caretta caretta*) presented the highest interaction with drifting longline (97% of incidental catches), mostly during summer-autumn seasons.

Keywords : Mediterranean; Fisheries effects; Conservation; Turtles tagging

Introduction

The Spanish fishing fleets in the Mediterranean include trawlers, purse seiners, longliners and an artisanal fleet fishing with a variety of gears. The surface longline fishery is officially formed by 73 annually licensed boats, which increase fishing effort during summer, the main abundance period for the target species. During the last decades the target species was swordfish (*Xiphias gladius*) (SWO gear), but the last years, a part of the fleet have changed the gears component (hooks size and number, fishing depth and fishing area, etc) to capture bluefin (*Thunnus thynnus*, BFT gear) or albacore (*Thunnus alalunga*, ALB gear) (1). The surface longliners capture protected species incidentally, mainly marine turtles (2, 3) Data on other protected species are scarce for Mediterranean Sea. Fisheries can affect the sea birds negatively causing an unwanted mortality but also the effect can be positive, increasing the sea bird populations as a direct effect of availability of discards from industrial fisheries (4). The Medmaravis Symposium (Benidorm, October 2000) supported the existence of some interactions between fisheries and sea bird in the Spanish Mediterranean area (5, 6) but also the lack of information from fisheries fishing in open sea, including surface longlines.

There is poor information on Spanish surface longlines and interaction with marine mammals. An EU project on direct fisheries effects in Western Mediterranean, showed marine mammal mortality in Western Mediterranean Sea due to incidental captures in driftnets close to Gibraltar Strait. Pelagic drifting nets are prohibited by Spanish authorities. A report of the Spanish Cethology Society showed an important number of marine mammals stranded along the Spanish Mediterranean coast, but details on direct relations between mortality and fisheries are uncertain.

Methodology

From 1999 to 2000 the Spanish onboard observer program was fulfilled in the Mediterranean. The main objective was to provide to the National Fisheries Authority with regular information on target species captured by the Spanish surface longlines, in order to implement the national and international regulations. During the same period, an EU Project on the incidence of the longlines on marine turtles give us the opportunity to increase the number of onboard observations to monitoring the Spanish fishing fleet at Western Mediterranean. The fishing area covered by both, national and EU Project include all western Mediterranean Sea, where Spanish fleet operate. To better use the investment, on board observers taking not only data related with target species, fishing areas, fishing operations but also information on non target species. Complementary forms and identification guides on non target species (sharks, turtles, mammals, sea birds) were provided to the observers after a training course at the Laboratory.

A total of 27 fishing vessels from 5 fishing ports (Aguilas, Carboneras, Cartagena, Garrucha and Motril) were used as platform for the observer Program, 11 vessels in 1999 and 16 in 2000.

Results

The most important incidence of the surface longlines affects marine turtles (n=2127), most of them were liberated hooked but alive. All the marine turtles captured were loggerhead turtle (*Caretta caretta*) except one leatherback (*Dermochelys coriacea*) each year. The onboard work included a tagging program of turtles taken onboard to study recapture events and ecology of population. 551 loggerhead turtles (*Caretta caretta*) were tagged. Three tagged loggerheads were recaptured by the fishermen hooked and two other stranded but alive.

Table 1 presents a summary of the total directly observed captures of marine turtles, sea mammals and sea birds during the observed period.

As showed Table 2, three species of cetaceans were captured, usually entangled with fishing line. Most of the marine mammals caught during 2000 fishing season were captured during summer and autumn season in an area from south Mallorca Island to Gata Cape. Striped dolphin (*Stenella coeruleoalba*) and Risso's dolphin (*Grampus griseus*) were the affected species. An unidentificated beaked whale (*Ziphiidae*) was also found entangled in a longline.

Regarding sea birds, sea gulls (*Larus cachinans, L. fuscus*) and gannets (*Morus bassanus*) were captured close to shore in depths under 100 m. in the coastal area between 37 an 38 degree north and in the Mallorca Islands coast. Manx shearwater (*Calinectris diomedea*) were incidentally caught in offshore waters.

Incidental catches of spanish surface longline include 2 species of marine turtles, 3 species of cetaceans and 3 species of seabirds. The monitoring of fisheries will be necessary to asses possible long-term effects on populations and to comply with International Action Plans and conservation policy.

Table 1. Incidental observed captures of marine turtles, sea mammals and sea birds and fishing effort from 1999 to 2000.

Year	Effort (fishing sets)	Effort (hooks)	Marine turtles	Marine mammals	Sea Birds
1999	291	907.148	499	3	10
2000	507	1.303.649	1628	12	42
TOTAL	**798**	**2.310.797**	**2.127**	**15**	**52**

Table 2. Marine turtles, mammals and sea birds caught by drifting longline fisheries from 1999 to 2000 by type of gear.

		1999			2000				
Species		ALB	BFT	SWO	ALB	BFT	SWO	Total	%
Loggerhead turtle	*Caretta caretta*		293	205	61	391	1175	2125	96.90
Leatherback turtle	*Dermochelys coriacea*			1			1	2	0.09
Cory's shearwater	*Calinectris diomedea*	5		1	3		6	15	0.68
Yellow-leddged gull	*Larus cachinans/fuscus*	3		1			20	24	1.09
Gannet	*Morus bassanus*	1					13	14	0.64
Striped dolphin	*Stenella coeruleoalba*	1		2			4	7	0.32
Risso's dolphin	*Grampus griseus*					2	5	7	0.32
Beaked whale	Ziphiidae sp.						1	1	0.05

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TRAWL FISHERY DISCARD IN THE SICILIAN CHANNEL

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Abstract.
The amount and composition of by-catch discarded by shrimp trawl fishery in two zones of the Sicilian Channel was studied between January and August 1993. The total catch in weight was composed of 55% landed and 45% discard. Bony fish were the largest component of the discards in both zones followed by cartilaginous fish. The weight of discard produced per kilo of pink shrimp was 3.8 and 0.8 in north and south area respectively.

Keywords: Trawl surveys, demersal, Sicilian Channel

Introduction.

Most fisheries catch a consistent number of non-target species which form the by-catch. Part of this by catch is retained, the rest is discarded. Between 17.9 and 39.5 million tons of marine organisms are discarded each year in commercial fisheries all over the world (1). The highest quantities of discards are from the Northwest Pacific region and tropical shrimp trawl fisheries. Among the many fisheries producing discards, demersal trawl fishery, being less selective than other fisheries and for the particular mode of action, results in the greatest level of discards (3). Such a kind of fishery is one of the most practised in Sicily. The main target species of the Sicilian Channel trawl fishery are *Aristaeomorpha foliacea, Aristeus antennatus* and the deep-water pink shrimp *Parapeneus longirostris*. This fishery also produces important by-catches of *Merluccius merluccius, Nephrops norvegicus, Mullus barbatus* and *M. surmuletus*. The aims of this study were to measure the composition and biomass discarded by the pink shrimp trawl fishery operating in the Sicilian Channel.

Material and Methods

Evaluation of discard production was carried out in the Sicilian Channel by observers on board of commercial trawlers to obtain more realistic estimates than those obtained from randomial surveys (3). The two zones of the Channel considered in the study were north (near Cap Bon) and south zone (near Pelagian Islands). Two different professional trawlers of the Mazara fleet were used for a spring survey in south and three season surveys (winter, spring, summer) in north. A total of 118 hauls, carried out from January to August 1993, were conducted on pink shrimp ground, from 151 to 462 m of depth. The organisms caught were divided by fishermen in two fractions, commercial and discard, and identified to the lowest possible taxon by researchers. All the species or taxa of the commercial and discard fractions were weighed before storing or discarding.

Results

The average catch over all the trips was 64 kg/hour in north and 99 kg/hour in south. Bony fish were the largest fraction of the total catch in weight (68%), followed by crustaceans (22%), cephalopods (4%) and cartilaginous fish (4%). The total catch was composed of 55% landed and 45% discard. In the north area, 58% of the landed catch was represented by bony fish and 29% by crustaceans; on the contrary, in the south area, crustaceans were 78% of the landings, 99.6% of which was pink shrimp, and bony fish were only 17%. In both areas, bony fish were the largest component of the discards, reaching 96% in the south area (fig. 1). 194 taxa were recorded : 85 bony fish, 36 crustaceans, 23 cartilaginous fish, 19 cephalopods, and 31 among bivalves, gastropods, sponges, cnidaria, echinoderms and brachiopods. Of those: 53 bony fish, 28 crustaceans, 13 cartilaginous fish, 6 cephalopods, and all the other taxa were completely discarded. 55 of the total taxa were present in both landings and discard. In the north area bony fish component of the discard consisted mainly of silvery pout *Gadiculus argenteus* and undersize specimens of hake *Merluccius merluccius*, followed by shortnose greeneye *Chlorophthalmus agassizi* and Atlantic horse mackerel *Trachurus trachurus*. In the south area, blue whiting *Micromesistius poutassou* dominated the discarded fish, followed by hake and Atlantic horse mackerel. Among cartilaginous fish, almost all skates were discarded in both areas, the gray skate *Raja batis* being the species most discarded. Most of the crustaceans discarded consisted on pandalids *Plesionika* sp., true crabs (Brachiura) and pink shrimp. Most of the cephalopods discarded belonged to the family Sepiolidae. Pink shrimp in both zones were discarded in a percentage lower than 1% of the total commercial pink shrimp caught; 25% and 81% of hake were discarded in north and south area respectively. The weight of discard produced per kilo of pink shrimp was 3.8 kg in north zone and 0.8 kg in south zone.

Discussion

Discard from trawlers represents a high incidence anthropic source of alteration for marine ecosystems. In the Mediterranean, an intense fishing activity producing great quantities of discard is represented by shrimp trawling. This fishery mainly acts on pink shrimp *P. longirostris*, the most interesting demersal resource of the epibathyal layer (between 200 and 450 m), especially in the Sicily Channel and in the Ionian Sea where it is particularly abundant (2). Pink shrimp is exploited all year round in these areas and almost the whole catch is marketable, the biggest specimens being of greater commercial value. During the usual fishing operations, Sicilian fishermen tend to maximise trawling time, as in other fisheries (4), in order to increase the total catch. Longer trawl hauls increase the amount of discard fraction, cause more damage to organisms and increase sorting time per haul which consists in higher mortality of discard species because of the exposure on the deck for a long time, particularly in summer time. By the results appears that about half of the total trawl catch is thrown back into the sea as dead or alive organisms. Moreover, data suggested a discard to shrimp weight ratio of 2.5:1 that is lower than those reported in literature for the same area and for shrimp world fisheries (1). The greatest majority of the by-catch is discarded, as is usual for Mazara's off-shore fisheries practicing trips of 18-20 days. This big amount of discard results in a high mortality and wastage of precious resources often returned to the sea to feed birds, epipelagic organisms and benthic scavengers. This produces also an increase of opportunistic small sized and fast growing species at the expense of large size more sensitive and vulnerable species. No significant differences in composition and weight between the two areas have been recorded. Seasonal pattern resulted in a higher discard in summer because of the high number of recruits caught (2) that usually are discarded. The only exceptions are juveniles of hake a part of which is sorted as marketable. The great quantity of discards produced by trawl fishery may have considerable impact on marine ecosystems, as it represents additional food for scavengers and could alter the composition and behaviour of communities living in the exploited grounds.

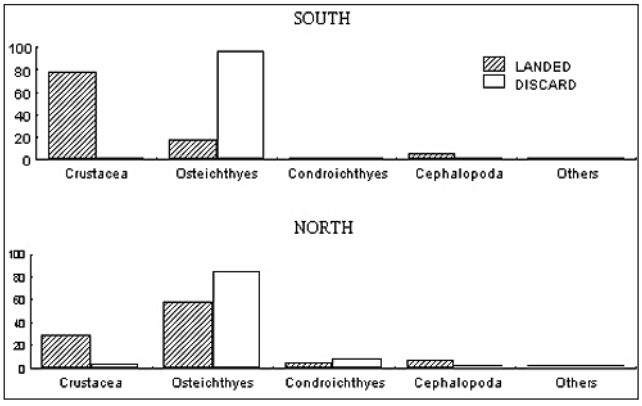

Fig. 1. Percent distribution of the five groups recorded in the two fractions of the total catch per area.

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SEASONAL STRUCTURE OF FISH LARVAE ASSEMBLAGES IN THE PAGASITIKOS GULF (GREECE)

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Abstract
Temporal abundance and species composition of fish larvae assemblages in the Pagasitikos gulf for the period January 1999-September 1999 are described. Seasonal differences in species composition and abundance in the study area appear to be associated with differences in the environmental conditions, particularly with temperature. Larvae of small pelagic fishes such as Engraulidae and Clupeidae, as well as larvae of shore-fishes, such as Gobiidae dominated the ichthyoplankton. Both larval diversity and abundance were higher by an order of magnitude in July and September 1999, corresponding to warmer waters.

Keywords: Ichthyoplankton, fishes, larvae, reproduction

Introduction

Information on species composition, distribution and abundance of eggs and larvae of marine fishes has great importance for the study of the population structure of exploited stocks, for understanding the reproduction rate of a population, and the fisheries exploitation of new areas.1,2,3 The objectives of the present work are to study the abundance and distribution of fish larvae in the Pagasitikos gulf in order to identify seasonal differences in larval compositions and by using the occurrence of fish larvae in the plankton to determine to limits of the spawning period of adults.

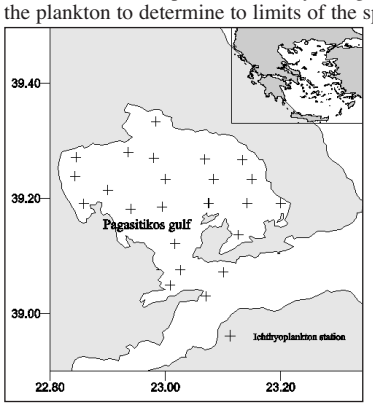

Figure 1. Map of the study area

Material and methods

A grid of 23 stations was designed in the study area (Fig 1), in which six ichthyoplankton surveys took place at January, April, May, June, July and September 1999. With the exception of a few stations that could not be resampled mainly due to the bad weather's conditions, the same stations were carried out repeatedly in each of the six ichthyoplankton surveys. Plankton hauls were made using a Bongo net with mesh sizes of 300 and 500 μm. Hauls were taken obliquely at a ship's speed of 2.5 knots, from just above the sea bottom to the surface. Continuous recording of temperature and salinity have been obtained using SEA CAT SBE 19 CTD.

Results and discussion

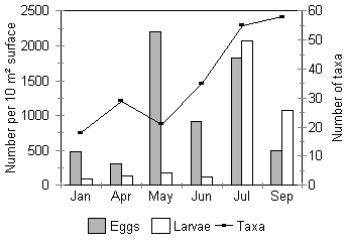

Figure 2. Average abundances (number per 10 m^2 surface water) of the total eggs and larvae and number of larval taxa, collected during the six cruises in the Pagasitikos gulf.

A total of 90 taxa of fish larvae have been identified representing 38 families. A list of the families of fish larvae for each survey, including relative abundance per cruise, is given in Table 1. The maximum egg abundance in the plankton was observed in May with 2196.69 egg per 10 m^2 and the minimum in April with 304.2 eggs. The maximum larval abundance was observed in July with 2071.49 larvae per 10 m^2 and the minimum in January with 84.59 larvae. The maximum species richness value for the fish larvae was found in September with 58 taxa and the minimum in January with 18 taxa (Fig 2). The average surface temperature (±SD) during the surveys were recorded at 12.21 °C * 0.54 in January, 13.81 °C ± 0.79 in April, 17.65 °C ± 0.96 in May, 18.22 °C ± 1.06 in June, 21.73 °C ± 2.43 in July and 22.22 °C ± 1.28 in September.

Larvae of the small pelagic families Engraulidae and Clupeidae and larvae of the family Gobiidae dominated the ichthyoplankton making up the ~56,1% of the total catch. E. encrasicolus represented of the 32.65% of the total number of larvae recorded. Other taxa caught at high percentages were Gobiidae 1. (8.98%), *S. hepatus* (7.63%), *S. aurita* (7.61%), *T. mediterraneus* (6.59%), *C. macrophalma* (5.78%) and *C. chromis* (5,29%).

Taking into consideration the description of the ichthyoplankton assemblages during the six surveys, it is clear that the number of taxa and the egg and larval abundance exhibited fluctuation during the study period. Small and medium-size pelagic fishes like *E. encrasicolus, S. aurita, S. pilchardus* and *T. mediterraneus*, dominated the ichthyoplankton samples throughout the year. This indicates that the Pagasitikos gulf is an important spawning ground for small and medium pelagic fishes. Larvae of shore fishes (Gobiidae, Serranidae, Cepolidae, Blenniidae, Labridae, Pomacentridae e.t.c.) recorded at relatively high abundances, could be possible correlated with the wide continental zone of the study area.

Taking into account the temporal distribution of the larvae of the most abundant species/genus collected during the six surveys in the study area, it appears that the majority presents an extended occurrence in the plankton, lasting more than four months. The high values of the larval abundances and number of taxa recorded during the period between the end of summer and the beginning of autumn could be possibly correlated with the high water temperatures as well as the autumn peaks of phyto- and zooplankton in this area.

Table 1. Average abundances (number per 10 m^2 surface water) of identified larval families,collected during the six cruises in the Pagasitikos gulf.

Family	Jan	Apr	May	Jun	Jul	Sep
Apogonidae					2.3	3.5
Belonidae		0.1		0.2		
Blenniidae	0.2	3.2	6.4	9.2	1.0	0.9
Bothidae	5.6	8.5	0.1	1.6	41.2	49.0
Callionymidae	4.4	3.7	1.2	7.1	27.4	9.5
Caproidae					0.5	
Carangidae		0.3		1.1	199.1	44.4
Carapidae		0.1				0.8
Centrolophidae					0.5	
Cepolidae				2.0	76.4	135.9
Citharidae						20.8
Clupeidae	41.8	13.9	0.3	3.2	276.8	2.0
Cynoglossidae						23.0
Engraulidae		1.1	61.1	22.9	839.1	286.3
Gadidae	37.7	0.6				
Gobiesocidae	0.2					
Gobiidae	41.9	91.0	39.8	23.7	85.7	252.1
Labridae	0.0	1.5	7.4	2.4	12.3	7.3
Lophiidae		0.3		0.2		
Merlucciidae	0.2	0.3				0.1
Mugilidae		0.3	0.3		2.3	6.6
Mullidae	0.3				0.4	
Myctophidae	0.9	1.6	0.5	0.1	7.1	1.3
Ophichithidae					0.8	1.0
Ophidiidae					1.4	6.6
Pomacentridae				1.7	130.3	63.9
Scombridae				1.2	82.0	6.7
Scopthalmidae					0.7	0.1
Scorpaenidae					4.7	4.8
Serranidae			3.1	12.0	183.4	87.5
Soleidae	0.7				1.1	0.5
Sparidae	0.3	10.5	37.2	18.9	9.2	20.9
Sternoptychidae					0.1	
Syngnathidae				1.0		
Trachinidae					1.7	4.1
Trichiuridae	1.0				0.8	
Triglidae				0.6	25.4	10.1
Uranoscopidae					0.3	
Unknown-Destroyed	0.8	1.7	17.3	9.3	57.7	18.1

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ANCHOVY BIOMASS ESTIMATE BY THE DAILY EGG PRODUCTION METHOD IN THE SOUTH-WESTERN ADRIATIC DURING 1999

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The Daily Egg Production Method (D.E.P.M.) is applied to estimate the spawning biomass. It was developed in the 80s by the USA National Marine Fisheries to estimate the small pelagic biomass. Both the method and its applications are widely described in the NOAA Technical Report NMFS 36 text (1).The biomass estimate is based on the following equation:

$$B = \frac{kP_oAW}{RFS}$$

where B = the spawning biomass in metric tons, P_o = the number of eggs per sampling unit, (m^2 per day), A = total survey area (in m^2 per sampling units), W = average weight of mature females (grams), R = sex ratio (fraction of mature females by weight), F = batch fecundity (average number of eggs per mature female), S = fraction of mature females spawning per day, k = conversion factor from grams to metric tons.

This survey has been carried out within the program "Estimation of the Mediterranean anchovy (*Engraulis encrasicolus L.*) biomass by the daily egg production method in Tracian Sea (Greece) and South Western Adriatic Sea (Italy)", contract n. 98/040, financed by the EEC, in the Lower Adriatic Sea.

The survey was carried out between 30 August and 18 September 1999, both during the day and at night, covering most of the reproductive zone in the eastern arc of the lower Adriatic. Both the egg surveys and adult surveys were carried out using chartered research ships equipped with midwater otter trawls. In order to catch more adult samples were additionally used commercial vessels equipped with flying midwater pair trawls and purse seine. The sampling and data processing methods as regards the egg and adult campaigns has been described by Casavola (2, 3).

A total of 122 ichthyoplancton samples were collected by means of a CalVET net (0.250 mm mesh), raised vertically from a depth, when possible, of 100 m, covering a sea surface of 12,862 km^2. The egg sampling procedure was based on a 5 nautical mile path (stations and transepts), with 20 transepts. In the laboratory, teleost eggs were separated in plankton samples caught in a CalVET net and fixed in 4% formalin . Anchovy eggs were then counted and staged according to the degree of embryonic development (4) in order to calculate mortality rates using specific software "Stageage" and "Eggreg" (5, 6), starting from the concentration of embryonic phases (divided by area) and water temperature at a depth of –20 mt., recorded in each sampling station. The elaboration of the data relative to the positive stratum, obtained using a weighted nonlinear least squares regression (7), has made it possible to define a mortality curve using the classic model, $P_{(t)} = P_{(0)} \times e^{-zt}$, where t = the age in days, $T_{(t)}$ = the number of eggs/0.05m^2 of age t, $P_{(0)}$ = daily egg production/0.05m^2, z = daily instantaneous death rate.

From a total of 43 trawls, 22 adult anchovies were sampled. The parameters relative to the adults (W, F, S and R), as the number of individuals sampled was not always equal in every trawl, were estimated by means of average weighted and variances using the equations of Picquelle and Stauffer (8). The average weight of females, W, was calculated as the average weight of mature females per haul, all females in the sample were active spawners. 1078 females were used in the estimate of this parameter. It was necessary to adjust the weight of females which were in the hydrated condition, due to the water retention during hydration, using the regression : W = -0,1343 + 1,0607 x W^* where W^*, is the ovary-free weight of females with no hydrated eggs.

The batch fecundity, F, was estimated using the regression between batch fecundity and weight (without ovaries, W_h^*), of 97 hydrated females, carefully chosen from among the 133 caught during the campaign. The weight of the hydrated females used ranged from 6.7 to 33.0 g, the length from 11.1 to 17 cm, with an average weight of 17.2 g and average length of 13.9 cm. The resulting linear regression is $F = 58.973 + 372.38 \times W_h^*$ ($R^2 = 0.79$).

The fraction of mature females spawning per day, (S), was determined by hystological analysis of post-ovulatory follicles (PO) classified in three age bands (9): day-0 PO = 0-8 hours, day-1 PO = 9-32 hours and day-2 PO = > 32 hours. The S, given that the day-0 PO females are oversampled, is expressed as a fraction of females with day-1 post-ovulatory follicles.

The relationship between the sexes, (R), was calculated as a proportion of the mature females by weight.

Table 1 shows the D.E.P.M. parameters and the estimated anchovy biomass. From 1994 to 1995, in the Lower Adriatic sea, there has been an increase of anchovy biomass from 8,129 metric tons to 14,307 (2, 3). In 1999 a value of 10.361 metric tons has been found, showing a reduction by 25% of the stock in these later years. The daily fecundity value of the population of *E. encrasicolus* observed in 1999 in the Southern Adriatic sea (20.17 egg/day g of spawner) is lower than that reported by García et al., (10) and Garcia and Palomera (11) (69.8: Catalan sea and the Gulf of Lions; 69.6: Ligurian and N. Tyrrhenian sea), and significantly lower than results obtained by Palomera and Pertierra (12) (100.1: Catalan sea). In the latter case, the higher values of daily fecundity in the anchovy population is due to higher values regarding both egg production of the sample and laying frequency. The daily mortality rate (0.65) is similar to the values reported by Palomera and Pertierra (12) for the Catalan sea (0.56) and it is, instead, lower than the value reported by Garcia et al., (10) for the Catalan sea and for the Gulf of Lions (1.09) and in the Ligurian sea and the N. Tyrrhenian (1.55).

Table I. - D.E.P.M. parameters estimate of *Engraulis encrasicolus* population from the Apulian Adriatic Sea; coefficient of variation in parentheses. Survey 30 August – 18 September 1999.

D.E.P.M. Parameters	
Po1	1.875 (0.23)
Po	0.812 (0.10)
z	0.648 (0.27)
A Stratum 0 (km^2)	7,288
A Stratum 1 (km^2)	5,574
W	16.97(0.039)
F	6,379 (0.039)
S	0.102 (0.098)
R	0.529 (0.042)
DEPM Biomass (MT)	10,361 (0.642)

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AGE ET CROISSANCE DU CORB MEDITERRANEEN (*SCIAENA UMBRA* LINNAEUS, 1758) DES COTES TUNISIENNES .

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Résumé

Tous les ans une ligne d'arrêt de croissance hivernale s'inscrit en mai-juin sur les écailles de *Sciaena umbra*. Dans ce travail, les équations de von Bertalanffy sont déterminées pour les mâles et les femelles. La croissance linéaire souligne un dimorphisme sexuel qui s'accentue surtout à partir de la maturité sexuelle acquise à partir de trois ans. La modalité de croissance du corb est évoquée.

Mots-clés: Poisson, Sciaena umbra, croissance, scalimétrie, Méditerranée occidentale, Tunisie.

Sciaena umbra s'étend, dans l'Atlantique est, de la Manche au Sénégal; elle est aussi présente dans toute la Méditerranée et rare en mer Noire et mer d'Azov. Dans cette communication, des résultats, relatifs à la croissance de cette espèce sélectionnée pour être protégée [1], sont présentés et analysés pour une meilleure connaissance de sa biologie.

Matériel et méthodes

Les poissons ont été acheté mensuellement dans les marchés de la région de Tunis. Pour chaque corb on a relevé, les poids brut (Pb) et éviscéré (Pe), les longueurs standard (Lst) et totale (Lt), le poids du contenu stomacal (Ps) ainsi que le sexe. La détermination de l'âge a été réalisée par scalimétrie. La validation des rythmes d'apparition des lignes d'arrêt de croissance (L.A.C) a été obtenue par la méthode statistique classique de l'allongement marginal (Am). Les paramètres de croissance (Lst_{∞}, k, to) de l'équation de croissance linéaire de von Bertalanffy ont été estimés en utilisant le logiciel Fishparm [2]. Les relations taille-poids sont établies par linéarisation logarithmique selon la méthode des moindres carrés. La taille de première maturité sexuelle correspond à celle où, après examen macroscopique des gonades, 100% des poissons sont mâtures. Pour tous les corbs mâtures, l'indice de condition Ic = Pe x 100/ Lst^3 ainsi que l'indice de nutrition In = Ps x 100 ont été suivis en fonction des périodes du cycle sexuel. Lorsque cela s'avérait nécessaire la comparaison des moyennes a été faite au moyen du test " t " de Student pour un risque de 5 %; la nature des allométries a été évaluée en comparant les pentes observées à la valeur 3 à l'aide d'un test " t " pour un risque de 5 %.

Résultats et discussion

Les fluctuations de l'allongement marginal en fonction du temps traduisent que ses valeurs les plus élevées s'observent d'août à novembre alors que les plus basses s'enregistrent de décembre à juin (Figure 1); ainsi la croissance cesse en novembre, sûrement à partir du moment où la mer se refroidit, et reprend en mai-juin au plus tard lorsque les eaux se réchauffent; il y a bien formation d'un anneau unique durant l'année et la scalimétrie s'avère une méthode valide pour l'étude de la croissance de *Sciaena umbra*. La naissance du corb ayant lieu en juillet [3], environ 12 mois s'écoulent avant que ne s'inscrive chaque nouvelle L.A.C; aussi n'est-il pas erroné de considérer que l'âge réel (en année) du poisson correspond au nombre de L.A.C enregistré sur l'écaille.

Nous avons déterminé les équations de von Bertalanffy suivantes :

Femelles $Lst = 58{,}220 (1- e^{- 0{,}113 (t + 0{,}896)})$

Mâles $Lst = 38{,}55 (1- e^{- 0{,}207 (t + 0{,}557)})$

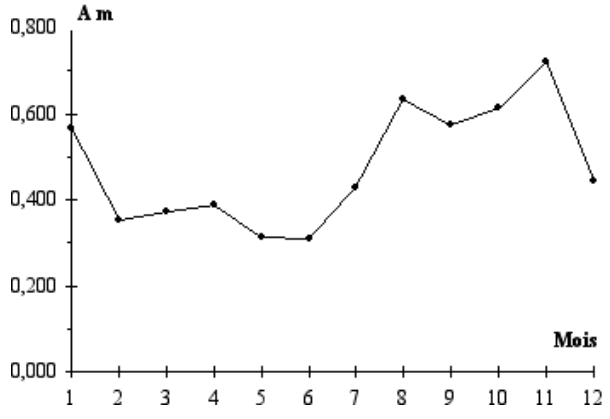

Figure 1 : Evolution mensuelle de l'allongement marginal (Am) sexes groupés

Le calcul des tailles prédictives aux différents âges indique qu'à âge égal et excepté la première année, les femelles sont plus grandes que les mâles, l'écart se creuse particulièrement à compter de la troisième année date d'acquisition de la maturité sexuelle. En effet tous les mâles et les femelles ont été estimés mâtures respectivement au-delà d'une longueur standard de 23 et 24 cm. La longueur asymptotique des femelles est plus élevée que celle des mâles. La valeur du taux de croissance (k) des mâles est inférieure à celle des femelles. Nous avons par ailleurs noté que nos tailles, aux différents âges, sont toujours supérieures à celles calculées par Chauvet [1]. Comme les poissons échantillonnés proviennent de la même zone maritime tunisienne nous pensons que ces écarts seraient essentiellement à mettre sur le compte de disparités dans le nombre de groupes d'âge des échantillons respectifs ainsi que dans les effectifs par groupe d'âge, bien que, nous ne puissions tout à fait exclure une divergence dans l'interprétation des pièces osseuses. L'analyse du tableau 1 nous aide à préciser la croissance de *Sciaena umbra*; ainsi pendant la saison froide, de novembre à mars, les valeurs élevées de l'indice de nutrition et de l'indice de condition attestent que le corb ne cesse de s'alimenter, qu'il grossit mais ne grandit pas. Puis, durant la période de maturation, d'avril à juin, l'indice de nutrition décroît sensiblement mais la condition du poisson se maintient puisqu'il utilise alors, pour mûrir ses gamètes, les graisses accumulées dans le foie durant le repos sexuel [3]. Au cours du fraye, en juillet-août, l'indice de condition est significativement à son plus bas et ceci est confirmé par l'allométrie de croissance négative constatée uniquement durant cette période (tableau 2.); cette baisse de l'embonpoint est aussitôt compensée par une reprise de l'alimentation. Ainsi durant la maturation et la ponte le poisson grandit mais ne grossit pas.

Tableau 1. Statistiques descriptives des indices de nutrition (In) et de condition (Ic) en fonction des périodes du cycle sexuel. n: effectif; m: moyenne; s : écart-type.

		In			Ic		
		Maturation	Ponte	Repos	Maturation	Ponte	Repos
Mâles	n	50	18	25	50	21	25
	m	1,029	1,237	1,609	2,305	2,220	2,305
	s	0,770	0,946	0,722	0,169	0,032	0,185
Femelles	n	64	24	49	65	26	50
	m	1,321	1,707	1,772	2,259	2,181	2,249
	s	0,787	0,871	1,516	0,233	0,042	0,184

Tableau 2. Valeurs des paramètres des équations de croissance relative log Pe = b log Lst + a en fonction des périodes du cycle sexuel, pour les mâles et les femelles. S: sexe, n: effectif, r: coefficient de corrélation, t: test d'allométrie.

Période	S	b	a	n	Moyenne		Variance		r	t
					log Lst	log Pe	log Lst	log Pe		
Maturation	M	3,070	-1,740	101	1,297	2,241	0,014	0,130	0,990	-
	F	2,997	-1,644	120	1,326	2,329	0,020	0,180	0,995	-
Ponte	M	2,907	-1,526	59	1,265	2,152	0,010	0,088	0,996	+
	F	2,880	-1,493	89	1,249	2,103	0,013	0,108	0,994	+
Repos	M	3,016	-1,665	78	1,276	2,182	0,009	0,082	0,993	-
	F	3,001	-1,649	134	1,239	2,069	0,017	0,152	0,995	-
Annuelle	M	3,016	-1,667	238	1,282	2,200	0,011	0,104	0,992	-
	F	2,975	-1,615	343	1,272	2,169	0,018	0,163	0,995	-

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CROISSANCE DU THON ROUGE *THUNNUS THYNNUS* PÊCHÉ EN MÉDITERRANÉE SUD OCCIDENTALE

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Résumé

Le thon rouge *Thunnus thynnus* fait l'objet d'une pêche industrielle depuis quelques années. Cette nouvelle situation se traduit par une modification de la structure démographique du stock capturable, objet d'une étude où sont fournis les résultats concernant la croissance. Les pièces osseuses pour déterminer l'âge présentent un remaniement qui masque les premières stries. Cet inconvénient a été pallié par une technique tendant à superposer sur les pièces opaques, les stries des premiers âges observées sur des pièces non remaniées appartenant à de jeunes individus . Les résultats obtenus ont été modélisés selon les équations de Von Bertalanffy et de Gompertz.

Mots-clé : croissance, migration

Introduction

La pêche du thon rouge *Thunnus thynnus* fait l'objet d'une exploitation saisonnière à caractère artisanal. En 1992, sous la demande croissante des marchés asiatiques, l'apparition d'une flottille industrielle rayonnant dans la quasi-totalité du bassin occidental de la Méditerranée, a modifié totalement l'ancienne stratégie d'exploitation caractérisée par des captures saisonnières littorales à la ligne morte et à la madrague. Les captures qui auparavant étaient relativement constantes, oscillant autour des 300 tonnes, sont passées brusquement à 500 tonnes, puis à plus de 700 tonnes en 1995, 1996 et plus de 800 tonnes en 2000, selon une estimation récente.

Si cette nouvelle situation présente un intérêt économique évident, les risques sur l'espèce, biologique et écologique sont réels, d'autant plus que des mesures législatives ont été prises pour étendre la limite des eaux sous juridiction nationale. C'est dans ce contexte qu'une étude a été menée à partir des captures commerciales de manière à caractériser la structure démographique du stock accessible, modifiée sous l'effet d'une nouvelle stratégie d'exploitation. Les résultats de la croissance sont présentés ci-après.

Matériel et méthodes

L'étude de la croissance a été menée par lecture d'âge à partir du premier Rayon Epineux de la Nageoire Dorsale REND, observé en coupe transversale sous lumière transmise.

L'étude porte sur 60 individus sélectionnés sur plus de 1000 spécimens capturés entre avril et juin 1997, et complétés par 05 individus juvéniles pêchés deux années auparavant. Seules 50 pièces osseuses ont fourni des résultats interprétables, soit un taux de lisibilité de 83%.

La procédure de préparation des pièces pour observation suit un schéma classique. Cependant, il a fallu élaborer une technique d'interprétation particulière en raison des remaniements de la matrice osseuse, ce qui se traduit par un recouvrement des premières stries situées près du nucleus. Afin de pouvoir discerner les premières stries chez les individus âgés, une méthode basée sur le principe de la diminution des accroissements avec l'âge a été appliquée. La position des premières stries a été calculée à partir de REND provenant de juvéniles capturés lors de leur apparition massive près des côtes algériennes durant l'hiver 94/95. Les individus mesurant entre 15 et 30 cm, et donc d'âge 0^+, présentent un nucleus dépourvu de stries. Le rayon des premières stries observées sur des pièces provenant de thons plus grands, mais de taille inférieure à 01,20 m, ont permis ensuite de positionner les âges I et II. Ces mesures ont ensuite été déduites de la matrice remaniée, et les bandes suivantes comptabilisées. L'âge a été ensuite comptabilisé à partir du nombre de bandes (hivernales) hyalines, en appliquant la convention du 1er janvier (1).

Les résultats de la clé âge-longueur, sous forme de couples de valeurs (t, l_F) ont permis de modéliser la croissance selon les modèles de Von Bertalanffy et de Gompertz (2). dans laquelle la longueur l_F représente la longueur à la fourche, classique chez les espèces présentant une caudale fourchue.

Résultats

La relation entre la longueur du poisson et le diamètre de la pièce osseuse, condition *sine qua none* de validation des observations, s'est avéré satisfaisante (tab. 1).

Tableau 1 : Relation L_F/R_T (R_T : Rayon Total de la pièce osseuses)

Equation	r	Etendue (cm)
$LF=1,23\ R_T + 0,018$	0.8	20 - 293

La clé âge-longueur obtenue (tab. 2) indique 07 groupes d'âge. L'écart inter-âge n'est pas systématiquement dégressif (tab. 2) en raison d'autres facteurs liés à la sélection de l'engin, notamment :

- pour l'âge 1: surestimation classique car les plus petits individus sont absents (phénomène e sélection de l'engin) ; cette hypothèse est vérifiée car :

• l'armement ciblait les gros thons péchés au longline à la profondeur moyenne de 60m correspondant à la thermocline, alors que les juvéniles sont généralement suprathermoclinaux ;

• le nombre d'individus de petite taille est relativement réduit dans les captures, correspondant à une profondeur moyenne élevée pour les jeunes âges ;

- pour l'âge 7^+ : sous-estimé, pour les mêmes raisons que précédemment mais dans l'autre sens, c'est à dire que les plus grands individus, rares en raison de la mortalité naturelle, sont peu représentés et plus profonds, ils échappent à l'engin, et la profondeur moyenne de cet âge est faible.

Tableau 2 : Longueurs moyennes (cm) obtenues par la lecture du REND

	Modèle linéaire de Von Bertalanffy			*Modèle pondéral de Gompertz*		
Paramètres	l_∞	K	t_0	W_0	G	g
Valeurs	298,5	0,24	- 0,315	38,36	1,92	0,46

Les équations calculées (tab. 3), indiquent les paramètres de croissance d'une équation en longueur pour le modèle de Von Bertalanffy et d'une équation pondérale pour celui de Gompertz. Il est aisé de retrouver l'équation pondérale du modèle de Von Bertalanffy à partir de la relation taille poids qui fournit :

- un coefficient d'allométrie voisin de 3 (b = 2,983) ;
- un poids éviscéré asymptotique de l'ordre de 798 kg.

Tableau 3 : Paramètres de l'équation de Von Bertalanffy et de Gompertz .

Age	**O**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**
$\bar{l}$ **(taille moyenne)**	25	82,5	119,2	160,5	191,3	215,0	243,2	265,8
Ecarts (taux de croissance)	57,5	36,66	41,34	30,75	23,50	28,21	22,62	
N total.	**5**	**3**	**6**	**7**	**7**	**8**	**9**	**5**

Discussion et conclusion

La méthode d'âgéage appliquée s'est avérée utile, même si certains écarts inter annuels ne sont pas dégressifs selon le principe de la croissance. Cette anomalie est liée à la particularité du thon rouge dont le développement est intimement dépendant de la quantité de nourriture disponible (petits pélagiques) et certains individus âgés peuvent avoir un taux de croissance faible si le milieu s'appauvrit (3).

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STRUCTURE DES POPULATIONS NATURELLES DE *MYTILUS GALLOPROVINCIALIS* LMK. DANS LE GOLFE DE THERMAIKOS

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Résumé

Les mytilicultures constituent les plus importantes aquacultures dans le Golfe de Thermaikos. Des recherches récentes ont mis en évidence la présence des populations naturelles considérables que dans 10 sites/stations. L'analyse de leur abondances ainsi que de la structure de ces populations ont révélé des variations significatives qui portent des relations directes avec la disponibilité du substrat dur, avec les phases de succession sur le substrat dur, ainsi qu' avec les niveaux différents de la pression halieutique exercée.

Mots-clés: Mytilus, Aegean sea, Population, Rocky shores, Zoobenthos

Bien que le Nord de la Mer Egée soit le site d'une intense aquaculture de moules, *Mytilus galloprovincialis*, depuis les 10 dernières années, il manque des données sur la biologie, la dynamique des populations et la répartition des réserves des populations naturelles de *M. galloprovincialis* (1). La connaissance de ces réserves contribue au développement de l'aquaculture des moules, vu que leur renouvellement ou remplacement joue un rôle important dans l' augmentation de leur production (2). Les buts de la présente étude sont d'une part de mettre en évidence la répartition du *M. galloprovincialis* dans le Golfe de Thermaikos, et d' autre part d'établir, pour la même région, la structure des populations de moules sur la base de la longueur de leur coquille. Parmi les 50 stations prospectées dans le Golfe de Thermaikos, seulement 10 sites /stations ont affirmé la présence de populations naturelles de *M. galloprovincialis* (Fig.. 1). Les données qui suivent concernent les résultats préliminaires de 10 réserves des populations naturelles de *M. galloprovincialis* .

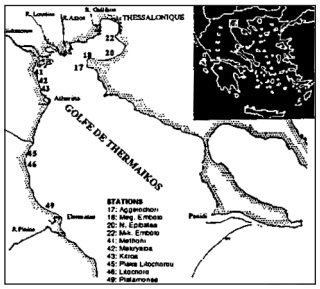

Figure 1. Localisation des stations

Matériels et méthodes

Le site d'étude se situe au long des côtes du Golfe de Thermaikos, sur une longueur de 257,4 km. Au total, nous avons prospecté 50 stations où nous avons noté la présence ou l'absence des populations de *M. galloprovincialis*. Chaque station est décrite après observation directe par plongée autonome et par prise de vue sous marine. Dans le cas où la population de moules était importante le prélèvement a été réalisé au hasard, en plongée autonome à l'aide d'un quadrat de dimensions de 20X20 cm (400cm^2) (1). Trois réplicats ont été pris à chaque station. Au total nous avons prélevé 30 échantillons quantitatifs. Les individus de *M. galloprovincialis* sont répartis en deux catégories en fonction de la longueur de leur coquilles (L en mm). Les moules ayant une longueur de coquille inférieure à 20 mm sont considérés comme juvéniles. La **L** a été mesurée à l' aide d' un vernier digital, et les mesures ont été effectuées sur le 1/4 de chaque échantillon, comme celui-ci a résulté après un sous-échantillonnage (100cm^2) (3). Le pas des classes des tailles de **L** est détermine à 3 mm, comme défini par Snedegore and Cochran (4). L'abondance moyenne (Ab) a été mesurée sur les 3 réplicats de chaque station. La comparaison de 10 stations d'étude à été réalisée après transformations logarithmiques des données à l' aide de l'Analyse de Variance (ANOVA) et de Fisher PLSD test (1).

Résultats et discussion

A. Abondance des populations - La comparaison de Ab entre les 10 stations a mis en évidence des variations significatives (F=2.7, p=0,03). Plus précisément, la station 42 présente des valeurs de **Ab** significativement supérieures par rapport aux autres stations (Fisher PLSD, t=342, p<0,05). Si nous considérons seulement les individus d'une longueur >20 mm, les 10 stations ne présentent pas de variations significatives en fonction de l' abondance (F=1.49, p=0.22). Ces différences s'expliquent par le fait que la population de la station 42 comporte un grand nombre de juvéniles (750+572 individus/400cm^2). Les populations d' individus >20 mm ne présentent pas de variations significatives. Néanmoins, dans le cas où le substrat propice à leur fixation fait défaut nous observons une grande concentration d'individus (surtout des juvéniles) sur une surface limitée. Cette observation met en évidence une relation de compétition intraspécifique au sein des populations. La comparaison entre les données obtenues et celles de travaux précédents (5) qui ont eu lieu au NE du Golfe de Thermaikos a mis en évidence une diminution significative de l'ordre de 2 l'abondance moyenne. Cette observation s'explique par la permission de pêche que subissent ces populations, sans ignorer la collecte des larves pour l'aquaculture.

B. Structure des populations - Les résultats de la Table 1 mettent en évidence que les variations de classes les plus marquées concernent les individus de petite taille (20-29 mm), de taille moyenne (30-50 mm) et de grande taille (>50 mm). Les individus de petite taille sont plus abondants aux ST 17 (68%) et ST 22 (62%). Les individus de taille moyenne sont plus abondants aux sites ST 20, ST 41, ST 42, ST 43, ST 45, ST 46 et ST 49, avec des valeurs comprises entre 47-82%. Les populations de ST 41 (43%) et ST 42 (16%) constituent la seule exception. L' absence d' individus de grande taille s'explique par la pression de pêche. En outre, il est à souligner que les populations des ST 41 et ST 42 sont favorisées par l'apport nutritif des rivières voisines.

Table 1. Distribution (en %) des populations de *M. galloprovincialis* par classe de taille dans les 10 stations de golfe Thermaikos.

		POURCENTAGE (en %)									
		ST 17	ST 18	ST 20	ST 22	ST 41	ST 42	ST 43	ST 45	ST 46	ST 49
CLASSE DE LONGEUR (mm)	20-23	23.529	1.119	13.793	5.833	0	12.844	7.438	1.869	0	6.977
	23-26	24.706	4.762	8.046	30.833	7.463	7.339	9.917	2.804	3.448	10.078
	26-29	19.412	7.143	8.046	25	1.493	5.505	9.091	7.477	5.172	10.853
	29-32	23.353	7.143	12.644	15.833	1.493	2.752	7.438	19.626	1.724	13.953
	32-35	4.706	8.33	10.345	10	2.985	2.752	4.959	16.822	1.724	14.729
	35-38	5.294	13.095	12.644	10	4.478	6.422	7.438	14.953	3.448	13.953
	38-41	0	19.048	18.391	1.667	5.970	7.339	11.57	14.953	10.345	10.853
	41-44	0	19.048	8.046	0	13.433	9.174	21.488	10.28	22.414	12.403
	44-47	0	13.095	4.598	0.833	7.463	14.679	7.438	6.542	32.759	3.876
	47-50	0	3.571	1.149	0	11.94	15.596	6.612	3.738	12.069	1.55
	50-53	0	2.381	1.490	0	11.94	7.339	4.959	0.935	5.172	0
	53-56	0	1.190	0	0	14.925	5.505	0	0	1.724	0
	56-59	0	0	0	0	7.463	0.917	0	0	0	0
	59-62	0	0	0	0	4.478	0	0.826	0	0	0.775
	62-65	0	0	0	0	4.478	0	0	0	0	0
	65-68	0	0	0	0	0	0	0.826	0	0	0
	68-71	0	0	0	0	0	0.917	0	0	0	0
	71-74	0	0	0	0	0	0.917	0	0	0	0
	74-77	0	0	0	0	0	0	0	0	0	0

La comparaison de la longueur moyenne aux 10 populations étudiées présente des variations significatives (F=65.125, p=0.0001). Seules exceptions sont les comparaisons des ST18vsST42, ST18vsST43, ST43vsST45, ST17vsST22 et ST49vsST20. Il est important de noter que plusieurs paramètres interviennent dans l'écosystème du Golfe de Thermaikos à savoir une pollution, une pêche et une aquaculture intense, ce qui rend difficile l'explication de nos observations. Néanmoins, on peut supposer que les données obtenues portent des relations directes avec la disponibilité du substrat dur (expl. ST42), avec les phases de succession sur le substrat dur (expl. 17), ainsi qu'avec les niveaux différents de la pression halieutique exercée (expl. ST18, ST43, ST45). En guise de conclusion générale nous constatons que la gestion est d'une importance primordiale pour le développement de l'aquaculture de la région. En outre, le présent sujet constitue un défit, tant scientifique qu'appliqué pour la gestion optimale des unités d'aquaculture dans le Golfe de Thermaikos.

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EFFECTS OF PHYSICAL AND CHEMICAL QUALITY OF THE SEA BOTTOM ON THE DISTRIBUTION OF THE SHRIMP *PENAEUS KERATHURUS* IN WESTERN GREECE

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Abstract

Sediment chemical quality and the associated aerobic and anaerobic chemical reactions on the sediment surface affect significantly the distribution and mortality of species that live on the sea bottom. The shrimp *Penaeus kerathurus* is native in Greek and Italian waters (Ionian Sea coasts). An important aspect of the biology of the species is that burrows in the sediment and therefore, pollution from the uses of the coastal human activities that degrade sediment quality affect the populations significantly. High concentrations of nutrients were measured in the habitat. resulting in high natural mortality and specific distribution patterns.

Keywords: sediment, Penaeus kerathurus, distribution

The shrimp species *Penaeus kerathurus* is endemic in North Mediterranean coast and an important fishery resource for Greece and Italy. The productivity of this stock has been decreasing the past 20 years as a result of pollution from coastal human activities and certain aspects of the species biology that hinder its survival potential. Most important of these aspects is the preference of the species to utilize closed gulf habitats, which are more susceptible to pollution and bioaccumulation of pollutants, which, in turn, reduce the survival rates of the species as well as the fishery productivity. The present study is focused on the Greek population of the shrimp *Penaeus kerathurus* located in Amvrakikos Gulf (Western Greece; Fig. 1). The data were gathered during the project 037/98/EU DG XIV [1].

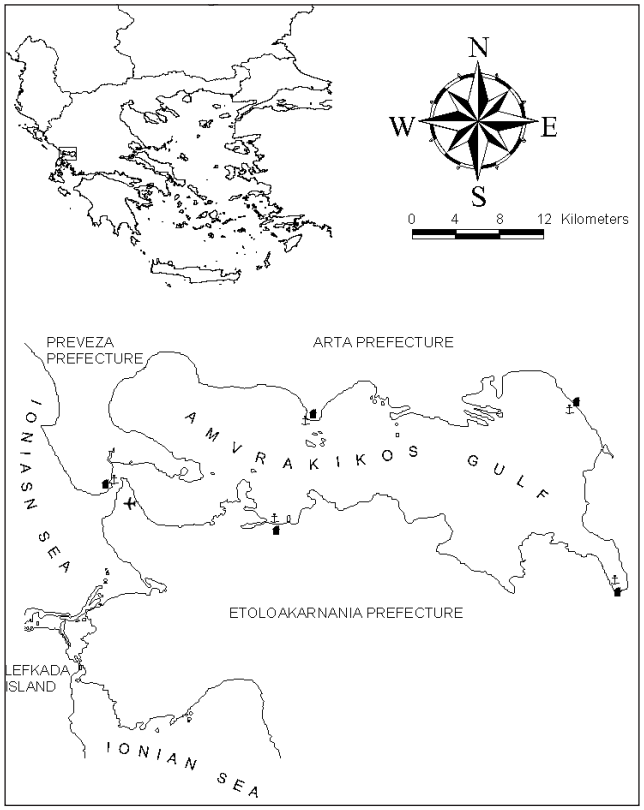

Figure 1. GIS map of the study area in Western Greece

The aim of the study is to analyse the population distribution patterns in Amvrakikos Gulf in relation to the physical and chemical quality on the sediment level taking into consideration the fact that the species lives on the sea bottom and usually burrows in the sediment. The means for this analysis is the fishery productivity index (C.P.U.E.; Catch Per Unit of Effort) in terms of landings (in g) per 1000 m of trammel net per month, which gives a direct indication of the distribution pattern of the shrimp in the Gulf. The physical and chemical parameters which were measured and used in the modelling, are: temperature (T; °C), pH, dissolved oxygen (mg/L and % saturation), Total Nitrogen (mg/L), Total Phosphorus (mg/L), sulfides (by product of H_2S, in ug/L) and a dummy variable (*AreaDummy*) which takes the values 1,2,3 and 4 for the West, North, South and East parts of the Amvrakikos Gulf. The dummy variable was included in the model in order to provide a spatial dimension of the fishery productivity. Cluster analysis of the four regions in Amvrakikos Gulf using all physical and chemical parameters, showed that there is a great similarity between the East-South and North-West regions at the 93% and 96% similarity level (Bray-Curtis dissimilarity index; [2]). The clustering of all regions occurs at the 70% level, which is high enough. The same results were obtained from Correspondence Analysis. The conclusion from these analyses is that the South and East parts of the gulf show high productivity (average C.P.U.E. =4630.1±456.8g) while the West and North regions show low productivity (average C.P.U.E. =2212.2±117.4g). The availability of the shrimps indicates that most of the population is gathered in the South and East regions of the Gulf. The productivity of the fishery, modelled using a simple multiple linear regression equation, showed significant correlation. The equation was found :

$$C.P.U.E. = -150.7 \cdot T + 868.2 \cdot pH + 62.9 \cdot DO(mg/l) - 39.9 \cdot DO(\%) - 225.7 \cdot (TotalN)$$
$$(-0.79) \quad (1.17) \quad (0.04) \quad (-0.38) \quad (-1.11)$$
$$+294.6 \cdot (TotalP) - 43.1 \cdot (S^{-2}) + 1402.3 \cdot (AreaDummy)$$
$$(1.16) \quad (-2.2) \quad (3.06)$$

r^2=0.938, P=0, d.f.=8,21, Durbin-Watson=2.434 (t-test in parentheses)

The high correlation showed that the C.P.U.E. index is affected significantly by the selected physical and chemical variables. The sensitivity of the C.P.U.E. to each parameter separately was analysed through a log multiple regression model. This model using the log10 values of the same parameters gave also a very good correlation. The log model is the following:

$$\log_{10} C.P.U.E. = +1.20 \cdot \log T + 15.2 \cdot \log pH + 4.9 \cdot \log DO(mg/l) - 8.34 \cdot \log DO(\%)$$
$$(-0.33) \quad (2.43) \quad (0.57) \quad (-1.2)$$
$$+0.18 \cdot \log(TotalN) + 0.522 \cdot \log(TotalP) - 0.219 \cdot \log(S^{2-}) + 0.763 \cdot \log(AreaDummy)$$
$$(0.19) \quad (0.54) \quad (-0.50) \quad (2.93)$$

r^2=0.902, P=0, d.f.=8, 26, Durbin-Watson=2.001 (t-test in parentheses)

The coefficients of the log model equal to the sensitivity of C.P.U.E. to each parameter. From the equation, it is clearly seen that temperature and dissolved oxygen (mg/L) are extremely important and affect positively C.P.U.E. Increase of temperature and/or dissolved oxygen (mg/L) will cause an increase of C.P.U.E. In addition, the Total Nitrogen, Total Phosphorus and the *AreaDummy* variables also affect positively the C.P.U.E. to a less extent than the others. The % saturation of dissolved oxygen shows a strong negative effect to C.P.U.E. The over-saturation values measured in various regions seem to affect the C.P.U.E. negatively. The conclusion of this study is that the physical and chemical quality of the sea bottom in Amvrakikos Gulf affects significantly the distribution of the shrimp population of *Penaeus kerathurus* as measured through the catch per unit of effort of the fishery activity in the area.

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SOMATIC AND OTOLITH GROWTH RATES OF ANCHOVY LARVAE FROM THE SICILIAN CHANNEL

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Abstract

Anchovy larvae (*Engraulis encrasicolus*) from the Sicilian Channel were collected in July 1997 in the area of Cape Passero under the framework of the EU project 96/052. Otolith microstructure, nucleic acids and protein content were analysed in the same larvae. Otolith and somatic growth rates showed a linear increase with larval age. Daily length increments (mm/day) were higher than those observed for anchovy larvae in NW Mediterranean. The relatively high rates of growth and the low values of the RNA/DNA ratio found could be due to the high regime of temperature found during the cruise. The RNA/DNA and protein/DNA ratios were related with recent otolith growth rate, indicating that for anchovy larvae both ratios were good predictors of recent larval growth.

Keywords : Sicilian Channel, Ichthyoplankton, Larvae, Growth

Introduction

The nursery grounds of anchovy larvae in the Sicilian Channel are located in the southern coasts of Sicily. As a result of the cyclonic circulation in this region, larvae are retained in this area. Otolith microstructure and larval condition analysis provide an insight on the effect of environment on the early life stages. Changes in the surrounding environment are reflected as changes in the width of the microincrements. In addition, the width of the most recently formed increments is used as a measurement of recent larval growth (1,2). The RNA/DNA ratio represents the rate of cellular metabolic rate, and as such, it is an indicator of the nutritional condition and the growth rates in larvae (3). Under experimentally controlled conditions, it has been shown that the RNA/DNA ratio is highly affected by environmental factors, namely temperature and prey density (3). Well-fed larvae and fast growing larvae show higher RNA/DNA ratios and wider daily increment deposition than starving larvae (1,3). This link between the condition analysis and the daily growth of the Sicilian Channel anchovy is shown in this document.

Material and Methods

During 19/07/97 to 8/08/97, a fish egg and larval survey (ANSIC-797) was carried out. In the region off Cape Passero, plankton tows were made with a Bongo 90 net. The tows were short in duration (~10 minutes). All tows were carried out during one night in shallow waters (~20 m depth). After capture, larvae were immediately sorted and conserved in liquid nitrogen. In the laboratory, anchovy larvae were thawed, measured for standard length by means of image analysis system, and weighed. The sagittae were extracted, mounted and increments were counted as described by 4. Nucleic acids and protein content were determined according to the results of a set of intercalibration exercises carried out under the EU funded project (PARS)(5). Standard length-at-age data were fitted using a power model where the intercept was fixed at 2.71 mm (6) in order to minimise any possible bias due to growth rate effects. Daily growth rates were calculated as described in Ramírez *et al* (7).

Results and Discussion

Standard length, wet-weight and otolith radius showed a power increase with larval age (R^2=0.81, R^2=0.80 and R^2=0.85, respectively). DNA (μg larva^{-1}), RNA (μg larva^{-1}), protein (μg larva^{-1}) also showed a power increase with larval age (R^2=0.73, R^2=0.81 and R^2=0.73, respectively). Somatic growth rates expressed as daily length increments (mm/day), daily wet-weight increase (mg/day), daily DNA increase (μg/day), daily RNA increase (μg/day) and daily protein increase (μg/day), showed a linear increase with age (Table 1). The daily length increment for an 8 mm larva was 0.62 mm/day. This rate is higher than daily growth rates reported for the Catalán Sea by García *et al*. (4), but lower than that reported by 6 for the Adriatic Sea anchovy.

Table 1. Linear regression analysis of the relationships between somatic growth rates and larval age (days).

Dependent variable (y)	Regression equation	R^2
Daily length increments (mm d^{-1})	y = 0,0107x + 0,5603	0,19
Daily wet-weight increase (mg d^{-1})	y = 0,1429x - 0,9656	0,89
Daily DNA increase (µg d^{-1})	y = 0,1467x + 0,1507	0,74
Daily RNA increase (µg d^{-1})	y = 0,5883x - 2,1499	0.88
Daily protein increase (µg d^{-1})	y = 13,647x - 98,967	0.89

The RNA/DNA ratios varied from a minimum of 0.98 to a maximum value of 4.24. The mean value of the population was 2.35. With respect to the Protein/DNA ratios the minimum and maximum values were between 4.61 and 86.73, respectively, with a mean value of 26.8. The RNA/DNA ratios were lower in comparison to those found by the other authors in anchovy larvae from the Mediterranean Sea (4; 8). The critical value of RNA/DNA ratio for most of fish larvae is around 1 (9). In this study 21% of the anchovy larvae analysed had a RNA/DNA value from 1-2, which can be considered near critical levels. This result may indicate that at least a 21% of anchovy larvae were under starving conditions. However, several authors have found a negative relationship between RNA/DNA ratio and water temperature (8; 10), where fish acclimated to cold temperature had higher RNA/DNA ratio than warm acclimated ones. The decrease of the RNA/DNA ratio with temperature is due to a compensatory mechanism for lower RNA activity, which produces an increase in RNA concentration (10). The high temperatures observed during the cruise (24.5ºC±1.0), could explain the low values of the RNA/DNA ratio found in this study and the relatively high rates of growth for anchovy larvae. Since RNA/DNA ratios is considered an indicator of recent larval growth, the relationship between average RNA/DNA ratios by age classes and recent otolith growth ROG were analysed. The RNA/DNA was positively correlated with ROG (μm) (R^2=0.55), indicating that the ratio was a good predictor of recent growth.

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MOUVEMENTS DES CETACES, EN PERIODE ESTIVALE, DANS LA MEDITERRANEE NORD-OCCIDENTALE

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Résumé

L'analyse des abondances relatives régionales des cétacés en Méditerranée nord-occidentale, au cours des quatre mois estivaux, fait apparaître un mouvement cyclonique des animaux associé à des déplacements relevant d'une convergence-dispersion entre différents secteurs. Ces mouvements sont certainement en relation avec ceux des masses d'eau et des organismes prédatés.

Mots-clés : Cetacea, Western Mediterranean, migration

Introduction

La richesse du Bassin Corso-Liguro-Provençal en terme de cétacés est connue, essentiellement en période estivale (1). Les animaux, dont la plupart sont absents en dehors de l'été, y viennent en grand nombre pour profiter d'une conjoncture courantologique générant des zones frontales à fortes productivités. Deux espèces sont communes, le Rorqual commun et le Dauphin bleu et blanc, et d'autres fréquentes (Cachalot, Globicéphale et Dauphin de Risso).

Matériel et méthodes

Cette étude se base sur les données récoltées par l'E.P.H.E., de juin à septembre durant les années de 1991 à 1998, selon la méthode du transect de ligne. Seuls les trajets effectués par vent et mer ≤ 3 Beaufort sont retenus (11687 Milles Nautiques, 10554 cétacés observés). La zone d'étude a été subdivisée, en se basant sur la topographie et la physionomie des fonds marins, en un domaine océanique (profondeurs ≥ 2000 m), trois secteurs sur la marge continentale (Golfe du Lion, Provence et Corse) et treize canyons importants.

Résultats

En juin, l'abondance relative des cétacés, toutes espèces confondues, est forte au " large " et dans quelques canyons (carte 1). En juillet la fréquentation du talus fait apparaître une arrivée massive des animaux par le sud, mais également par l'Ouest, tandis qu'on observe un maximum au large. En août on assiste à un déplacement vers les deux secteurs Nord de la zone, avec de fortes abondances relatives dans celui de Provence et une concentration particulière dans ses canyons. Enfin, en septembre, une translation générale s'opère vers l'Ouest.

Discussion

Si les distributions spatiales mensuelles des cétacés présentent des points communs pour les différentes espèces, des décalages temporels existent, très certainement dus au fait que ces espèces s'alimentent sur des organismes situés à des niveaux différents dans la chaîne alimentaire marine. Ainsi les Rorquals sont les premiers à arriver puisqu'ils se nourrissent de zooplancton. Les Stenella suivent de près, chassant les petits poissons planctonophages qui se développent rapidement. Les espèces teutophages apparaissent plus tardivement, traquant les céphalopodes, organismes à développement lent se nourrissant eux-mêmes des échelons inférieurs. Les mouvements observés semblent reliés à ceux des masses d'eau et des proies.

Conclusion

La Méditerranée nord-occidentale est une zone trophique capitale pour l'ensemble des cétacés, dont les déplacements suivent un mouvement cyclonique, lié à la courantologie globale (Courant Nord Méditerranéen), associé à un schéma de convergence-dispersion entre les différents secteurs. Peut-on réellement parler de migrations ou s'agit-il des déplacements de certaines populations à l'intérieur de la Méditerranée ? Le suivi d'individus par balises Argos et le développement d'études sur les espèces consommées par les cétacés devraient concourir à mieux connaître cet écosystème marin d'une grande richesse.

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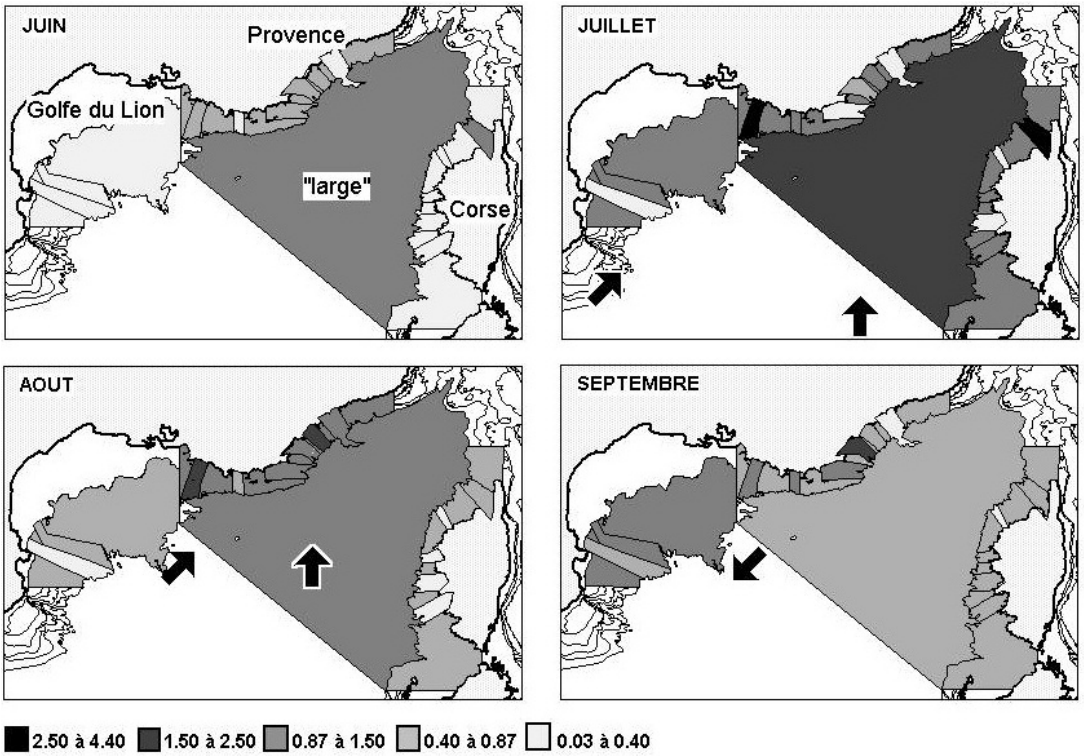

Carte 1. Evolutions mensuelles des abondances relatives (en nombre d'individus/mille nautique) des cétacés dans différents secteurs de la Méditerranée nord-occidentale

INVENTAIRE DES POISSONS DES CÔTES DE L'EST ALGÉRIEN

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Résumé

Un inventaire qualitatif de la faune ichtyologique est réalisé dans la région d'Annaba, sur des fonds hétérogènes, rocheux (à herbiers, corraligènes) et meubles (sableux, vaseux, sablo-vaseux, coquilliers), dans la tranche bathymétrique comprise entre 0 et 500 m. L'essentiel de l'effort d'inventaire concerne l'étage infralittoral (0 - 40 m). Une attention particulière est accordée à l'ichtyofaune de la frange côtière, entre 0 et 10 m. Les apports de la pêche professionnelle et les observations visuelles en plongée sous-marine nous ont permis d'identifier 165 espèces de poissons, dont 139 téléostéens et 26 sélaciens. Le premier groupe est représenté par 57 familles dont 21 familles de perciformes.

Mots-clés : Diversité, poissons, Méditerranée Est, Annaba.

Introduction

Sur les côtes algériennes, les compagnes océanographiques *Président Théodore-Tissier* et *Thalassa* (1) ont permis de connaître davantage les zones de pêche chalutables et d'estimer le rendement des principales espèces d'intérêt économique, mais l'inventaire des poissons reste incomplet, notamment en ce qui concerne les espèces côtières, souvent inaccessibles aux engins de pêche ou dont la valeur économique est faible. Depuis Dieuzeide *et al* (2, 3), seuls Djabali et al (4) ont tenté d'actualiser nos connaissances sur les poissons du littoral algérien. Nous présentons ici un inventaire des principales espèces inscrites par notre laboratoire depuis une quinzaine d'années, basé aussi bien sur les apports de la pêche professionnelle que sur les résultats de nos investigations sous-marines.

Matériel et méthodes

L'étude est réalisée dans le Golfe d'Annaba, entre le Cap Rosa (8°15' E et 36°58' N) et le Cap de Garde (7°16' E et 36°58' N), et à l'ouest de celui-ci, jusqu'au secteur communément appelé ''pain de sucre''. Le plateau continental est généralement étroit. Le fond marin débute par du sable fin dans le secteur Ouest, mélangé avec de la vase fine dans le secteur Est. Une ceinture discontinue d'herbiers à posidonie est installée sur des substrats rocheux et meuble tout le long de la côte. Au large du Golfe, le fond est constitué essentiellement de vase terrigène molle mélangée à du sable ou à des débris coquilliers.

La reconnaissance des différentes espèces est effectuée aussi bien sur les poissons pêchés (sennes, chaluts, filets monomaille et trémail, palangre, palangrotte et arbalète), qu'à partir des observations en plongée sous-marine (apnée et plongée avec scaphandre autonome). L'essentiel de l'effort d'inventaire a concerné l'étage infralittoral (0 – 40 m), au fond hétérogène (sableux, rocheux et à herbiers à posidonie). Une attention particulière est accordée à l'ichtyofaune de la frange côtière comprise entre 0 et 10 m. Dans cette zone, sont observées surtout les formes juvéniles, rencontrées sur les sites de plongée situés à l'Ouest de ''Ras El Hamra''.

Résultats et discussion

Nous avons inventorié 165 espèces de poissons, dont 139 téléostéens et 26 sélaciens. Au sein du premier super-ordre, 51 familles ont été déterminées dont 21 appartenant aux perciformes qui regroupent 66 espèces, soit 47,5% des téléostéens trouvés. Les sélaciens sont numériquement moins importants avec 7 familles de pleurotrêmes (13 espèces) et 5 familles d'hypotrêmes (12 espèces). Les Holocephales sont représentés par une seule espèce *Chimaera monstrosa*. En Méditerranée (zone de pêche 37), 124 familles et 532 poissons téléostéens ont été inventoriés. Les sélaciens englobent 13 familles, 27 genres et 45 espèces de squales contre 9 familles, 12 genres et 35 espèces de raies (5).

Dans la région d'Annaba, la richesse spécifique est assez variable selon les biotopes, avec une tendance à l'appauvrissement avec l'augmentation de la profondeur. Dans l'étage infralittoral, accessible en plongée, les observations montrent que les fonds accidentés et les herbiers à posidonie sont plus riches, qualitativement et quantitativement (notamment en téléostéens), que les fonds meubles. Sur ces mêmes fonds accidentés, on distingue aussi des différences dans la richesse spécifique qui seraient dues à la structure architecturale des fonds rocheux; les plus riches étant les plus hétérogènes, car il offrent une multitude de situations environnementales favorables (abris, paturage, frayère). Ces fonds abritent particulièrement des espèces grégaires et erratiques, comme les sparidés et de nombreux labridés, notamment *Coris julis* et *Thalassoma pavo*. Les labridés du genre *Symphodus* préfèrent les herbiers à posidonie à des profondeurs inférieures à 15 m. Les autres sparidés des fonds hétérogènes, comme *Dentex dentex, Pagrus pagrus, D. puntazzo, D. annularis, D. cervinus cervinus* et le Mullidé *Mullus surmuletus* sont relativement moins fréquents.

Dans les eaux superficielles du large jusqu'à – 200 m, les poissons les mieux représentés sont les sparidés (*B. boops, Pagellus acarne, P. erythrinus, P. bogaraveo, D. marocannus*), le Mullidé *M. barbatus*, le Xiphiidé *Xiphias gladius*, le Carangidé *Trachurus mediterraneus*, l'Engraulidé *Engraulis encrasicholus* et notamment les Clupéidés *Sardina pilchardus* et *Sardinella aurita*. Les captures des trois dernières familles sont relativement les plus importantes.

Sur les fonds de 200 à 400 m, on rencontre principalement dans les captures les Rajidés, les Scorpaenidés, le Merluccidé *Merluccius merluccius*, le Gadidé *Micromesistius poutassou* et le Mullidé *M. barbatus*. Au delà de – 400 m, on rencontre également les squales et les raies dont les débarquements sont insignifiants.

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Liste des poissons des côtes de l'Est algérien.

Sous classe : Elasmobranches

Alopiidae (*Alopias vulpinus*) Dasyatidae (*Dasyatis pastinaca, D. violacea*) Hexanchidae (*Hexanchus griseus*) Myliobatidae (*Myliobatis aquila*) Rajidae (*Raja meraletus, R. batis, R. oxyrinchus, R. asterias, R. clavata, R. radula*) Rhinobatidae (*Rhinobatos rhinobatos*) Scyliorhinidae (*Galeus melastomus, Scyliorhinus canicula, S. stellaris*) Sphyrnidae (*Sphyrna zygaena*) Squalidae (*Dalatias licha, Squalus acanthias, Centrophorus granulosus Etmopterus spinax*) Squatinidae (*Squatina squatina*) Torpedinidae (*Torpedo marmorata, T. Torpedo*) Triakidae (*Mustelus punctulatus, M. mustelus*)

Sous classe: Holocéphales

Chimaeridae (*Chimaera monstrosa*)

Super Ordre: Téléostéens

Anguillidae (*Anguilla anguilla*) Apogonidae (*Apogon imberbis*) Atherinidae (*Atherina boyeri*) Balistidae (*Balistes carolinensis*) Belonidae *(Belone belone*) Blenniidae (*Lipophrys nigriceps, L. trigloïdes, Parablennius tentacularis, P. gattorygine, P. sanguinoleutus, P. zvonimiri, Coryphoblennius galerita*) Bothidae (*Bothus podas podas*) Callionymidae (*Synchiropus phaeton*) Caproidae (*Capros aper*) Carangidae (*Lichia amia, Seriola dumerili, Trachinotus ovatus, Trachurus mediterraneus*) Centracanthidae (*Spicara maena, S. flexuosa*) Cepolidae (*Cepola macrophtalma*) Chlorophthalmidae (*Chlorophthalmus agassizi*) Citharidae (*Citharus linguatula*) Clupeidae (*Sardina pilchardus, Sardinella aurita*) Congridae (*Conger conger, Gnathophis mystax*) Dactylopteridae (*Dactylopterus volitans*) Echelidae (*Echelus myrus*) Engraulididae (*Engraulis encrasicholus*) Exocoetidae (*Exocoetus volitans*) Gadidae (*Gadiculus argenteus argenteus, Micromesistius poutassou, Molva diperygia macrophtalma, Phycis blennoïdes, P. phycis, Trisopterus minutus capelanus*) Gobiidae (*Lesueurigobius friesii, Gobius cobitis*) Labridae (*Labrus bergylta, L. viridis, L. merula, Thalassoma pavo, Coris julis Symphodus mediterraneus, S. roissali, S. tinca, S. ocellatus, S. rostratus, S. doderleini, Xyrichthys novacula*) Lophiidae (*Lophius piscatorius*) Macroramphosidae (*Macroramphosus scolopax*) Macrouridae (*Nezumia aequalis*) Maenidae (*Smaris chrysalis*) Merluccidae (*Merluccius merluccius*) Molidae (*Mola mola*) Moronidae (*Dicentrarchus labrax, D. punctatus*) Mugilidae (*Mugil cephalus, Chelon labrosus, Liza aurata, L. ramada, L. saliens*) Mullidae (*Mullus barbatus, M. surmuletus*) Muraenidae (*Muraena helena, Gymnothorax unicolor)* Myctophidae (*Lamanyctus crocodilus*) Nettastomatidae (*Faciolella physonema*) Ophidiidae (*Ophidion barbatum*) Peristédiidae (*Peristedion cataphractum*) Pomacentridae (*Chromis chromis*) Pomatomidae (*Pomatomus saltatrix*) Sciaenidae (*Argyrosomus regius, Sciaena umbra, Umbrina canariensis, U. cirrosa*) Scombridae (*Euthynnus alletteratus, Sarda sarda, Scomber scombrus, Thunnus thynnus thynnus*) Scophthalmidae (*Lepidorhombus boscii, L. whiffiagonis*) Scorpaenidae (*Scorpaena notata, S. elongata, S. porcus, S. scrofa, Helicolenus dactylopterus*) Serranidae (*Serranus scriba, S. cabrilla, S. hepatus, Epinephelus marginatus, E. caninus, E. costae, E. aeneus*) Soleidae (*Solea vulgaris, S. nasuta, S. senegalensis, Dicologoglossa cuneata*) Sparidae (*Boops boops, Dentex dentex, D. gibbosus, D. maroccanus, D. macrophthalmus, Diplodus annularis, D. cervinus cervinus, D. puntazzo, D. sargus sargus, D. vulgaris, Lithognathus mormyrus, Oblada melanura, Pagellus acarne, P. bogaraveo, P. erythrinus, Pagrus auriga, P. pagrus pagrus, Sarpa salpa, Sparus aurata, Spondyliosoma cantharus*) Sphyraenidae (*Sphyraena sphyraena*) Syngnathidae (*Hippocampus guttulatus, H. europaeus, Syngnathus sp*) Synodontidae (*Synodus saurus*) Tétraodontidae (*Ephippion guttiferum*) Trachichthyidae (*Hoplostethus mediterraneus*) Trachinidae (*Trachinus araneus, T. draco*) Trichiuridae (*Lepidopus caudatus*) Triglidae (*Eutrigla gurnardus, Aspitrigla obscura, A. cuculus, Trigla lucerna*)

REGIME ALIMENTAIRE DE *POMATOMUS SALTATRIX* (TELEOSTEI, POMATOMIDAE) DANS LE GOLFE DE GABES, TUNISIE

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Résumé

L'étude du régime alimentaire de *Pomatomus saltatrix* du golfe de Gabès montre qu'il est carnassier, essentiellement piscivore, ayant une prédilection pour les Clupeïdae et les Engraulidae. Il se nourrit secondairement et accessoirement d'autres espèces pratiquement toutes pélagiques.

Mots-clés : Teleostei, diet, Gulf of Gabes

Dans le golfe de Gabès, zone sud de pêche maritime en Tunisie, la production en *Pomatomus saltatrix* est régulière et importante. Cependant, aucune étude n'a été menée sur la biologie de cette espèce. Dans cette note, nous donnons quelques résultats relatifs à son régime alimentaire.

Matériel et méthodes

Pour cette étude, nous avons utilisé 654 individus de *Pomatomus saltatrix* de longueur totale (LT) comprise entre 109 mm et 445 mm. Les estomacs vides ont été notés. Les proies extraites des estomacs pleins ont été identifiées puis comptées et pesées par item. Le coefficient de vacuité (Cv) a été déterminé et ses variations ont été analysées en fonction des mois, par sexe. Pour étudier l'aspect quantitatif du régime alimentaire et pour classer les proies ingérées, nous avons déterminé pour chaque item les indices alimentaires : pourcentage en nombre (Cn), pourcentage en poids (Cp), coefficient alimentaire (Q) et fréquence d'occurrence (F). Le classement des proies a été fait selon la méthode de Hureau (1) et la méthode de Geistdoerfer (2).

Résultats

Globalement, le coefficient de vacuité de *Pomatomus saltatrix* du golfe de Gabès est en moyenne de 53,67%. Il ne varie pratiquement pas avec le sexe (55,85% pour les mâles et 53,33% pour les femelles). Par contre, ce coefficient est légèrement inférieur chez les individus de taille moyenne (longueur standard comprise entre 170 mm et 200 mm où il est de 48,98%) que chez les individus plus petits et plus grands où il est respectivement de 52,67% et 56,02%. Le coefficient de vacuité annuel supérieur à 50 % ne reflète pas la grande voracité présumée de cette espèce. Mais, il reste inférieur à celui des rascasses (Cv ≥59,83%) qui sont connues comme voraces (3) et à celui du petit pagre (Cv = 66,42%) (4).

L'analyse des variations mensuelles du coefficient de vacuité (fig. 1) a montré que, chez les deux sexes, les coefficients sont plus ou moins comparables pendant la période défavorable (janvier, février, mars, avril). Les femelles se remettent à bien se nourrir au mois de mai (Cv% = 33,33), pour compenser le déficit provoqué par les conditions difficiles. Quant aux mâles, ils gardent un appétit modéré jusqu'au mois d'août où ils se rassasient (Cv = 26,67%). Pendant la bonne saison qui coïncide avec la période de préponte, le (Cv) diminue chez les deux sexes, ce qui traduirait que *P. saltatrix* du golfe de Gabès se nourrirait et stockerait des réserves pour mener à bien le phénomène d'émission des produits génitaux. Au mois de septembre, les mâles surtout, ont un coefficient de vacuité très élevé, ce qui pourrait s'expliquer par le fait que leurs gonades occupent la majeure partie de la cavité abdominale. En octobre, bien que les gonades n'aient pas encore émis leurs produits génitaux en totalité, le coefficient de vacuité baisse chez les 2 sexes. La faim aurait-elle pesé sur ces poissons ou ces derniers auraient-ils été tentés par un banc de proies, en rejoignant leurs frayères. A notre avis, *P. saltatrix* du golfe de Gabès commence à ce moment à se nourrir davantage pour pallier le déficit qui pourrait être provoqué par la ponte.

Pour l'échantillon étudié comptant 303 estomacs pleins, le serre a ingéré en tout 356 proies (soit en moyenne 1,175 proies par estomac plein) pesant 990 g (soit 3,27 g par estomac plein et 2,78 g par proie). Les résultats relatifs aux indices alimentaires et le classement des différentes proies sont consignés dans le tableau 1.

La première constatation qui ressort de cette analyse est que le serre est essentiellement piscivore ; les Clupéidés et les Engraulidés sont des proies préférentielles ; les Athérinidés sont des proies secondaires. Les Céphalopodes qui constituent des proies accessoires, d'après la proposition de Hureau, deviennent au même degré que les Athérinidés c'est à dire secondaires d'après la subdivision de Geistdoerfer. Toutes les autres proies ingérées sont accessoires d'après Hureau et complémentaires d'après Geistdoerfer. Cependant, bien que les végétaux (posidonies) soient des proies accessoires ou complémentaires pour le serre dans les deux classements, nous pensons qu'ils sont pris avec d'autres proies. Les proies "indéterminées" et "poissons indéterminés" ont un coefficient Q élevé. Elles sont probablement des poissons appartenant aux familles déjà signalées, mais sont difficiles à déterminer à cause d'une digestion avancée.

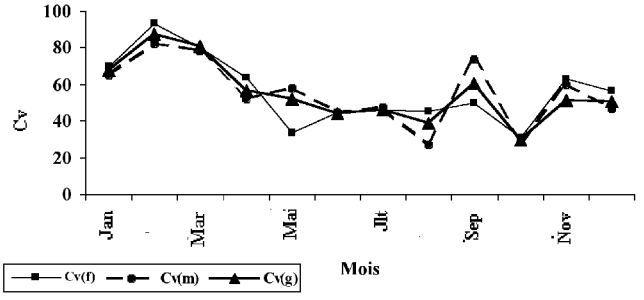

Fig. 1. Variations mensuelles du coefficent de vacuité (Cv) chez *Pomatomus saltatrix* du golfe de Gabès

Tableau 1 : Valeurs des différents indices alimentaires et classement des proies de *P. saltatrix* du golfe de Gabès. C1 (d'après Hureau) et C2 (d'après Geistdoerfer).

Proies	F%	Cn%	Cp%	Q	C1	C2
Ascidies	0,33	0,28	0,24	0,067	Accessoires	Complémentaires
Céphalopodes	3,96	3,37	5	16,847	Accessoires	Secondaires
Indéterminés	5,94	5,06	1,69	8,529		
Végétaux	2,31	1,97	0,45	0,886	Accessoires	Complémentaires
Crustacés	0,99	1,40	0,07	0,094	Accessoires	Complémentaires
Cnidaires	0,33	0,28	0,01	0,003	Accessoires	Complémentaires
Poissons	90,43	87,64	92,55	8811		
Clupeïdae	27,72	26,97	31,14	839,77	Préférentielles	Principales
Engraulidae	16,50	16,57	19,82	328,51	Préférentielles	Principales
Atherinidae	2,97	7,02	6,68	46,94	Secondaires	Secondaires
Poissons ind.	38,28	32,87	22,30	733,03		
Mugilidae	0,66	0,56	1,57	0,883	Accessoires	Complémentaires
Sparidae	1,32	1,12	4,06	4,556	Accessoires	Complémentaires
Centracanthidae	1,32	1,12	4,73	5,316	Accessoires	Complémentaires
Gobiidae	0,66	0,56	0,69	0,388	Accessoires	Complémentaires
Carangidae	0,99	0,84	1,55	1,305	Accessoires	Complémentaires

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THE OCCURRENCE OF THE LESSER WEEVER, *ECHIICHTHYS VIPERA*, IN THE EASTERN ADRIATIC

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Abstract
The occurrence, total number of individuals and day/night differences in catch with a small beach seine are reported for a population of lesser weever at Duæe Glava area, eastern middle Adriatic from April to December 2000. The highest catches in shallow water occurred in may, and were during both day and night (in April only night catch, while from October to December only day catches).

Keywords : fisheries, Adriatic

Introduction

The lesser weever, *Echiichthys vipera* (Cuvier), occurs from the Skaggerak and the Shetland Isles to the Atlantic coast of Morocco and the Canaries and throughout the Mediterranean, generally on sandy bottoms from the intertidal to 50 m depth (1). It is fairly rare and there is no data about its biology and ecology in the Adriatic Sea (2).

The aim of this paper is to present some new data on lesser weever from the eastern Adriatic.

Material and methods

Monthly small beach seine (total length is 22.40 m, wings length 10 m, place for collecting catch is 2.40 m in length, mesh size in wings is from 4 to 8 mm depending on part of wing, mesh size in place for collecting catch is 4 mm) sampling from April 2000 to Decembar 2000, at 4-h intervals over 24 h, revealed weavers at Duæe Glava area (near town Omis and River Neretva Estuary, 43°26'30"N 16°41'E) in the eastern middle Adriatic at depths between 1.5 and 2 m on clean sandy bottom. The fish were measured to the nearest 0.1 cm and weighed individually to the nearest 0.01 g. The length-weight relationship was calculated by equation: $W = aL_t^b$.

Results and Discussion

The total length range of individuals ranged from 2.7 to 15.7 cm (mean length = 7.81 ± 2.761), and the weight from 0.22 to 39.96 g (mean weight = 6.53 ± 6.317), and comparable with those reported by (3, 4), it is visible that the lowest total length value is recorded in our study. The slope of the total length-weight relationship indicate isometric growth (b=2.99), and the value of b is similar to those reported for the North Sea (4) and for Azores (3).

Lesser weever were most abundant in May (N=40), what is earlier than that found at Porto Pim Bay in Azores (3), and at the British and Dutch coasts (5, 4). Their numbers then declined gradually (Fig. 1) to a minimum in September and October (N=3). The catches of weevers were even during both day and night (in April only night catch, while from October to December only day catches) (Table 1) contradicting the results of (3, 5), whose fish were caught generally at night in the shallow water, and those of (4), whose fish were caught generally during day at their offshore sampling depth.

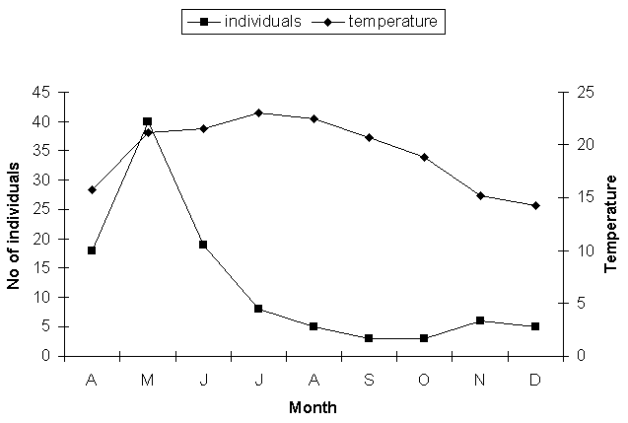

Figure 1. Monthly change in shallow water catches of lesser weever at Duæe Glava, eastern middle Adriatic, and sea temperature, from April to December 2000.

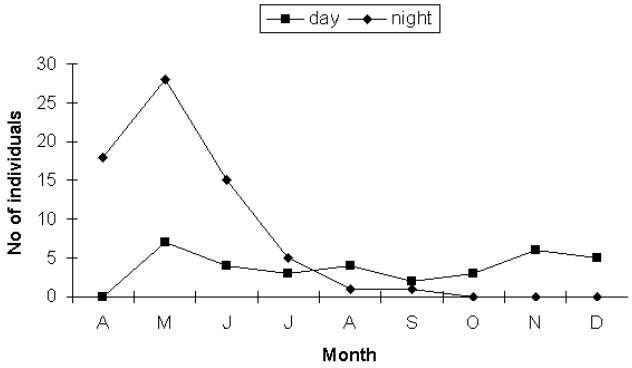

Figure 2. Day/night catches of lesser weever in shallow water at Duæe Glava, eastern middle Adriatic.

Table 1. Mean length (cm) and weight (g) of the catch (N=number of specimens).

month	N	Mean Lt ± SD (cm)		Mean Wt ± SD (g)	
		day	night	day	night
Apr	18	/	8,71±1,678		7,02±3,795
May	40	7,93±1,306	7,66±2,972	5,76±3,115	6,82±6,686
Jun	19	7,10±3,649	7,18±3,910	5,91±7,122	7,98±11,434
Jul	8	5,90±2,022	6,00±3,171	2,89±2,864	4,24±5,372
Aug	5	9,95±4,295	9,70	5,22±4,381	9,21
Sep	3	6,35±0,071	8,00	2,76±0,339	5,98
Oct	3	8,13±1,617	/	5,80±3,294	/
Nov	6	7,75±1,389	/	5,26±2,974	/
Dec	5	9,14±1,460	/	8,58±4,294	/

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FISHING OF NORWAY LOBSTER, *NEPHROPS NORVEGICUS* (L.), WITH LOBSTER POT IN THE VELEBIT CHANNEL (EASTERN ADRIATIC)

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Abstract
The effects of pots for Norway lobster on its population in Velebit Channel (northern Adriatic) were researched. It was found that pots have got no damaging influence on its. population in the researched area.

Keywords: fisheries, Adriatic Sea

Introduction

Catch of Norway lobster, *Nephrops norvegicus* (Linnaeus, 1758), in Croatian fisheries has a great commercial value. Its catch exceed total catch of all crusctaceans, or all shells together, and even catch of some commercially important fishes. The reason for that is its larger abundance and dispersion in the Adriatic in relation to other crustaceans and higher efficiency of fishing gear used for its catch. The area of its distribution has been spread and could be found in commercial quantities in many areas along the eastern Adriatic coast. Such area, among others, is Velebit Channel where this research was conducted. Catch of Norway lobster in Croatia, in last 10 years, varies between 500 to 600 tons per year (according to Croatian statistical data), but those data can be consider quite underestimated, because the data for Norway lobster are collected only from trawlers through their regular reports and none from fisherman who are using pots for Norway lobster (1).

The aim of this paper was, according to obtained results such as length structure, presence of immature specimens and sex ratio, to evaluate influence of pots on population of Norway lobster in Velebit Channel in order to protect it in the research area.

Material and methods

Research was conducted monthly during 1997. and 1998. in the area of Velebit Channel (northern Adriatic) on 7 general areas (see in Fig. 1). Fishing was carried out within 1NM from coast at depth between 70-80 m. The pot immersion time was usually one day except on occasions when bad weather conditions didn't allow lifting. Pots used for this research were made of netting material with mesh size not lower than 40 mm. Total of 12 077 pots was used and their dimension was 70x45x25 cm (Fig. 2). Pots were ordered in series of 20-40 pieces and time of immerse of the one series was 5 - 10 min, while time of its lifting was 35 - 45 min. Following parameters were determined for each specimen: total length (L_t) in cm, from tip of rostrum to posterior margin of telson, weight (in g) and sex. Fishing effort of pot was calculated according to average weight and number of specimens caught during one immersion of pot.

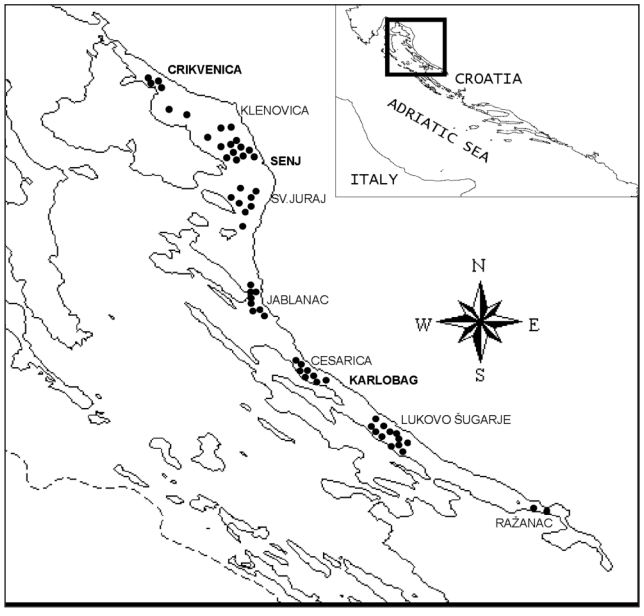

Figure 1. The research area - Velebit Channel (∑ - stations).

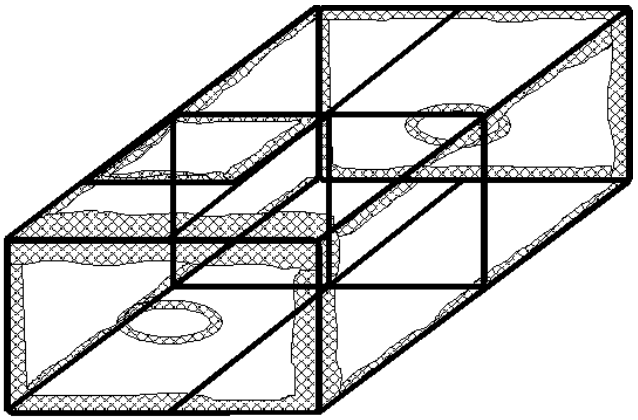

Figure 2. Pot for Norway lobster used in Velebit Channel.

Results and discussion

The total length of Norway lobster ranged from 9.5 to 19.5 cm (mean length = 12.5 ± 1.51 cm). Of the total specimens examined (N=6212) 2653 (42.7%) were male and 3559 (57.3%) females. The sex ratio was 1:1.34 in favour of female. Males were mostly dominant in length classes 12.0-12.5 cm (29%), and females in length classes 11.5-12.0 cm (45.2%).

Fishing effort of pot was 19.76 g, while number of specimens 0.57 for one immersion, and those are the lowest values according to results obtained by other authors for the same area and others in the eastern Adriatic : 78 g for 36+44 m pots (3), 66.7 g for 36+38+40 mm pots (4), and 96.87 for 36 mm, 71,86 for 40 mm, 64.90 for 44 mm pots (1).

According to recently finished research (2), the size of first maturity of Norway lobster in the eastern Adriatic was 9 cm, so it can be said that no immature specimens were caught in pots, because a minimum length of caught specimen was 9.5 cm. That means pots for catch of Norway lobster are selective fishing gear and it can be consider as fishing gear with no harmful influence on its population, because normal reproduction of species has been allowed.

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EMBRYONIC DEVELOPMENT OF SEA BASS, *DICENTRARCHUS LABRAX,* AFTER HORMONAL TREATMENT IN EGYPT

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Abstract

Human chorionic gonadotropin alone has been successfully used to induce spawning in *D. labrax* species. It is possible to obtain full ripe eggs during the spawning season with cumulative doses ranging from 3.37 to 4.90 IU of HCG per gram of total body weight of fish. Milt could be flown from male after injection with one or two doses ranging from 1.32 to 2.90 IU of HCG per gram. The fertilized eggs pass through various stages of embryonic development until the embryo becomes fully formed. By age 72 ± 4.0 hours after fertilization, the hatching process occurred (mean temperature:15 ± 0.60°C). On the third day after hatching, larvae start to take exogenous food of rotifers, at water temperature of 16.4 ± 4.0 °C.

Keywords : Fish, induced spawning, Egypt.

Introduction

The European sea bass, *Dicentrarchus labrax*, is an euryhaline species and can be found in the open sea as well as in lagoons and near river estuaries. Recently in Egypt, sea bass has been introduced in commercial aquaculture. Numerous studies on eggs and larval development of sea bass, *D. labrax* were carried out by many authors (1, 2). The control of reproduction, the various problems of larval rearing, and growth of *D. labrax* have also been studied. The present paper reports the results of induced spawning of *D. labrax* using chorionic gonadotropin injection, artificial fertilization and embryonic development. This knowledge may help to overcome problems in commercial aquaculture production by increasing the available amounts of sea bass juveniles.

Materials and methods

The species *Dicentrarchus labrax* studied in the present work were collected alive from the Mediterranean sea along El-Maadeia coast, during the period of spawning season (1995). After the collection of samples, the fish were transported in special aerated tanks in the hatchery located at Alexandria, Egypt. The ripe fish were held in tanks supplied with flowing sea water, good aeration and siphoned out daily for about (2-5) weeks prior to the beginning of each experiment. Their body length ranged from 33.2 cm to 45.0 cm, while their body weight ranged from 500 to1400 g. The fish were divided into two groups : The first group composed of 12 fish which were injected with two doses, ranging from 1000-2500 IU HCG/fish, with 48 hours interval. In the second experiment, 11 fishes (Females and Males) were injected with one single high dose ranged from 1000-5000 IU/fish, which was enough to cause ovulation. The response to the hormone treatment was studied.

The hand stripped method was used also for marking out different stages of embryos and their duration. After the start of the spawning, the individuals were stripped by the dry method. The eggs and milt were stripped manually with abdominal pressure. The milt was mixed gently with eggs without adding any sea water. After fertilization, eggs were washed with sea water and placed in aerated aquaria. The eggs were reared until hatching and their development was studied. The natural water temperature and salinity during the experiments fluctuated between 13 to 17°C and 36 to 38 ppt, respectively. Results and discussion

The results of these experiments showed that it was possible to obtain full ripe eggs (40% of total eggs spawned) from female sea bass, *D. labrax* during spawning seasons with cumulative doses ranging from 3.57 to 4.9 IU of HCG per grams of total body weight. On the other hand, milt could be flown from males after injection with one or two doses if required, with a total dose ranging from 1.32 to 2.9 IU of HCG per gram.

Embryonic development and hatching larvae

I. Blastodisc stage. When eggs were discharged by the female, they were translucent, spherical in shape and about 1.12 ± 0.02 mm in diameter. The whole egg was full of undifferentiated yolk material. The eggs exhibited two or four oil globules, with diameter ranging from 0.1 to 0.35 mm. A perivitelline space was formed at 30 minutes after fertilization, and comprised about 6-8% of the egg size. One hour after fertilization, the protoplasm was gradually differentiated from yolk so as to form a circular blastodisc which was about 0.75 mm in diameter, and 0.32 mm height.

II. Cleavage stages. At 1 hour and 50 minutes after fertilization, the first cleavage had been completed, giving two distinct elliptical blastomeres, with a length of 0.75 mm and height about 0.32 mm. Within 2 hours and 30 minutes, the second cleavage occurred at right angles to the first one, and four blastomeres became clearly defined. The third cleavage furrow appeared after 3 hours and 30 minutes parallel to the first cleavage producing the 8-cell stage. The fourth cleavage occurred after 4 hours and 30 minutes, parallel to the second giving rise to 16 blastomer stage. After 4 hours and 45 minutes the fifth cleavage produced 32 cells. Cell division continues and after 7 hours, the morula stage appears. The blastoderm, has a flat, multicellular body similar to the germinal disc. Blastula stage appeared at 9 hrs after fertilization. The blastomeres, were spread over half the surface of the yolk, while the germ ring appeared to be slightly getting thicker in the deeper layer at the edge of the blastodisc.

III. Gastrulation stage. At the 12 hr stage, the blastoderm had become symmetrical and spread over the whole surface of the yolk during the process of epiboly. During this stage, the embryonic shield was visible. By 15 hr, the embryo now apeeared as a slight fold (keel) of the blastoderm in the lower hemisphere of the egg.

IV. Organogenesis. At the 18 hour, the head had begun to be slightly differentiated. At stage 19 hr, the embryo was distinct throughout its length with the optic lobes, while the caudal swelling was evident on either side of the posterior extremity. The anterior part of the head is still fused with the yolk sac. At 22 hour the optic and olfactory lobes became more prominent. The melanophores start to appear on the head and trunk of the embryo.

V. Tail separation and embryo movement stages. At the 27 hour stage, the various parts of the brain were visible. A first trace of the olfactory placode could also be seen. The auditory capsules were plainly discernible as pits on either side of the posterior part of the head. The rudiment of the heart may be seen just below the olfactory lobe. At this stage, the tail was separated from the yolk. More or less, about 47 hr, the embryo was fully formed. The heart beats were more regular and the frequency of the movement of the embryo inside the egg membrane increased.

Larval stage. At temperature ranging from 15 to 17°C hatching occurred at the age of 72 ± 4 hours. The newly hatched larvae tended to float near the surface of the water. The larvae measured 3.0 ± 0.15 mm in length. The yolk sac was 1.025 ± 0.12 mm in length and 0.7 ± 0.10 mm in width; it contained one oil globule (about 0.35 ± 0.02 mm in diameter). The eyes were unpigmented and large. The body of the larvae was pigmented with melanophores. Two rows of melanophores were situated dorso-laterally on each muscle segment of trunk and tail regions.

On the third day after hattching, the mouth and the anus open, and the larvae started to take rotifers as exogenous food. The well developed mouth parts allowed the larvae feed on a mixture of Clorella salina and Brachionus plicatilis . The full absorption of the yolk occurred on the 6th day after hatching, almost at the same time as the oil globule absorption began. The convolution of the digestive track occurred on the 7th day after fertilization.

For two decades, *D. labrax* has proved to be an important species for marine fish culture(2) . Knowledge of the pattern of early larval development, particularly in reared fish, is important, as it facilitates aquaculture research and fish resources management(3). In the present study, *D. labrax* in captivity did not spawn naturally. Chorionic gonadotropin hormone was used to enhance gonadal maturation and to induce spawning.

In the present study, the fertilized eggs of *D. labrax* were transparent, buoyant and measured about 1.12 ± 0.02 mm in diameter with yolk diameter about 1.04 ± 0.03 mm. The same result has been recorded for this species(1).

The hatching occurred at about 72 ± 4 hours after the fertilization with temperature ranging from 15 to 17°C. In the present study, the newly hatched larvae measured 3.0 ± 0.15 mm and had a mean total length of 3.20 mm.

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ETUDE DE LA CROISSANCE DE LA SEICHE *SEPIA OFFICINALIS* LINNÉ, 1758 (CEPHALOPODA, DECAPODA) DE LA RÉGION NORD DE TUNISIE

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Résumé

L'étude a porté sur la croissance de la seiche *Sepia officinalis* des eaux tunisiennes par application de la méthode de Bhattacharya. Les paramètres de croissance et la clé âge-longueur sont déterminés par sexe et pour l'ensemble de la population. La durée maximale de vie est théoriquement estimée à 3 années au plus pour une longévité moyenne de 1.5 an. Le rythme de croissance est rapide durant la première année de vie de la seiche puis diminue progressivement en fonction de l'âge avec un ralentissement très accusé chez la femelle par rapport au mâle.

Mots-clés : croissance, Sepia officinalis, nord Tunisie, méthode de Battacharya.

Introduction

Les Céphalopodes ont longtemps posé un problème dans la détermination de l'âge à cause de l'absence totale ou quasi totale de squelette et des essais ont été portés sur les quelques organes solides de Céphalopodes (mandibules, radula, coquille). Plus récemment, on s'est intéressé aux statolithes (1) mais l'interprétation des stries nécessite davantage d'investigation.

Le recours à l'élevage pour la détermination de l'âge n'est pas sans inconvénient car les conditions de vie de l'animal en captivité ne sont pas similaires à celles en milieu naturel. C'est pourquoi que nous avons adopté la méthode indirecte basée sur l'analyse modale des fréquences de taille afin d'actualiser les paramètres de croissance de *Sepia officinalis* estimés pour la première fois sur la population du golfe de Tunis entre les années 1978-1981 (2).

Matériel et méthodes

L'étude est basée sur les données recueillies à partir des échantillonnages réguliers de seiches depuis juillet 1996 à avril 1998. Ils sont réalisés dans les ports de débarquement le long de la côte nord tunisienne englobant les pêches artisanales et les pêches au chalut et également à bord du bateau de recherche lors des campagnes de prospection expérimentales. Au total, 2459 individus ont été l'objet de cette étude.

L'application de la méthode de Bhattacharya est réalisée à partir du logiciel le FISAT (3). Les paramètres de croissance sont déterminés pour les mâles, les femelles pris séparément et pour l'ensemble de la population sans considération du sexe.

Expressions mathématiques de la croissance

D'après Von Bertalanffy, la croissance d'un organisme peut être considérée comme la résultante des réactions simultanées de facteurs anaboliques et de facteurs cataboliques. L'équation de la croissance déduite à partir de ces bases physiologiques est une relation linéaire écrite sous la forme suivante :

$lt = l\infty\ [1\text{-}e^{-k(t-t_0)}]$ pour la seiche, *lt*, la longueur dorsale du manteau de l'animal (en cm) au temps t (année).

Résultats et interprétations

Estimation des paramètres de croissance

Par application du logiciel le FISAT, nous avons pu estimer les paramètres de croissance pour chacun des deux sexes et pour l'ensemble de la population :

Mâle : $lt = 29.51\ [1\text{-}e^{-0.723(t+0.061)}]$

Femelle : $lt = 27.06\ [1\text{-}e^{-0.831(t+0.048)}]$

Ensemble de la population : $lt = 28.58\ [1\text{-}e^{-0.739(t+0.069)}]$

Lt en cm; t en année.

La clé âge-longueur a été également établie (tableau 1).

Tableau 1 - clé âge-longueur et accroissement linéaire par sexe et pour l'ensemble de la population de *Sepia officinalis* de la région nord.

Classe d'âge	0	I	II	III	IV	V
âge en mois	6 au plus	7 à 12	13 à 18	19 à 24	25 à 36	Plus de 36
mâle Lmoy (cm)	7.610	14.497	19.888	23.817	25.600	26.000
accroissement		6.900	5.391	3.929	1.782	0.402
femelle Lmoy	7,598	14.497	18.642	21.600	23	23.4
accroissement		6.900	4.146	2.958	1.398	0.298
ensemble Lmoy	9.060	15.262	19.425	23.818	25	25.6
accroissement		6.204	4.164	3.392	1.182	0.600

Des résultats obtenus découlent un certain nombre de remarques :

- Les seiches mâles atteignent à la fin de leur vie une taille supérieure à celle des femelles. Pour les mâles, la taille maximale limite est théoriquement de 29.53cm, tandis qu'elle est de 27.06cm chez la femelle. Dans la nature, les plus grandes seiches observées des deux sexes sont de taille très proche, respectivement de 27cm et 26cm.
- La croissance de la seiche suit un rythme rapide pendant la première année de sa vie, ensuite elle diminue progressivement pour atteindre son minimum à la fin de la vie de la seiche ; la croissance de la femelle subissant un ralentissement plus accusé.
- La longévité maximale de la seiche est identique chez les deux sexes et elle est estimée au plus 3ans; les proportions des individus dans la classe 0 et I étant de loin les plus élevées.
- Les tailles moyennes théoriques du mâle et de la femelle sont semblables pour les classes d'âge 0 et I; ce n'est qu'à partir de la deuxième année que la différence devient assez significative.

Comparaison des résultats

Il est intéressant de comparer nos résultats avec ceux obtenus sur la seiche du golfe de Tunis d'une part, et ceux publiés sur d'autres régions marines.

Les présents résultats réactualisent les paramètres de croissances estimés en 1983 (2) sur la seiche du golfe de Tunis. En dehors de la Tunisie, à ma connaissance, seules les travaux de Mangold-Wirz (4) et de Jeon (5) sont comparables aux nôtres. Des seiches en culture (Richard, 6) vivant à une température proche de la température moyenne du golfe de Tunis, soit 18°C, évoluent suivant une croissance beaucoup plus rapide que celle des seiches exploitées dans les eaux tunisiennes; d'autres facteurs autres que la température y interviennent certainement (nourriture,...).

L'espèce catalane (4) semble avoir une allure de croissance comparable à celle de la seiche du nord tunisien mais avec un rythme de croissance différent: d'abord lent au cours de la première année, il devient ensuite nettement plus accéléré à partir de la deuxième année. Aussi les seiches catalanes âgées de moins d'une année sont-elles plus petites que les seiches tunisiennes du même âge; mais au terme de leur vie, elles marquent une taille supérieure chez les deux sexes avec toujours un taux de croissance plus élevé chez les mâles que chez les femelles dans les deux secteurs. Ces résultats confirment bien ceux de Richard (6) à savoir que la température augmente le rythme de croissance de la seiche.

Par ailleurs, Jeon (5), en procédant à l'étude de la croissance de la seiche du golfe de Gascogne, sépare la cohorte annuelle de seiches en générations, l'une printanière et l'autre estivale. La génération de l'été est celle qui présente un rythme de croissance comparable à celui des seiches locales. Ceci confirme d'une part l'influence de la température sur le rythme de croissance de la seiche et d'autre part, vient appuyer, indépendamment de cette espèce, l'intérêt porté aux études de l'interaction entre la biologie de l'espèce et son milieu environnant.

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TEMPORAL PLANKTON VARIABILITY IN A NERITIC AREA OF THE BALEARIC SEA-W. MED. (1994-2000)

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Abstract

Covering 7 years sampling observations, seasonal and inter-annual variability of chlorophyll *a* and zooplankton has been analysed and related to the physical structure of the water column in SW waters off Mallorca Island (Balearic Sea). During the period studied the sea temperature has ranged from 13.1ºC to 27.6ºC, February 1996 and August 1998 respectively and the salinity ranges varied from 37 to 38.2 PSU. The lower salinity was found during autumn 1995 and the highest during winter 1996 and 2000, both of these coinciding with the cooler winters of the time-series. Seasonal fluctuations were found in phyto and zooplankton, with winter and late spring peaks rather important. However, higher inter-annual variations were observed in relation to the changes appeared in the hydrographic conditions of the area. The relationship between physical and planktonic variables is discussed.

Keywords: Hydrographic conditions, chlorophyll, zooplankton, time-series, Balearic Sea.

Introduction

In response to climatic forcing, plankton exhibits great variability over time, at seasonal and inter-annual level. However, the mechanisms controlling that variation are still far from properly understood. In this sense, long-trend plankton studies made in the Mediterranean (1,6) emphasise the need for assessing temporal trend and for identifying the causes of observed changes. The strategic position of the Balearic Sea (4) and the interest of temporal studies in open areas (2) motivated the present study. Our aim was to describe the results of 7 years planktonic study in relation to physical properties of the sea water in order to highlight the long-trend and the relationship between them.

Material and Methods

From January 1994 to December 2000 sea water and plankton samples were collected every 10 days interval from a neritic and very open area of Mallorca island (39º28´54"N; 2º25´57"E). To determine hydrographic and chlorophyll data 5l Niskin bottles were used at 0-15-25-50 and 75 m depth. A CTD- Sbe19 was also used. Zooplankton was collected by a Bongo Plankton net of 20 cm diameter and 250 mm mesh by means of oblique haul (75 to 0 m). The zooplankton samples were subsamples, the samples for biomass were frozen at -20ºC and the composition samples were fixed in 5% of neutralised formaldehide. The laboratory analysis were made as previous study (3).

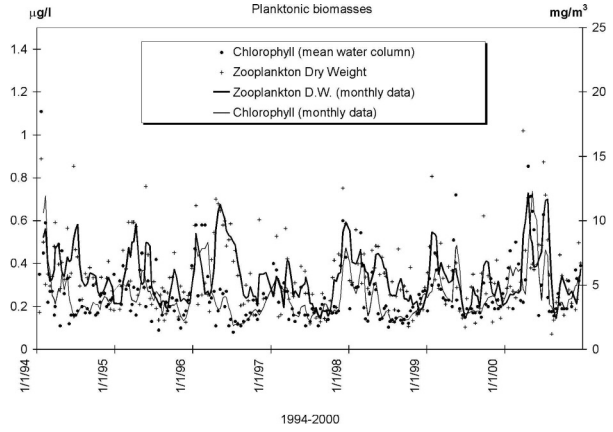
Results and Discussion

Physical environment - Annual changes of temperature based on measurements made synchronously with salinity were registered (time-serie annual mean of 17.89º C) and monthly data calculated. A seasonal cycle was clearly marked as a typical thermic regime of these temperate latitudes (2). Interannual variability was observed, with cooler winter during 1996 and spring 2000 and the warmest year in 1998. During the period study, annual mean values were slightly increased during 1994 and 1995, but the highest increase was during 1997, it kept going until the end of 1998 as a result of the warming tendency during both years (annual mean increased by 0.74º C). During 1999 and year 2000 the annual temperature decreased (0.6ºC from 1998).

Besides that, from December to March the water column remains mixed whereas the stratification period (between 20 to 70 m depth) occurs between April and November. Throughout the summer, the termocline goes sinks close to the bottom.

Seasonal behaviour of the salinity was also analysed (mean annual water column of 37.58 PSU) with the highest value during 1996 (38.19), near to spring 2000. The annual mean salinity varied during the period study (from 37.42 in 1995 to 37.72 in 1996). Lower values where found (37) during autumn 1995 and related to recent Atlantic waters (5). The higher salinities were detected during 1996 and 2000, related to northern Mediterranean waters (5).

Chlorophyll.- Annually chlorophyll maxima were observed in early winter due to the convective mixing period. However, the magnitude varied widely from year to year. The annual mean of the series was very low (0.25 μg/l) and only during 1994 and year 2000 slightly increased (to 0.34 μg/l), indicating the oligotrophy of the water. The highest chlorophyll value was registered in January 1994 (1.1 μg/l), being lower the other years. Another important peak was regularly observed during May, with the highest value in 1999 (3.5 μg/l) followed by 2000 (2.5 μg/l) at deeper layer. During the stratified period, below the thermocline high chlorophyll concentrations appeared and undetectable values in the upper layers, as it is usual in the W.M. (2). Interannual variability seems to be strongly influenced by the mesoscale patchiness characteristic of the stratified period (7).



Zooplankton - Mesozooplankton pattern showed more complex fluctuations although seasonal variations were also observed, with higher peaks in March and late spring, that seem to follow the phytoplankton blooms. Both of them, were almost due to the copepods. However, when the summer peak appears, as in 1994 and 2000, the cladocerans were the most abundant group. In the whole study period higher zooplankton abundance was observed during 1996 (6.7 mg D.W./m^3) and year 2000 (6.3 mg/m^3) as well, when the cooler and densier waters were found in the area. The annual mean zooplankton abundance was estimated as 5.7 mg/m^3 (9.7*10^2 ind/m^3).

All this data suggested that despite important interannual zooplankton variability observed, due to strong changes in environmental parameters, seasonal plankton dynamic also was evident. And from the analysis of the physical variables and plankton abundance the presence of a recurrent pattern could be observed, although it confirms the considerable interannual variability in the Balearic Sea, with differences on timing and magnitude, and not very different to other areas of the Mediterranean (1,6). In this sense we realise that to analyse forcing mechanisms of definite cause-effect is a very difficult task. Therefore in order to find out general trends in the Mediterranean in relation to Global Change longer time-series must be taken into consideration.

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PRELIMINARY RESULTS ON MEGAFAUNA VARIATIONS DUE TO EXPERIMENTAL TRAWLING DISTURBANCE

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Abstract
Experimental trawling disturbance on a muddy seabed was carried out in order to study the effect on fish and benthic fauna. Immediate and short-term changes in the structure of fish and the benthic community due to extraction of number of specimens and biomass as a direct effect of fishing activity has been analysed. Possible indirect effects as an increase of scavenging species attracted to the area by carrion generated by the fishing activity have been examined. Effects on day-night variations have also been considered.

Keywords: Western Mediterranean, fisheries, demersal, zoobenthos

Introduction

Fishing activities using bottom trawl gears are thought to have the potential to cause changes in marine seabed habitats and the animal communities associated with them.

Multispecies commercial Mediterranean otter bottom trawl produce high mortalities both direct and indirect varieties. Catch and discards are the mainly direct mortality due to trawling (1). Furthermore, trawling also damages and kills an important proportion of benthic fauna. This study tries to achieve some knowledge about direct impact of trawling on the seabed analysing the evolution of both biomass and abundance of demersal and benthic taxa along either 7 or 14 consecutive tows. Special attention was made to animals with significant changes.

Material and methods

The study was carried out on a muddy seabed off the Catalan Coast (NW Mediterranean) (41º 10'N – 2º 04'E to 41º 17'N – 1º 56'E). A typical commercial trawl otter bottom trawl was used to create two different intensities of fishing disturbance: 7 hauls in wayline 1 (single disturbance) at 30m deep, and 14 hauls in wayline 2 (double disturbance) at 40 m deep. Samples were collected from each of four stations on both the experimental waylines (a box 200x40 m) and in adjacent control areas without fishing disturbance. This protocol effectively ensured that each line was entirely swept once or twice by the trawl gear (2). A Sercel differential global satellite positioning system (DGPS) was installed on board. The co-ordinates of two experimental waylines were transcribed onto the DGPS system, such that trawling and sample collection was possible with a high degree of precision (Fig. 1). The experiment was conducted on 1996 and 1997 but only 1997 results are considered. The trawler began fishing the wayline 1 at 10:50 am over a period of 14 hours. The second wayline was trawled over a period of 21 hours from 9:45 am. The length of each haul was about 2700 m, and fishing speed was about 3 knots. Data were standardised to hauls of 30 min to avoid differences between hauls due to time of trawling. All hauls were sorted to species level and weighted separately. In order to study the effect of disturbance, all species were pooled into four groups: benthic fishes, crustaceans, pelagic fishes and cephalopoda. Moreover, subsamples were stored to further analysis of composition of stomach contents, length frequencies distribution and length-weight relationship (data not presented in this paper). The possible effect of scavengers aggregation due to reject the rest of samples was avoided by keeping this material out of the experimental area. Furthermore, survival experiments were conducted in order to evaluate mortality rates of fauna caught by the trawl (3).

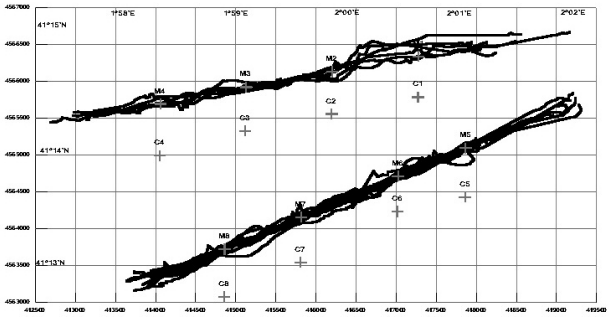

Figure. 1. Plotted trawl tracks of line 1 and 2

Results and discussion

During both 7-14 consecutive hauls a total of 89-84 species were caught in each wayline, respectively: 39-35 fish, 12-9 crustaceans, 19-17 mollusc and 19-23 others invertebrates. Around 40% of benthic fish on both Line 1 and Line 2 decrease in biomass comparing control haul, the first three hauls and the last three haul, but only *Trigla lucerna* (p=0.0036) decrease significantly in Line 1. In contrast, other species as Arnoglosus laterna, *Cepola rubescens* and Gobidae increased considerably in biomass although not significantly on both Line 1 and Line 2. Much more evident is the case of crustaceans *Liocarcinus depurator, Medoripe lanata, Goneplax rhomboides* and *Squilla mantis* but only the last one differed significantly (p=0.001), presenting a strong tendency to aggregate with increasing trawl disturbance on both lines. Some target species as *Merluccius merluccius* and *Scophtalmus rhombus* tended to avoid the experimental area after disturbance.

The survival of the organisms captured by the trawling process varied according to species. Gobius niger showed high percentage of mortality after three days (88.9%). On the contrary the percentage of Solea vulgaris was lower (28.6%). Invertebrates, in general, showed lower mortality rates after three days: Liocarcinus depurator and Medoripe lanata presented only a 14.3% and 0% of mortality, respectively.

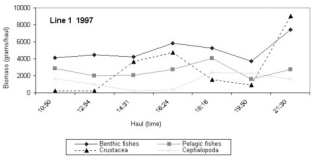

Figure 2. Variation of biomass along hauls in line 1.

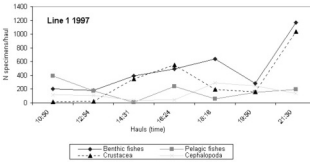

Figure 3. Variation of abundace along hauls in line 1.

Well known scavenging groups such as crabs and some benthic fishes aggregate immediately in recent trawled areas to feed with the carrion left by the passage of the trawl (4), as it shown in figures 2 and 3. Furthermore, the results showed that the effect of consecutive trawl disturbance was much more important that effect day-night confirmed by as pelagic species response. Number of specimens and biomass of pelagic species was highly variable but not evidenced an increase during night towns. In the case of sardine and anchovy the response is on the contrary (Fig. 4 and 5).

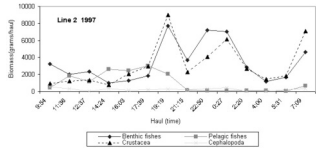

Figure 4. Variation of biomass along hauls in line 2.

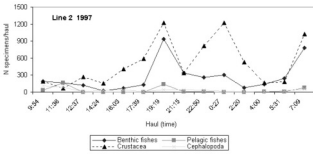

Figure 5. Variation of abundace along hauls in line 2.

The end results of this study suggest that changes in the abundance (number of specimens and biomass) on the fished lines could be attributed either to the depletion of organisms by the trawling activity or due to aggregation of mobile predators or scavenging species in response to animals killed by the passage of the trawl.

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ON A SPAWNING AGGREGATION OF THE BROWN MEAGRE *SCIAENA UMBRA* L., 1758 (SCIAENIDAE, OSTEICHTHYES) IN THE MALTESE WATERS (SICILIAN CHANNEL-CENTRAL MEDITERRANEAN)

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Abstract

A spawning aggregation of *Sciaena umbra* was sampled, during an experimental trawl survey, in low-exploited fishing-grounds off Maltese coasts (Sicilian Channel). The Gonado-somatic index was calculated and used to estimate the natural mortality rate (M; year^{-1}). The age structure was estimated by otolith thin section reading, resulting a maximum age in the samples of 17 and 26 years in males and females respectively. The total mortality rate (Z) was estimated with the catch curve. The comparison between M (0.20) and Z (0.24) supports the hypothesis that the sample was gathered on slight exploited or totally unexploited fishing grounds.

Keywords: Sciaena umbra, spawning, mortality, Sicilian Channel.

Introduction

The Brown meagre, *Sciaena umbra* Linnaeus, 1758, is a moderate size fish (up to 50 cm of total length; TL), occurring in the coastal waters of the Mediterranean and the Eastern Atlantic [1]. Once a very common species, both experimental observations [2] and historical statistics [3] evidenced clear signs of depletion in the Mediterranean populations. However, any assessment of the actual status of the stocks in the area is hampered by the poor knowledge on the biology of the species. An unusual considerable catch of spawners of Brown meagre allowed deriving information on the maturing condition, demographic structure of spawners and mortality rates.

Material and Methods

A total of 234 specimens (total weight of 127 kg) of *S. umbra* were caught in one half-hour haul performed off the Maltese coast (35°60' N; 14°27' E; mean depth of 47 m). The haul was carried out during an international experimental bottom trawl survey [4], on 7 June 2000 from 04:40 to 05:10 (solar time). The specimens proved to be mature and hence 180 fish were randomly selected for the laboratory analyses. Total length (0.5 cm; TL), somatic and gonad weights (0.1 g; SW; GW), and sex were determined after defrosting. The Gonad-somatic index (GSI=GW/SW*100) was calculated. For females showing fully developed ovaries, the mean value of GSI was used to estimate the instantaneous coefficient of natural mortality (M; year^{-1}) according to the empirical equation : $M = 0.03 + 1.68*GSI$ [5]. Thin transverse sections of otolith were read in water under reflecting light. Ages were determined by counting the number of dark zones [6]. Total mortality rate (Z) was estimated by the catch curve method on combined sex.

Results

In both sexes (51 females and 129 males) the gonads were in advance stages of maturation or fully mature; the plot of GSI vs. TL shows also that the samples were composed of large individuals (fig. 1). GSI up to 15.7 and 11.9 % were observed in females and males, respectively.

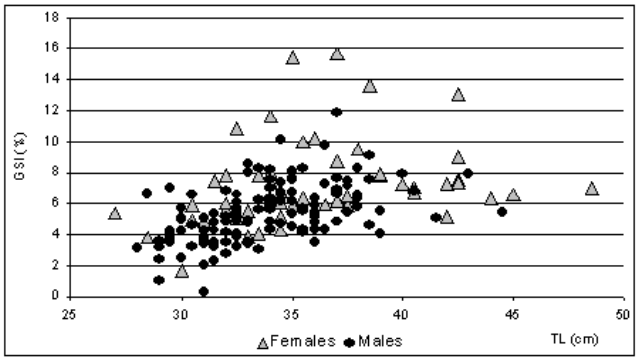

Fig 1- Gonado-somatic index vs. total length in females and males of *Sciaena umbra*

Considering only the fully mature female (13 individuals), GSI values ranged between 6.5 and 15.7% with a mean of 10.3 (standard error =3.3); this corresponds to an empirical M value of 0.20 (fiducial interval of 0.17-0.24).

Up to 14 age groups were identified, resulting in a maximum age in the samples of 17 (1 male) and 26 years (1 female). The age groups used for the catch curve are reported in tab.1. Beside the oldest specimens, one male of 14 years and two females aged 2 and 18 years respectively, were also excluded from the catch curve computation.

The regression of $\log_e$ of number at age (Y) versus age (X) resulted in a straight line (Y= -0.2377X+4.354; R^2=0.84) and, consequently, the Z estimate was 0.24 (se = 0.034).

Tab. 1 – Age group abundance of *Sciaena umbra* used in the catch curve estimation

Age (years)	3	4	5	6	7	8	9	10	11	12	13
Females	9	7	8	5	2	4	4	2	3	2	2
Males	31	16	24	20	12	11	1	2	4	4	2

Discussion

Present results agreed with the reproductive period (March-August) reported for the Mediterranean populations [1;2], and also with the aggregation behaviour of spawners of *S. umbra* [7]. The similarity between Z (0.24) and M (0.20), considering also the uncertainties in the estimates, supports the hypothesis that the sample was gathered on slight or exploited totally unexploited fishing grounds.

The presence of several age groups in the spawners and the relatively low gonadic investment indicates *S. umbra* as a slow growing and long living species; in fact the observed maximum age (26 years) is higher than the value previously reported (21 years) for the Mediterranean [2]. Although limited, these findings suggest that the high fishing pressure could be the most important factor in the declining of the Brown meagre of the Mediterranean Sea and that this species should be protected in some manner [2;7].

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NOTES ON DISTRIBUTION OF *SCYLIORHINUS STELLARIS* (LINNAEUS, 1758) IN THE SOUTHERN TYRRHENIAN SEA

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Abstract

The main distribution of *Scylhiorinus stellaris* during MEDITS and GRUND trawl surveys is analysed. Data are collected from five campaigns carried out in spring and autumn from 1994 to 1998 in the Tyrrhenian Sea, from Cape Suvero (Calabria) to Cape S. Vito (Sicily). The density and biomass indexes are reported by year, strata and areas.

Keywords: trawl surveys, biomass, Tyrrhenian Sea

Introduction

Scyliorhinus stellaris is an inshore and offshore shark of the Eastern Atlantic continental shelf, common in Mediterranean Sea, it is mainly distributed between 20 and 150 m of depth; occasionally it was found also over 400 m (1).

Specimens of *S. stellaris* were collected during 10 trawl surveys carried out in spring (MEDITS UE project) and autumn (GRUND National Program) during the years 1994-1998.

Observing the data coming from the different Operative Units (OU) both of MEDITS and GRUND, located all around the Mediterranean Sea as well as the Italian seas, it is evident that this species is rarely found (2, 3). Infact the presence of this species was recorded only in North Eastern Corsica, in Eastern Ligurian Sea, in Tyrrhenian Sea, in the Channel of Sicily, Croatian coasts and in Argosaronikos (2). Although the species is widespread in these areas, the catches are always very low with the exception of those coming from NE Adriatic Croatia and Thyrrenian Sea (2). On this respect, the data related to Density and Biomass indeces of the area of the Southern Tyrrhenian Sea, studied by our OU, included from Capo Suvero (Calabria) to Capo S. Vito (Sicilia) are reported.

Material and Method

The data come from 5 MEDITS surveys, carried out amongst May and July and from 5 GRUND trawls carried out from September to October. The gears used has 20 and 36 mm of stretched mesh size, respectively for international and national project.

In the whole 357 hauls were carried out, according to a stratified random sampling method, in five bathymetrical strata included between 10 and 800 m of depth (4). Because in the first two strata (A:10-50 m and B: 50 – 100 m) no specimens of *S. stellaris* were found, only the hauls (244) carried out in the deepest strata were considered for this paper: 70 in stratum C (101-200 m), 86 in the stratum D (201-500 m) and 88 in the stratum E (501-800 m).

The mean biomass (kg/km^2) and density (N/km^2) indices per years, stratum and sector (Cochran, 1977) were calculated.

Results and discussion

In the whole studied area, the catches of *S. stellaris* were irregular during these five years. During springtime (MEDITS) the species was not caught al all in 1994 and 1996. The highest indeces both in weight and in number (Tab. 1) were recorded in 1998 with values of 5,54 kg/km^2 (CV: 58.07) and 45.63 N/km^2 (CV: 69,62). A trend during the years was observed for both indeces. As regard the distribution by different strata (Tab.2), the species showed the highest values always in stratum D (201-500m) with a peak in 1998, with 9.40 (kg/km^2) and 87.87 (N/km^2). It is worth underlining that only in 1998 the species was found with appreciable values (3.04 kg/km^2; 18.18 N/km^2) in the deepest stratum (501-800 m).

Tab.1 - Mean Abundance and Density indeces and relatives coefficients of variation of *Scyliorhinus stellaris*, during the years 1994-1998, in trawl surveys MEDITS and GRUND.

Year	MEDITS				GRUND			
	Kg/Km^2	CV	N/Km^2	CV	Kg/Km^2	CV	N/Km^2	CV
1994	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
1995	0,02	92,05	0,58	92,05	0,00	0,00	0,00	0,00
1996	0,00	0,00	0,00	0,00	1,52	83,13	3,09	56,22
1997	1,14	66,82	12,57	71,23	2,47	59,27	8,22	75,45
1998	5,54	58,07	45,63	69,62	1,80	71,66	10,03	70,01

Tab.2 - Mean Abundance and density indeces by stratum of *Scyliorhinus stellaris*, during the years 1994 – 1998 in trawl surveys MEDITS and GRUND.

YEAR	Depth	MEDITS		GRUND	
	(m)	Kg/Km^2	N/Km^2	Kg/Km^2	N/Km^2
1995	101-200	0,00	0,00	0,00	0,00
	201-500	0,04	1,43	0,00	0,00
	501-800	0,00	0,00	0,00	0,00
1996	101-200	0,00	0,00	0,00	0,00
	201-500	0,00	0,00	4,29	8,73
	501-800	0,00	0,00	0,00	0,00
1997	101-200	0,00	0,00	0,68	1,95
	201-500	2,75	30,43	6,42	21,64
	501-800	0,00	0,00	0,00	0,00
1998	101-200	1,00	3,33	0,55	1,84
	201-500	9,40	87,87	4,64	26,72
	501-800	3,04	18,18	0,00	0,00

During the autumn (GRUND) the species was not catched in 1994 and 1995. The density index showed a trend since 1996 (3.09 N/km^2; CV: 56.22) to 1998 (10.03 N/ km^2; CV: 70.01). Otherwise the abundance index was higher in 1997 (2.47 kg/km^2; CV: 59.27) than in 1996 and in 1998. The bulk of the catch was recorded, also for this season, in the stratum 201-500 m; the highest values were recorded in 1997 and in 1998 for abundance index (6.42 kg/km^2) and for density index (26.72 N/km^2) respectively (Tab.2).

As regard the spatial distribution of *S. stellaris* throughout the studied area, the species was not present in the southern part, in the zone extended from C.pe Zafferano (PA) to C.pe San Vito (TP). The highest catches were generally recorded in the area comprised between C.pe Milazzo (ME) and C.pe Zafferano. This phenoma is probably dued to the presence in this area of the Gulf of Patti interdicted to trawl inside the bathimetrical of 500 m.

Analysing the data here reported it is possible to ipotize that *S. stellaris* finds in this restricted Mediterranean area a favourable habitat both for juveniles and adults. Probably the species can reach the deepest part of the continental slope because of the nearness of the bathymetric strata which characterise some zones of the surveyed area.

On the basis of these results and considerations it should be interesting to analyse the interspecific relationship existing between *Scyliorhinus stellaris*, his preys and the environment in which it lives.

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DIFFERENTIAL EGG PRODUCTION OF SARDINE OFF THE CENTRAL HELLENIC COASTS IN DECEMBER 1999

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Abstract

An ichthyoplanktonic and an adult survey were conducted concurrently during December 1999 in the central Aegean and Ionian Seas. Spawning was much more intense in the Aegean than in the Ionian Sea. The overall pattern of the distribution and abundance of eggs was attributable to regional differences in the length/age structure and maturity state of the local adult populations. Higher egg abundance coincided with areas of increased productivity.

Keywords: Fishes, reproduction, ichthyoplankton, Ionian Sea, Aegean Sea

In the Hellenic seas, sardine (*Sardina pilchardus*, Walb.) forms the basis of commercially important fisheries comprising 11,4% of the mean total marine catch (1). As most members of the subtropic Hellenic ichthyofauna, sardine deploys the "bet hedging" spawning strategy producing multiple batches of eggs during a single spawning season. Reproductive traits of clupeoids are highly influenced by the fluctuating biological and physical oceanography of the upper water column which may result in substantial recruitment variability (2). The present paper presents preliminary results on the distribution of the spawning grounds of sardine in the coastal waters of central Greece in relation to reproductive traits of the adult populations and oceanographic characteristics of the area.

Materials and methods

In December 1999, sardine eggs were collected during and ichthyoplanktonic cruise onboard the R/V *Philia* (Fig. 1A). A total of 105 stations were sampled. At each station, a vertical profile of salinity, temperature and fluorescence was made using a Seabird 25 CTD. A standard oblique Bongo-net tow was performed (3). An adult survey was made concurrently onboard the purse-seine fleet and by means of a pelagic trawl operated from the R/V *Philia*. A total of 29 adult samples were collected covering the whole survey area. Fish were preserved in 10% neutral buffered formaldehyde and analyzed in the laboratory (n=1648). Females were measured (total length in mm) and ovary samples were subjected to histological analysis. Histological scoring included the reproductive state of the ovaries (yolk accumulation, presence of postovulatory follicles -POFs).

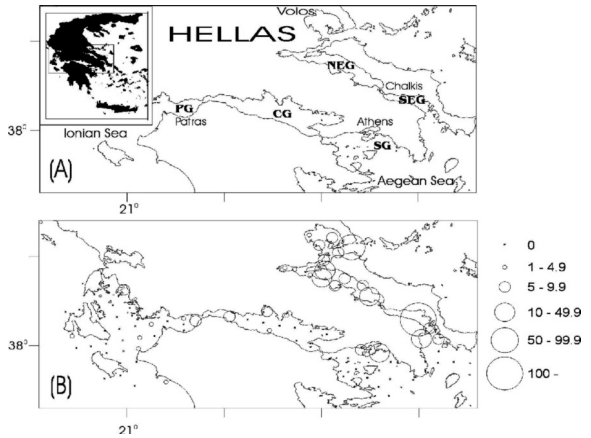

Fig. 1. (A) The study area: NEG=North Evoikos Gulf, SEG= South Evoikos Gulf, SG=Saronikos Gulf, CG=Corinthiakos Gulf, PG=Patraikos Gulf (B) distribution and abundance of sardine eggs (eggs/m²

Results and discussion

Sardine eggs (Fig. 1B) were more abundant in the N. Evoikos Gulf, the central part of S. Evoikos Gulf and the inner Saronikos Gulf. On the contrary, egg production was very low in the Ionian Sea (Corinthiakos Gulf, Patraikos Gulf and outer Ionian Sea). This difference in spawning intensity might have been due to the under-representation of mature age/length classes in the Ionian Sea and/or the mismatch of spawning periods or spawning peaks between the two seas. Adult samples collected from the Aegean (N.Evoikos Gulf, S. Evoikos Gulf, Saronikos Gulf; Fig. 2) were dominated by individuals larger than 11,5 cm, which is the length at first maturity (4). On the contrary, most individuals were smaller than 11,5cm in the Ionian Sea. Histological analysis of the ovaries showed that in Saronikos and Evoikos Gulfs the bulk of females larger than 11,5cm were mature (presence of yolk in the oocytes) (Fig. 3A). In the Ionian Sea, the fraction of mature females was lower. This pattern was more pronounced

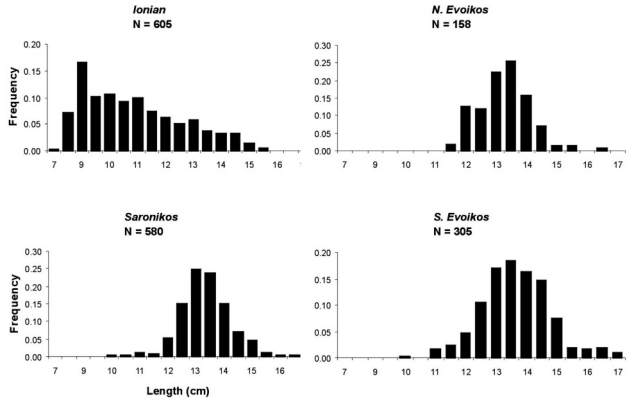

Fig. 2. Length frequency distributions of sardine

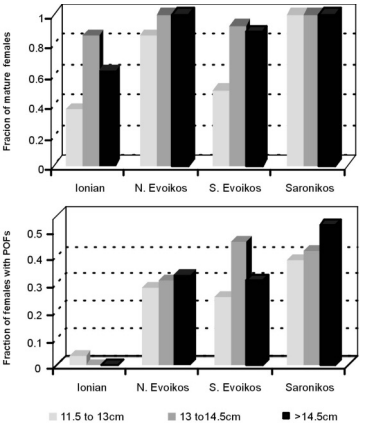

Fig. 3. Fraction of female sardines with (A) yolked oocytes, and (B) POFs, by length classes.

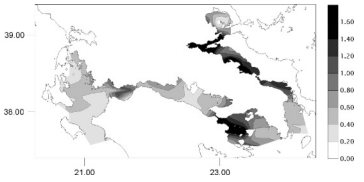

Fig. 4. Mean Chlorophyll-a values (µg/l)

when the comparison concerned the presence of POFs in the ovaries (Fig. 3B). Incidence of recent spawning was very low in the Ionian samples.

The regional differences in egg production found in the present study seemed to be partially related to the specific productivity features of the two seas. The waters of the Aegean Sea were generally cooler and characterized by higher chlorophyll-a concentrations than the Ionian Sea (Fig. 4). As the energetic component of vitellogenesis in sardine is affected by the feeding capacity of the environment (5), differences in productivity might affect the reproductive output of sardine.

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LENGTH COMPOSITION, GROWTH AND REPRODUCTION OF A MEDITERRANEAN RED SHRIMP (*ARISTEUS ANTENNATUS* (RISSO, 1816), DECAPODA, DENDROBRANCHIATA) POPULATION IN THE ALICANTE GULF (S.E. SPAIN)

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Abstract

The pink shrimp (*Aristeus antennatus*) is a demersal species that is the target of a very specific trawl fishery in the Alicante Gulf (SE Spain). This paper describes, for first time in this area, certain biometric relationships, as well as growth parameters and reproductive patterns of the species. The results showed a sexual size dimorphism, with a negative allometry of growth that was higher in females. In addition, females dominated in the catch composition. The spawning period occurred between the months of June to September and the maturation stage, both for males and females, took place within the first year of life.

Keywords: Decapoda, Biology, Western Mediterranean

Introduction

The pink shrimp (*Aristeus antennatus*) is a demersal species that is found on the muddy bottoms in the Mediterranean Sea and Atlantic Ocean south of the Iberian peninsula, at depths from 200 m to deeper than 2000 m. It is the target of a very specific trawl fishery, which is considered to be monospecific. Despite the fact that it has been studied in neighbouring areas (1), we describe the biological parameters of the species for the first time in an area defined between Cape Palos and Cape San Antonio.

Materials and Methods

Monthly random stratified samplings were carried out on pink shrimp commercial catches from the Alicante Gulf landed in the port of Santa Pola, from January 1995 to December 1998. Individuals from a total of 15,683 specimens were sexed and measured by their cephalothoracic length (CL). In addition, monthly biological sampling from 5,062 additional individuals was carried out during 1997. The parameters of the size-weight relationship were determined by regression. The estimates of the Von Bertalanffy growth parameters were obtained by the FISAT statistical package (2) from monthly length frequency distributions by sex for the 1995-1998 period. Maturity was determined by macroscopic observation. For females, a scale of five maturity stages modified from (3) was adopted, whereas for males maturity was a function of the shortening of the rostrum and the presence or not of petasma fusion (4). Moulting of the individuals was determined by the hardness of the carapace considering two stages: postmoulting (soft carapace) and premoulting (hard carapace). Sexual ratios were calculated by size class, expressed as the ratio of females to the total number of individuals. Finally, the percentages of maturity by size for each sex were calculated, in order to determine the size at 50% first maturity.

Results

The sizes of the females in the catches varied from a minimum of 10.0 mm to a maximum of 66.2 mm CL, with a mean size in the sampling period of 29.3 mm CL. The males varied from a minimum of 14.6 mm to a maximum of 35.6 mm CL, with an average of 22.8 mm CL. Males represented 30% of the landings in number, whereas the remaining 70% corresponded to females. The contribution by size class of the individuals by sex to the yearly total landings showed a size dimorphism for the species (Fig. 1). The results obtained for the different size-weight relationships by sexes (Table I) showed a negative allometry between the considered parameters. Absolute growth parameters (Table II) gave high growth rate values (K, f'), which were higher in females. The mean contribution of postmoulted individuals was very low for the period studied (7.7% for males and 3.0% for females) and appeared as a clear bimonthly pattern.

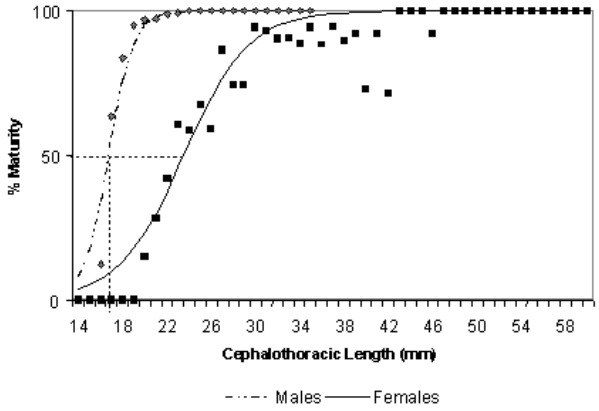
The sexual ratio (sr) by size class showed that, after an initial stage (18-22 mm) when males predominated significantly, females started to dominate significantly throughout the whole range of sizes above 26 mm. The mean sexual ratio for the whole period of the study was dominated by the females (Ps = 0.70). The percentages of mature males showed a high ratio throughout the year, with the immature ratios increasing from November to March. In females, the ratios of mated females started to increase in spring, reached the maximum during the summer (June-September) and then decreased in the autumn. The spawning period occurred during the same period, and it was especially intense in July and August. The percentages of maturity by size class showed a 50% size at first maturity of 16.7 mm for males and 23.5 mm for females according to the logistic model (Fig. 2). However, the maturation stage, both for males and females, would have to take place within the first year of life, but with a life expectancy of four and five years respectively.

Table I. Parameters of relative growth (size (mm)-weight (g) relationship: Weight = a * Sizeb) calculated for males and females of *Aristeus antennatus*. Level of significance ***=p<0.001, **=p<0.01, *=p<0.05 and NS=p<0.1 in the Student *t*-test.

Group	a	b	err.b	signif.	r2	n
males	0.00206058	2.53225	0.02016	***	0.92	1332
females	0.00187869	2.56269	0.00654	***	0.98	3730

Table II. Results of the growth parameters (size-age relationship) for the VBGF model obtained using the FISAT (ELEFAN) programme, for males and females of *Aristeus antennatus*, with t0 being adjusted for a CL_D (first modal class obtained by Battacharya) of 21.46 mm in males and 25.65 mm in females.

Years	Group	L_∞ (mm)	K ($year^{-1}$)	t_0	Rn	ϕ'
95-98	males	51.0	0.360	-0.520	0.382	2.97
	females	77.0	0.380	-0.065	0.128	3.35



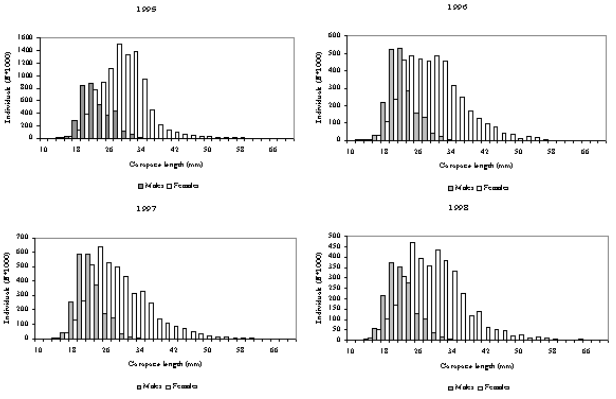


Figure 1. Size contribution by sex to the annual landings of *Aristeus antennatus* in Santa Pola port.

Figure 2. Logistic curves of sexual maturity in *Aristeus antennatus*.

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PRELIMINARY DATA ON MESOPELAGIC ICHTHYOPLANKTON IN THE JONIAN SEA (EASTERN MEDITERRANEAN)

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Abstract

During POP-EOCUMM '95 oceanographic cruises, zooplankton was collected in the southern Jonian sea, by a multinet BIONESS. The early life stages of fishes were sorted and studied to characterize their horizontal and vertical distribution. Gonostomatids *Cyclothone braueri* and *C. pygmaea*, Myctophid *Myctophum punctatum* and Sternoptychid *Argyropeleus hemygimnus* were the most abundant species.

Keywords: ichthyoplankton, distribution, Eastern Mediterranean

Introduction

Mesopelagic fishes are one of the most promising unconventional fishery resources in the world. They are distributed throughout all the oceans and dominate the mesopelagic zone (1).

The actual knowledge on the ecology of Mediterranean mesopelagic ichthyoplankton is fragmentary. Data about taxonomy and distribution of ichthyoplankton are available for the Jonian sea and the Strait of Messina (2-7).

Materials and methods

Zooplankton samples were carried in the southern Jonian sea during the POP-EOCUMM '95 oceanographic cruises (15-30 July '95), using BIONESS (8), equipped with ten nets of 250 mm mesh size. The BIONESS continuously measured temperature, salinity and depth during tows. Four stations were sampled along the study area following regular intervals of six hours (6.00, 12.00, 18.00 and 24.00).

The early life stages of fishes were sorted, identified into families and species. The larval stages were divided into three sub-stages: preflexion, flexion and postflexion that are based on the degree of flexion of the terminal section of the notochord during caudal fin development (8). The standard length-frequency distribution and the occurrence of the most abundant species were studied.

Tab. 1 – Mesopelagic ichthyoplankton collected in the whole study area, positive stations and depth ranges for each species.

N° of Species	Stations specimens collected	Depth	range (m)
Cyclothone braueri Jesp. .& Taning, 1926	829	J1-J2-J3-J4	0-1770
Cyclothone pygmaea Jesp. & Taning, 1926	118	J1-J2-J3	0-1770
Argyropelecus hemigymnu Cocco, 1829	30	J1-J2-J3	0-1770
Vinciguerria attenuata Cocco, 1838	4	J1-J2-J3	150-500
Chauliodus sloani Schneider, 1801	1	J1	500-600
Stomias boa Risso, 1810	4	J1-J2-J3	0-200
Myctophum punctatum Rafinesque, 1810	44	J1-J2-J4	0-1770
Ceratoscopelus maderensis Lowe, 1839	1	J1	0-1770
Benthosema glaciale Reinhardt, 1837	2	J2	0-200
Lampanyctus crocodilus Risso, 1810	2	J2	200-1293
Hygophum benoiti Cocco, 1838	6	J1	0-1770
Hygophum hygomi Lutken, 1892	1	J3	400-500
Lobianchia gemellari Cocco, 1838	1	J2	700-800
Diaphus rafinesquei Cocco, 1838	2	J1-J2	0-600
Electrona rissoi Cocco, 1829	2	J1	500-1000
Paralepis speciosa Bellotti, 1878	6	J1-J2-J3	0-1000

Results and discussion

A total of 16 mesopelagic fish species belonging to Gonostomatidae, Sternoptychidae, Chauliodontidae, Myctophidae and Paralepididae were collected in the whole study area (tab. 1). The table showed a increasing specific density moving north-south, contemporaneously with decrease of bottom depth.

Cyclothone braueri (transforming stages and juveniles) represented the most abundant species (829 individuals) and was collected mainly between 200-300 m. *C. pymaea* (89 collected juveniles and adults) and larvae, postlarvae and juvenile stages of *Myctophum punctatum* and *Argyropelecus hemigymnus* (44 and 30 individuals, respectively) followed. The size of *C. braueri* ranged between 13 and 31 mm SL (mean 20.32 mm ±2.68) while in *C. pygamea* varied between 13 and 21 mm SL (mean 17.81 mm ±1.40). Day-night vertical occurrence, in relation to the temperature and salinity profiles, was given for C. braueri at station J2 (fig.1). The early life stages of *C. braueri, M. punctatum and A. hemigymnus* occurred at surface during the day and migrated deeply during the evening hours; the oldest stages of *C. pygmaea* did not migrate. There was a rich literature concerning the migratory and trophic activities of the mesopelagic fishes. They can be separated into two categories, based on vertical distribution: "deep non-migrating" and "mesopelagic migrating", but this also depend on the trophic activity of mesopelagic fishes. These organisms do not have a very hydrodynamic shape, which inhibits long-range displacements as seen in the great superficial migrations. Underwater observations demonstrate that they spend long periods in an immobile position, with the head pointing downward, and often in dense aggregations (10).

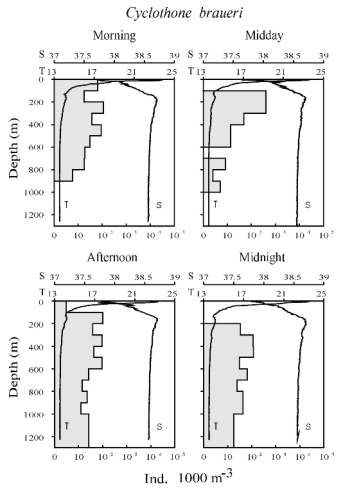

Fig. 1 - Day-night vertical distribution of *Cyclothone beaueri* at station J2

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MORPHOLOGICAL CHARACTERISTICS OF MEDITERRANEAN SLIPPER LOBSTER, *SCYLLARIDES LATUS* (LATREILLE, 1803) (DECAPODA: SCYLLARIDAE) STAGE I PHYLLOSOMA

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Abstract

General morphological characteristics are given on phyllosoma stage I of Mediterranean slipper lobster, *Scyllarides latus*, Latreille, 1803. The phyllosomas were obtained from ovigerous female in the laboratory and put under periodical and dark regime of illumination. The first molt that was expected within 10-12 days was not achieved due to the inadequate feeding (starvation).

Keywords: phyllosoma, slipper lobster, laboratory rearing.

Introduction

Mediterranean slipper lobster, *Scyllarides latus* (Latreille, 1803), Mediterranean and temperate water species is common in southeastern Adriatic. It is of low economic importance due to the restricted catching localities and scarse populations. The published data on this species is limited to various reports on their planktonic larval stages (1) and biology of the adult stage (2).They lack defensive mechanisms, aside from its robust and heavy armour. Slipper lobster relies on fast swimming , escape, camouflage and shelter for defense (3). The reproductive strategy of slipper lobster relies on production of large number of eggs (more than 10000 in our case), because the period of larval development is very long. The aim of this paper is to present the results of spawning and larval rearing trial, as well as basic morphometric characteristics of phyllosoma stage I of *Scyllarides latus* larvae under laboratory conditions.

Materials and methods

Ovigerous female of *Scyllarides latus* 250mm TL, was wild caught, and kept in 0,5m3 aquarium, with running sea water (23,7°C, 35,4‰S). On July 19-th during the night and early morning hours several thousand (approximately 7-12000) I stage larvae hatched (ecclosed). The larvae were transfered into three black 0,4m3 tanks (at appr. 15 larvae per litre) similar to Kriesel containers used for rearing lobsters (4), with approx. two changes of seawater/day, with temperature 24, 1 - 24,9°C and salinity 35,9 - 36,5‰S. Two of those tanks were exposed to diurnal light cycle (12l/12d), and third was covered with non transparent black plastic. Larvae were fed rotifer Brachionus plicatilis (10-20 ind/ml) from day 3. Mortality was checked from samples. Samples of larvawe were collected daily, and preserved in 5% buffered seawater formalin. The larvae were examined on Wild Heerbrugg binocular microscope. Total length of each larva was measured from the anterior end of cephalic shield, between eyestalks to the posterior tip of the telson.

Results

In laboratory reared phyllosomas of stage I of *Scyllarides latus*: pereiopods I and II are well developed, with exopodites bearing five pairs of feather-like setae, pereiopodes III are longer than I and II, and their exopodites present only as buds in stage I. Buds of pereiopodes IV are visible between pereiopodes III and pleon at each side. Eyes not stalked. Pleon in stage I is approx. 25% if TL, rectangular in shape and with two sets of setae posterodorsal at each side: (Fig. 1b). Antennulae unsegmented, and bearing on the tip three setae and one short spine (Fig. 1d). Antennae are shorter than antennulae and biramous, with articulated endopodit bearing three spines on its tip. Exopodit little longer than endopodit, bearing two spines on tip (Fig. 1e). All phyllosomas under photoperiod were lost at the day 10, and under darknes at the day 12 (85% mortality at the day 10). TL measured at the day 2 (+25h) was: 1.691±0.1048mm, and at the day 10 (+245h) was: 1.735±0.0289mm. Increase coeficient for TL measure in 10 days was 0.00214. No trace of morphological change was detected in larvae collected on day 10, and 12 (light and dark regimes, respectively).

Discussion

There has been information on laboratory rearing and early life history of other Scyllaridean species of genera Jasus, Palinurus and Panulirus (5, 6), Thenus (7), *Scyllarus americanus* (8) and *Scyllarus demani* (9). As the mean duration of first phyllosoma stage for suptropic species *Scyllarides aequinoctialis* (Lund) at 24°C was 8,1 days (10), and for Ibacus peronii Leach at 23,3°C was 13,2 days (11), phyllosomas of *Scyllarides latus* were expected to ongo the first molt within first ten to twelve days at temperature of 24-25°C. We did not achieve molt probably due to the inadequat feeding. Kittaka (5) concluded that adding mussel tissue as food in the culture water is important for maintaining palinurid phyllosomas, which are generally more sensitive of water quality and stress. Kittaka and Abrunhosa (12) also note that phyllosoma larvae of *Palinurus elephas* exhibit strong predatory behaviour rather than filter feeding. So, the adequate live food, such as the *Artemia nauplii* must be used instead of rotifers, to acchieve transition between instars.

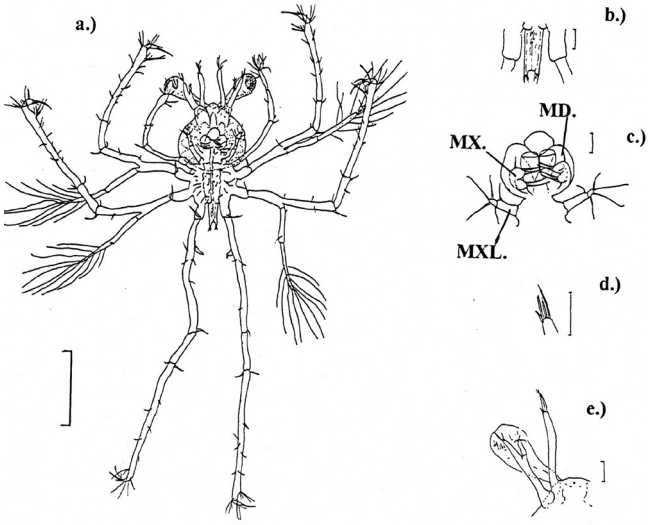

Figure 1. Stage I phyllosoma of *Scyllarides latus* **(Latreille, 1803).**
a.) ventral view (scale bar = 1mm); b.) ventral view of the abdomen with the buds of pereopodes IV; c.) oral field with MD – mandibula, MX – maxilla, MXL – maxillula; d.) tip of the left antennula; e.) left antennula and antenna. Scale bars: b, c, d and e = 100mm.

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RÉPARTITION ET COMPORTEMENT DES COPÉPODES PÉLAGIQUES DANS LE BASSIN ALGÉRIEN

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Résumé
L'Analyse en Composantes Principales utilisée pour l'étude des relations des copépodes avec les paramètres du milieu (physico-chimiques et biologique [chl. *a*]), a montré que la présence d'une espèce dans un lieu donné est conditionnée par la nature des masses d'eaux. Sur le front, les fortes concentrations chlorophylliennes sont corrélées au groupement des espèces herbivores. Dans le système côtier, l'A.C.P. révèle un groupement des populations néritiques lié à la biomasse végétale. Il n'existe pas de corrélation entre le groupement des populations ubiquistes et la concentration de chlorophylle *a*.

Mots-clés : Basin Algérien, copépodes, hydrologie, chlorophylle, oxygène

Matériel & Méthodes

Cette étude utilise les données récoltées au cours de la campagne Médiprod VI (Juin - Juillet, 1990) réalisée dans le bassin algérien où trois écosystèmes (*Cf.* 1) ont été mis en évidence (2): - système oligotrophe côtier d'origine atlantique (5 stations) de salinité de surface < à 36.6 p.s.u.; - un système frontale installé sur le bord nord du courant algérien à 30 milles de la côte caractérisé par un gradient horizontal de salinité compris entre 36.6 et 36.8 p.s.u. (10 stations); - un système oligotrophe méditerranéen (6 stations) situé à 60 mille marins des côtes de salinité située entre 36.8 et 36.9.

Les pêches planctoniques ont été effectuées, de 0 à 200 m, par traits verticaux avec un filet WP2 de 200 μm de vide de maille. Afin de mettre en évidence la relation des peuplements de copépodes avec les facteurs du milieu, nous avons utilisé un traitement mathématique qui fait appel à l'Analyse en Composantes Principales. Nous avons recherché une ordination des espèces suivant les caractéristiques physico-chimiques et biologiques des zones hydrologiques en utilisant le modèle multiregressif (3). Pour ce faire, notre choix s'est porté sur (Tab.I) :

Tab. I : paramètres choisis pour l'analyse mathématique

Température	Salinité	Oxygène	Chlorophylle *a*
Surface (ϕA)	Surface (SA)	Surface (O_2A)	Surface (Chl *a* S)
Thermocline (ϕB)	Halocline (SB)	Minimum relatif (O_2B)	Maximum de subsurface (DCM)
Infra-thermocline (ϕC)		Couche réoxygénée (O2C)	0-100 m (Chl a I)

En outre, Nous avons utilisé les espèces de copépodes les plus fréquemment présentes dans les prélèvements. Nous présenterons en superposition sur le même graphe les projections des points espèces et physico - chimiques et biologiques.

Résultats

Le premier axe factoriel (fig. 1) met en opposition les copépodes herbivores fortement abondants sur le front correspondant au groupe I (*Paracalanus parvus, Clausocalanus furcatus, C.arcuicornis, Mesocalanus tenuicornis* et *Eucalanus elongatus* ; sélectionnées négativement) aux copépodes ubiquistes correspondant au groupe III (*Spinocalanus longicornis, Scolecithricella vittata, S.dentata, Oithona helgolandica, Corycaeus brehmi, C.ovalis, C.sp., Oncaea media, O.venusta, O.sp., Scolecithrix danae, Microsetella rosea* et *Clausocalanus sp*, sélectionnéés positivement). Cet axe est corrélé négativement à la biomasse chlorophyllienne intégrée sur les 100 premiers mètres superficiels (r = -0.85) et au maximum chlorophyllien de sub-surface (r= -0.90). Sur le demi-plan positif, des corrélations significatives s'observent avec la température au sein de la thermocline (r =+0.62), la température au sein de la couche infra-thermoclinale (r = +0.68), le minimum relatif de l'oxygène dissous (r = +0.58) et la couche réoxygénée (r = +0.52).

Le second axe factoriel (fig. 2) sélectionne les espèces typiques du système côtier correspondant au groupe II (*T. stylifera, A. clausi, E. acutifrons* et *O.nana*) et les espèces ubiquistes (groupe III). Sont également sélectionnées par l'axe, les variables O_2A et Chl *a* S (saturations négatives de -0.77 et -0.74), SA et SB (saturations positives de +0.55 et +0.50). Les teneurs d'oxygène et de chlorophylle de surface sont déterminantes pour l'entretien des effectifs maximums des espèces du groupe II. Par ailleurs, les copépodes du groupe III sont inféodés à la fois aux faibles salinité en surface (36 p.s.u.) et dans l'halocline (36.55 p.s.u. à 36.72 p.s.u.).

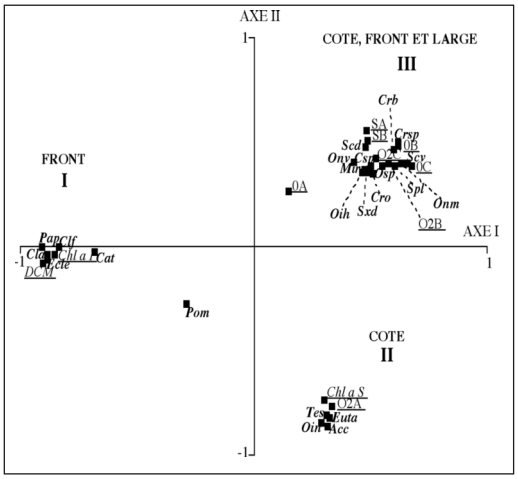

Fig.1 : Ordination des variables copépodes et paramètres du milieu sur les axes I et II

Discussion

Les plus fortes concentrations de chlorophylle a au sein de la DCM favorisent le développement des espèces du groupe I. Il s'ensuit une forte densité (plus de 800 ind.m-3) et biomasse zooplanctonique (plus de 20 mg.m-3) (1). Ainsi, les fortes productions primaires, au niveau du front utilisées par les copépodes, sont celles qui gouvernent l'abondance des herbivores (4). La prolifération de certaines espèces du système côtier (T.stylifera et E. acutifrons) est liée à un apport en particules sestoniques (phytoplanctons, détritus et bactéries) et en nutriments du à l'existence de processus hydrodynamiques à moyenne échelle (5; 6). Ces espèces se trouvent dans une période très active de reproduction. Ceci corrobore les résultats obtenus par ordination des variables (fig. 2). Cependant le lien qui existe entre la biomasse chlorophyllienne et la répartition des espèces n'apparaît pas pour celles qui sont ubiquistes (groupe III). Des exigences moins strictes pourraient expliquer la grande étendue de leur habitat. En outre, ces espèces se rencontrent aussi bien au niveau de la thermocline qu'au niveau de la couche infrathermoclinale traduit l'effet d'une dispersion (7). Celle-ci conduit ainsi, à introduire un aspect dynamique dans la distribution verticale de ses espèces. Cette interprétation est conforme au schéma dynamique des masses d'eaux proposé dans le bassin algérien (2).

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NOUVELLE LISTE COMMENTÉE DES REQUINS DE LA CÔTE ALGÉRIENNE

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Résumé.
Les requins rencontrés sur les carreaux de la pêcherie d'Alger sont recensés régulièrement depuis 1996. La liste actuelle non limitative,est comparée aux observations publiées en 1953 (1). La comparaison de ces deux listes permet de constater que certaines espèces nouvelles de la famille des Carcharinidae sont apparues le long des côtes algériennes, alors que d'autres ont disparu (*Sphyrna tudes*) ou tendent à disparaître (*Sphyrna zygaena*). Ce phénomène concerne surtout les requins pélagiques. Il convient de remarquer pourtant la très récente capture d'un squaliforme *Echinorhinus brucus*, qui n'a pas été signalé en Méditerranée depuis de nombreuses années.

Mots-Clés: Biodiversity , Fishes, Elasmobranch, Algerian basin.

Introduction.

Les requins appartiennent à la sous-classe des sélaciens qui fait partie de la classe des Chondrichtyens ou poissons cartilagineux (également appelés Elasmobranches). Ces poissons sont plus connus sous l'appellation de chiens de mer ou 'kelb el bhar' par les pêcheurs et les non initiés.

La liste exhaustive des requins capturés par tous les types d'engin de pêche et provenant de toutes les régions d'Algérie a été dressée par nos soins : trente espèces ont été identifiées. Les individus des différentes espèces ont fait l'objet d'observations dans le but d'une connaissance exacte de ce groupe, des points de vue écologique, biologique et systématique.

Méthodes d'étude

L'étude menée est basée sur des observations bi-hebdomadaires depuis octobre 1996, des apports exposés sur les carreaux de la pêcherie d'Alger et provenant de toute la côte algérienne. Les espèces ont été identifiées, mesurées en longueur totale et/ou standard et lorsque cela était possible, pesées. L'identification s'appuie essentiellement sur des ouvrages de référence (1, 2, 3, 4, 5). La sous-classe des Sélaciens se subdivise en deux super-ordres: les Pleurotremata (requins, anges de mer et chimères) et les Hypotremata (raies et batoides). Seul le groupe des requins fait l'objet de notre travail. Ce groupe se subdivise en trois ordres qui peuvent aisément se différencier: les Hexanchiformes, les Galeiformes et les Squaliformes. Nous nous sommes efforcés, au cours de cette étude, d'établir un inventaire aussi détaillé que possible des requins débarqués à la poissonnerie d'Alger. La liste établie est comparée à celles de Dieuzeide et al. (1) et Lalami (6).

Résultats et discussion.

Trente espèces (tableau 1) ont été recensées au cours de nos quatre années d'observation. Ces espèces appartiennent aux familles suivantes: Echinorhinidae, Squalidae, Scyliorhinidae, Triakidae, Carcharinidae, Sphyrnidae, Alopiidae, Hexanchidae, Oxynotidae, Cethorinidae, Odontaspididae et Lamnidae.

Trente populations de requins sont capturées actuellement le long des côtes algériennes (tableau 1), alors que 17 espèces (surtout démersales) ont été signalées dans la littérature (6, 1). Le poids éviscéré approximatif (en kg) que peut atteindre un individu dans l'espèce ou dans la famille est mentionné à titre indicatif, en gras dans le tableau 1. La comparaison des deux listes dressées en l'espace d'un demi-siècle, permet de constater que certaines espèces nouvelles de la famille des Carcharinidae sont apparues sur nos côtes, alors que dans le genre *Sphyrna* certaines ont disparu (*Sphyrna tudes*) ou tendent à disparaître (*Sphyrna zygaena*). Il convient de remarquer la raréfaction du requin pèlerin *Cetorhinus maximus*; ce requin est d'ailleurs classé par certaines institutions internationales (CITES , IUCN) comme espèce en voie de disparition. Des photos mises à notre disposition par les pêcheurs laissent supposer l'existence de *Lamna nasus*, décrite par Dieuzeide et al. (1) et Lalami (6). La liste dressée par nos soins est encore loin d'être exhaustive. Quelques espèces pourraient figurer dans l'inventaire dans un futur proche, comme *Odontaspis taurus*, déjà mentionné par les chercheurs de Castiglione en 1953 (1) et signalé au large des côtes du Liban par certains articles récents. La présence de *Mustelus asterias* et d'*Alopias superciliosus* reste douteuse ; en effet la littérature présente des ambiguïtés qui rendent leur détermination incertaine.

Le phénomène d'apparition et de disparition concerne surtout les grands requins pélagiques. Il convient de remarquer pourtant la très récente capture (fin mars 2000) au large de la région de Annaba d'un squaliforme, *Echinorhinus brucus* ou squale bouclé, individu femelle de 250cm pour un poids éviscéré de 97kg. Ce dernier , inconnu en Algérie même auprès des plus anciens pêcheurs n'a pas été signalé en Méditerranée depuis de nombreuses années et depuis plus de trente ans en Tunisie (7). De plus, d'après ce même auteur, *Hexanchus griseus* est absent des côtes tunisiennes, alors qu'il apparaît régulièrement sur les étals des marchés algériens; il semble plus fréquent dans les captures commerciales, surtout au mois de septembre.

Tableau 1: liste des requins capturés le long de la côte algérienne.

Ordres	Familles	Espèces An 2000	Dieuzeide (1953)	
Hexanchiformes	Hexanchidae	1) *Hexanchus griseus* **(500kg)**	√	
	Heptranchidae	2) *Heptranchias perlo* **(10 kg)**	√	
Galeiformes	Lamnidae	3) *Carcharodon carcharias*	√	*Lamna nasus*
		4) *Isurus oxyrhincus* **(30kg)**	√	
	Alopiidae	5) *Alopias vulpinus* **(100kg)**	√	
		6) *Alopias superciliosus*	-	
	Sphyrnidae	7) *Sphyrna zygaena*	√	*Sphyrna tudes*
	Carcharinidae **(50kg)**	8) *Carcharinus altimus*	-	
		9) *Carcharinus obscurus*	-	
		10) *Carcharinus brachyurus*	-	
		11) *Carcharinus falciformis*	-	
		12) *Carcharinus plumbeus*	√	
		13) *Prionace glauca*	√	
	Odontaspidae	14) *Odontaspis ferox*	√	*Odontaspis taurus*
	Scyliorhinidae	15) *Galeus melastomus* **(0.2 kg)**	√	
		16) *Scyliorhinus canicula* **(0.1kg)**	√	
		17) *Scyliorhinus stellaris* **(2kg)**	√	
	Triakidae **(15 kg)**	18) *Galeorhinus galeus*	√	*Mustelus asterias*
		19) *Mustelus mediterraneus*	-	
		20) *Mustelus mustelus*	√	
	Cetorhinidae **(1500kg)**	21) *Cetorhinus maximus*	√	
Squaliformes	Squalidae **(5kg)**	22)Centrophorus granulosus	√	
		23) Centrophorus uyato	√	
		24) Dalatias licha	√	
		25) Etmopterus spinax **(0.2kg)**	√	
		26) Squalus acanthias	√	
		27) Squalus blainvillei	√	
	Oxynotidae	28) Somniosus rostratus	√	
		29) Oxynotus centrina **(4kg)**	√	
	Echinorhinidae	30) Echinorhinus brucus **(100kg)**	√	

√ : observé en 1953 - : non observé en 1953 : espèces non observées actuellement.

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ESTIMATION DE LA CROISSANCE PAR ANALYSE DES FRÉQUENCES DE TAILLE DU REQUIN-HÂ (*GALEORHINUS GALEUS*, LINNAEUS 1758) DANS LE BASSIN ALGÉRIEN

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Résumé.
Un suivi a été réalisé au niveau des différents carreaux de la pêcherie d'Alger, d'octobre 1996 à décembre 1998, et a permis d'établir les distributions de fréquence des longueurs totales de *Galeorhinus galeus*, requin démersal. Quatre cents quatorze individus (259 mâles et 155 femelles) provenant des régions est et ouest de la côte algérienne ont été mesurés. En moyenne deux classes d'âge constituent l'essentiel des captures. L'analyse des structures d'âge a permis de déterminer les paramètres de croissance, sans distinction de sexe : $L\infty$ = 184.91cm, K = 0.327/an, to = -1.35 an.

Mots-Clés: Fishes, Demersal, Growth. Algerian basin

Introduction

Galeorhinus galeus est un requin de fond, appartenant à l'ordre des Galeiformes et à la famille des Triakidae. Les données relatives aux captures de cette espèce, et des requins en général, ne font pas l'objet d'une collecte systématique et fiable. Ce poisson cartilagineux peut être capturé par les chalutiers mais est beaucoup plus accessible au trémail et au palangre de fond; ce qui se traduit par une grande vulnérabilité due à son accessibilité sur les différents biotopes qu'il fréquente. Afin de déterminer les paramètres biologiques ainsi que les paramètres d'exploitation, un suivi a été réalisé au niveau des différents carreaux de la pêcherie d'Alger, d'octobre 1996 à décembre 1998, et a permis d'établir les distributions de fréquence des longueurs totales. En moyenne deux classes d'âge constituent l'essentiel des captures. L'analyse des structures d'âge, basée sur l'analyse des distributions de fréquence des tailles a permis de déterminer les paramètres de croissance sans distinction de sexe.

Matériel et méthodes

Les individus observés sur les carreaux de la pêcherie d'Alger, proviennent des régions est et ouest de la côte algérienne, essentiellement de Beni-Saf, Ghazaouet et Annaba. Les données ont été récoltées à raison de trois sorties hebdomadaires, d'octobre 1996 à décembre 1998: quatre cents quatorze individus (259 mâles et 155 femelles) ont ainsi été mesurés et pesés. La longueur totale (Lt) est exprimée en cm; le poids éviscéré (Pe) est exprimé en grammes. Les méthodes conduisant à l'estimation des paramètres de croissance sont basées sur les analyses de distribution de fréquences de taille. Les données relatives à la période de prélèvements, regroupées sur une année, ont permis la construction de polygones de fréquence de taille établis sur la base d'échantillons mensuels, pour des intervalles de taille de 6cm. La décomposition des polygones en modes a été effectuée selon la méthode des maximums répétitifs (1) et par la méthode des courbes normales (2) réalisée par le programme FISAT (3) . Les couples de données âge-longueur obtenus ont ensuite été introduits dans le logiciel cité ci-dessus, qui procède à l'ensemble des calculs menant à l'obtention des paramètres de croissance ($L\infty$, K et to) . Les longueurs totales moyennes des mâles et des femelles ont été comparées en fonction des régions: est et/ou ouest. Cette analyse a été menée à l'aide du test de l'écart-réduit (4).

Résultats

Les valeurs de l'écart-réduit relatives aux tailles moyennes, montrent qu'il n'y a pas de différence significative entre les mâles et les femelles, quelle que soit la région. Ces résultats ont permis d'étudier la croissance et l'exploitation, sans distinction des sexes. Les polygones de fréquences de taille (exprimés en %), pour les années 1996-1997-1998 regroupées, ont été analysés. Cette analyse met en évidence des modes qui apparaissent à 84, 96, 108, 126, 132, 138, 150, 156 et 174 cm. Les modes 144cm et à 162cm sont des modes cachés, car en chevauchement avec d'autres modes mieux représentés. Le mode 150cm est présent dans tous les mois considérés. La présence des jeunes individus est observée pendant les périodes estivale et automnale. La longueur modale de chaque génération déterminée, un groupe d'âge lui est attribué. Une taille à la naissance de 35cm (5; 6) a été retenue pour notre étude. Dans ce travail, le groupe d'âge I est représenté par les individus compris entre 84 et 110cm. Le groupe d'âge II par ceux qui ont une taille supérieure à 110cm et ne dépassent pas 132cm. Les individus du groupe d'âge III ont une taille comprise entre 133 et 144cm, alors que ceux du groupe d'âge IV ont une taille qui varie de 150 à 156cm. Le groupe d'âge V est représenté par des individus distribués autour de la valeur modale de 162cm et le groupe d'âge VI par les spécimens de 174cm. En se basant sur ces informations, une clé âge-longueur a été établie (tableau 1) pour les données mensuelles.

L'équation de croissance linéaire $Lt = 184{,}91\ [1 - e^{-0.327\ (t + 1.35)}]$ ainsi que la relation taille-poids $Pe = 0.012\ Lt^{2.77}$ (r = 0.745) permettent d'écrire l'équation de croissance pondérale : $Pe = 22380\ [1 - e^{-0.327\ (t + 1.35)}]^{2.77}$.

Discussion

La gamme de taille 81-123cm est très rarement présente dans les captures, ainsi que les individus ayant une taille au delà de 160cm de longueur totale; seuls 2 individus de 174cm ont pu être observés. De ce fait, le groupe d'âge I ainsi que le dernier groupe d'âge n'apparaissent pas dans la méthode de Bhattacharya (2); $L\infty$ (174,5cm) calculé par cette méthode est de l'ordre de la longueur maximale (Lmax observé: 174cm), alors qu'il devrait lui être supérieure. Ce modèle sous-estime les résultats, qui ne seront donc pas pris en considération. La longueur asymptotique $L\infty$ (184, 91cm) déterminée par la méthode de Petersen (1) est supérieure au Lmax observé et se rapproche de celui mentionné (200cm) par Fischer et al. (5). De plus ces valeurs sont très proches de l'approximation (7) où Lmax / 0,95 = 183,16cm. Cette méthode fournit des résultats satisfaisants. Une étude de la croissance de *G. australis* (synonyme de *G. galeus*) des côtes australiennes (8), basée sur la lecture des vertèbres, attribue un âge théorique de 40 ans à un individu de 160cm. Par contre notre étude affecte une taille de 185cm pour cet âge théorique.

Groupes d'âge	I	II	III	IV	V	VI
Mois						
Février				150	162	
Mars				150		
Avril		126		150	162	
Mai		132		150		
Juin		126	138	156	162	174
Août	84			150	162	
Novembre	108		144	150		
Décembre				150	162	
Lt moyen (cm)	96	128	141	151	162	174
	Lmin=84cm				Lmax=174cm	

Tableau 1 : Clé âge-longueur obtenue par la méthode de Petersen chez *G. galeus*

Conclusion

Ce travail est une approche relative à la croissance d'une espèce de requin présentant un intérêt commercial certain. Elle est réalisée pour la première fois dans le bassin algérien. Les paramètres de croissance déterminés dans cette étude ne peuvent être vérifiés, aucune source de comparaison n'étant disponible dans cette partie de la Méditerranée. Il serait très utile de collecter plus d'informations, relatives à la fraction jeune et aux individus les plus âgés. Cette étude est un premier pas vers la conservation d'espèces en danger, qui nécessitent plus (et un maximum) d'attention .

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ARTIFICIAL REEF EFFECTS ON FISHABLE RESOURCES IN THE GULF OF SALERNO (MIDDLE TYRRHENIAN): A PRELIMINARY ANALYSIS.

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Abstract

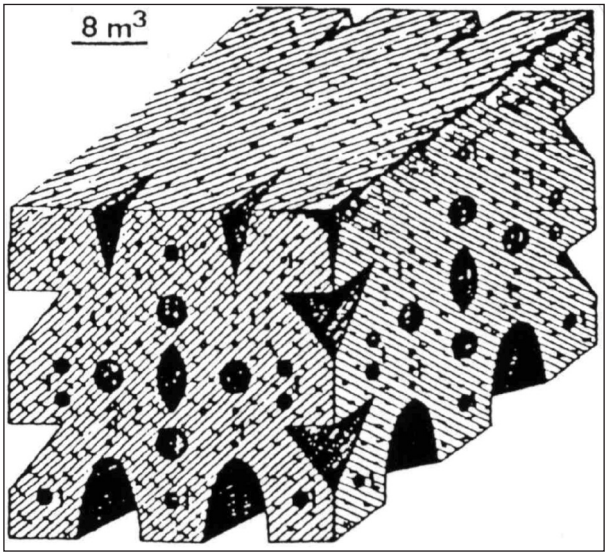
In the Gulf of Salerno during 1994, in the sea area in front of the town of Agropoli, at a depth ranging from 20 to 25 meters, a small artificial reef has been set up. The structure was built with concrete cubes disposed in a pyramidal design with four cubes in the inferior part and one on the top. A preliminary analysis on the effects of the setting up of this structure on the species of Teleosteans, Molluscs and Crustaceans, targets of the fishing activities in the area, is here reported.

Keywords: Artificial reefs; trammel net catch analysis.

In the year 1994, the administration of the town of Agropoli (Salerno) decided to set up a small artificial reef, which was at that time the first structure of this type employed along the coasts of the Region Campania (Southern Italy). The decision was caused by the will to set a serious obstacle to the illegal near shore trawl fishery, which, at that time, was a big problem in the area of the Gulf of Salerno.

It must be noticed that near shore trawl fishery causes, as it is well known, serious damages to the small-scale fishery, operating with traditional systems like trammel-nets, bow-nets, etc. Must be noticed also that in the whole bay of Salerno operates a relevant fleet of little boats attending to the small scale fishery (1).

In order to protect the local small-scale fishery, from the damages caused by trawl vessel and, at the same time to increase the marine production in the area, which is also a well known, the first Campania artificial reef was set up, built with concrete cubes (Fig.1).



To analyze artificial reef setting up effects on the fishable resources samples were collected bimonthly from October 1993 to September 1994, before the setting up of the reef, and from June 1995 to May 1996 after the placing of the structure. A trammel net (height 3 meters, length 500 meters) was the fishing-gear used, placed at a medium depth of 25 meters, lowered into the water at sunset and pulled up at dawn for an average of about 12 hours in the sea. In the data analysis, the presence of a group of species common to the period before and after the setting up of the artificial reef, can be evidenced : *Sepia officinalis* (L.), *Diplodus annularis* (L.), *Pagellus erythrinus* (L.), *Scorpaena porcus* L., *Mullus surmuletus* (L.), *Solea vulgaris* (Quens) while a consistent presence of *Seriola dumerili* (Risso) and *Trachurus mediterraneus* (Stdr.) typically pelagic teleosteans, was noted only after the placing of the artificial reef and the same was for *Scorpaena notata* (Raf.), *Phycis phycis* (L.) and *Serranus cabrilla* (L.) typical rocky bottom species. After the placing of the reef the presence of *Diplodus annularis* and *Sepia officinalis* became less considerable while, on the contrary, a more remarkable presence of relevant fishing interest species like *Pagellus erythrinus* and *Solea vulgaris* has been evidenced.

It has to be considered that data are relating only to the first life year of the reef and that, however, changes in the spectrum of the species targets of fishing activities can be evidenced. It is possible to agree with the opinion of D'Anna *et al*. (2) that the artificial reef doesn't develop a particular nectonic community but that there is a very close relation between reef community and the surrounding area one.

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ABUNDANCE AND DISTRIBUTION OF *MNEMIOPSIS LEIDYI* IN THE NORTHERN MARMARA SEA

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Abstract

The abundance and distribution of *Mnemiopsis leidyi* in the Northern Marmara Sea was studied on 1-9 August 2000 . The samples were collected by vertical towing. *M. leidyi* was sampled from all of the 11 stations where the abundance varied between 0.2-25.1 ind./m^3.

Keywords: Ctenophora, Sea of Marmara, Biomass

Introduction

The Marmara Sea is an interior sea which establishes the Turkish Straits System together with the Bosphorus and Dardanelles Straits. It is directly connected to the Black Sea with the Bosphorus, therefore the upper layer (0-20m) is strongly under the influence of the Black Sea water. *Mnemiopsis leidyi* is an exotic species to the Black Sea, which might have been carried by ballast waters of ships passing through, and caused great changes to the ecosystem of the Black Sea (1). It spread out the entire Black Sea in 1989 and afterwards it was determined in the Marmara Sea in huge quantities in 1992 (2). In this study, the abundance of *M. leidyi* in August 2000 was studied in the Northern Marmara Sea, and was compared with the former years.

Material and Methods

The presence of *M. leidyi* in the Northern Marmara Sea and Dardanelles was investigated with R/V *Yunus* on 1-9 August 2000. The samplings were made at 11 station (Fig.1). The samples were collected by vertical towing of a WP2 plankton net with a diameter of 57 cm and 200 μm between the sea surface and the lower layer where waters of the Black Sea and the Mediterranean Sea mix. The jellyplankton samples were identified, measured and classified in three length groups (I ≤ 10mm, I=10-45mm, I >45 mm) immediately on the board. The wet weight was computed by the formula $W=2{,}36xL^{2{,}35}$ where W is the weight and L is the length of *M. leidyi* (1).

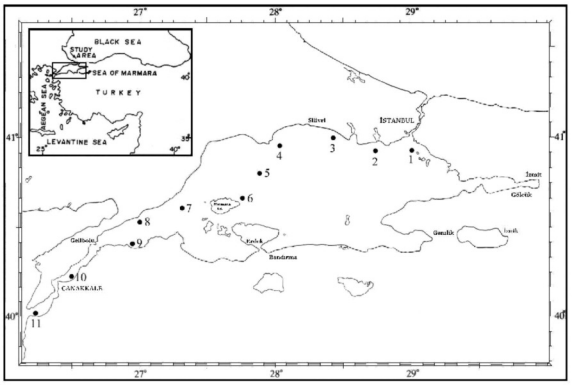

Figure 1. Location of sampling stations in the Northern Marmara Sea.

Results

In total, 865 individuals were counted at the 11 stations in the Northern Marmara Sea and Dardanelles. *M. lediyi* which was detected at every station, was 50mm at maximum in length. While the maximum biomass was measured at the third station (125.11 g/m^3), the maximum abundance was recorded at the seventh station (25.1 ind/m^3) (Fig.2). Near the Bosphorus, biomass varied between 14.6-38.4 g/m^3 whereas near the Dardanelles ranged between 1.14-30.9 ind/m^3.

Although samples of three separate length groups were found, the individuals of the small and medium size were more abundant. Small size specimens (I≤10mm) comprised 54.45 % of the total quantity, the second-medium size (I=10-45mm) with 45.31 % and the large ones (I>45mm) constituted the remaining 0.24 %. At two stations located in the Dardanelles merely 32 medium size individuals were detected.

Beside *M. leidyi, Pleurobranchia pileus* was found at seven stations, while *Boroe ovata* was not detected anymore, and medusa *Aurelia aurita* were sampled only at two stations.

Discussion

There are a few studies about the abundance of *M. leidyi* in the Marmara Sea. In another study made at the Black Sea the maximum abundance of *M. leidyi* was determined as 31 ind./m^3 (1) whereas it was >50 ind./m^3 in its natural habitat at the Narraganset Gulf in the northeastern region of USA (3). In the Northern Marmara Sea, the total abundance of *M. leidyi* (0.2-25.1 ind./m^3) was found much lower than as in the Black Sea and Narraganset Gulf.

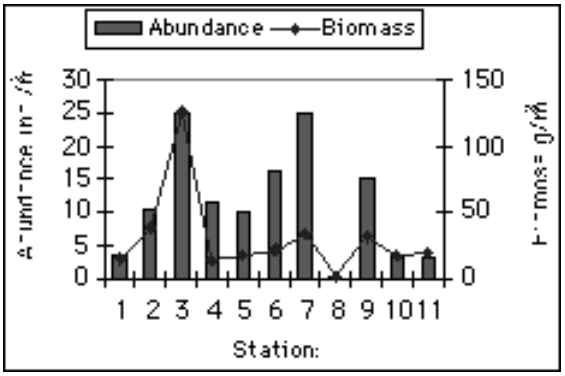

Figure 2. Abundance and biomass of *Mnemiopsis leidyi* at sampling stations in the Northern Marmara Sea.

In 1992, the small and medium size specimens prevailed at all stations and near the Bosphorus, biomass was 68-100 g/m^3, near the Dardanelles it reached 159 g/m^3 at the Marmara Sea (2). In this study, the small and medium size individuals were highly dominant at all stations. The average biomass was 14.64-38.39 g/m^3 near the Bosphorus and 1.14-30.9 g/m^3 near the Dardanelles. As shown by these parameters, a decrease was observed in the abundance of *M. leidyi* in the Marmara Sea.

The abundance (3.23 ind/m^3) and biomass (19,93 g/m^3) of *M. leidyi* recorded in the Southern Bosphorus in July 2000 (4) were similar to the parameters near the Bosphorus (3.6 ind/m^3; 14.64 ind/m^3) in this study. Although the abundance of *M. leidyi* determined in the Dardanelles was 0.002-0,073 ind/m^3 (5), it was found as 3.4 ind/m^3 in this research. The difference between the values could be caused by the different sampling method and current systems.

The low saline surface currents of the Black Sea is continuously carried to the Marmara Sea and because of this reason, it is considered that *M. leidyi* which is found in the Black Sea at every season (6) passes to the Marmara Sea with this currents. (2,4). As a result, one can conclude that the abundance of *M. leidyi* in the Northern Marmara Sea decreased, population of *M. leidyi* is rather young and there is intensive reproduction in August because of suitable temperature and food. As *M. leidyi* feeds on mesozooplankton, eggs and larvae of fishes (7), it is going to be harmful for the upper layer of the Marmara Sea. Thus, the abundance and distribution of *M. leidyi* in this area has to be monitored closely because of this reason.

Acknowledgement

We thank to crew of R/V *Yunus*, to Dr. Ayaka Öztürk and Cem Elemen for their kind helps.

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CUTTLEFISH, *SEPIA OFFICINALIS* L., 1758, IN THE TRAMMEL BOTTOM SET CATCHES ALONG THE EASTERN ADRIATIC COAST (CROATIA)

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Abstract

Length frequency distribution, sex ratio, length-weight relationship and frequency of occurrence (CPUE) of cuttlefish, *Sepia officinalis*, sampled from trammel bottom set catches in the eastern coastal Adriatic (Croatia) were analyzed. A total of 2105 specimens (*ML* = 6.5 – 22.5 cm, *W* = 35 – 1800 g) were measured in 428 positive trammel bottom set catches. Preliminary data on trammel bottom sets selectivity for six different "maha" mesh-size was also given.

Keywords: cuttlefish, trammel bottom set catches, eastern Adriatic

Introduction

Cuttlefish, *Sepia officinalis*, is one of the most abundant cephalopods species in the eastern coastal Adriatic, where it is commercially exploited all over the year (2-5). In early spring large individuals leave the deeper water, where they spend the winter, and migrate into shallower water owing to spawning (1-3, 5, 6, 8), when it is particularly abundant species in catches of some coastal fishing gears, i.e. benthic trawl, drift net and trammel bottom set. It is demersal, neritic species occurring predominantly on sandy to muddy bottoms from the coastline to about 100 m depth (2, 5-7), rarely deeper (8). In the Adriatic Sea, in spite of commercial value, its biology and ecology are poorly known (2-6). The aim of this study is to give some new information on length frequency distribution, sex ratio, length-weight relationship and frequency of occurrence of cuttlefish collected with trammel bottom sets in the eastern Adriatic.

Material and methods

Cuttlefish samples were collected in coastal water to cca 30 m depth by trammel bottom sets of 24, 28, 30, 32, 35 and 40 mm "maha" mesh-size from 1975 to 2000. A total of 2105 specimens were analyzed in 428 positive trammel bottom set catches. Mantel length (*ML*) was measured to the nearest 0.1 cm and weight (*W*) to the nearest 1 g. The commonly used length-weight relationship was applied: $W = a(\mathrm{ML})^b$. Differences in *ML* – *W* relationship between sexes was tested by ANCOVA, and hypothesis of isometric growth by the t-test.

Results and discussion

Length frequency distribution : *ML* of total sample ranged from 6.5 to 25.5 cm ($\bar{x}ML$ = 11.70 ± 2.8563). *ML* of females (*N* = 286) ranged from 7.9 to 23.5 cm ($\bar{x}ML$ = 12.66 ± 2.6490) and of males (*N* = 457) from 7.5 to 22.5 cm ($\bar{x}ML$ = 11.53 ± 2.5188) (Fig. 1). Obtained mean *ML* of female cuttlefish was significantly larger than males (*t*-test, *t* = 5.7887; *p* > 0.05).

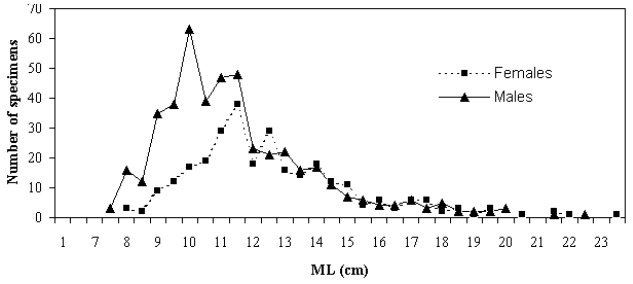

Fig. 1. *Sepia officinalis* - Length frequency distribution of males (N =457) and females (N = 286).

Sex ratio : Sex was determined in 743 specimens; 286 were females and 457 were males, and sex ratio (males/females) was 1 : 1.60 in favour of males. A chi-square test revealed a significant departure from the theoretical 1 : 1 sex ratio (x^2 = 39.36, *Cv* = 3.84, *p* > 0.05).

Length-weight relationship : The weight of all sampled specimens ranged from 35 to 1800 g ($\bar{x}W$ = 222.0 ±184.142). The range for males was from 55 to 1092 g ($\bar{x}W$ = 199.9 ± 145.653) and for females from 60 to 1200 g ($\bar{x}W$ = 267.15 ±181,104). Obtained mean body weight of female cuttlefish was significantly larger than males (*t*-test, *t* = 5.297; *p* > 0.05). On account of this length-weight relationships were calculated separately for males, females and both sexes. The slopes (*b* values) of the total length-weight relationships, which differ significantly between sexes (ANCOVA, p > 0.05), indicate negative allometric growth for males, females and both sexes (Tab. 1). The value of *b* for males, females and both sexes were significantly different from 3.0 (*t*-test, *Cv* = 2.576): males *t* = 9.402, *p* > 0.05; females *t* = 5.969, *p* > 0.05; both sexes *t* = 18.808, *p* > 0.05.

Frequency of occurrence : In the trammel bottom sets the best cuttlefish catches (catch per one net, CPUE) down to 30 m depth were noticed during the spring and early summer (Fig. 2), which is in agreement with seasonal pattern of offshore-inshore migrations (1, 2, 5, 7, 8).

Table 1. *Sepia officinalis* - Parameters of the length – weight relationship (W = aMLb) for females, males and both sexes.

Sex	*a*	*b*	SE (*b*)	*N*	r^2
Females	0.2326	2.7307	0,03498	286	0.9280
Males	0,2443	2.6938	0,03965	457	0.9376
Both sexes	0.2366	2.7195	0.02558	2105	0.9405

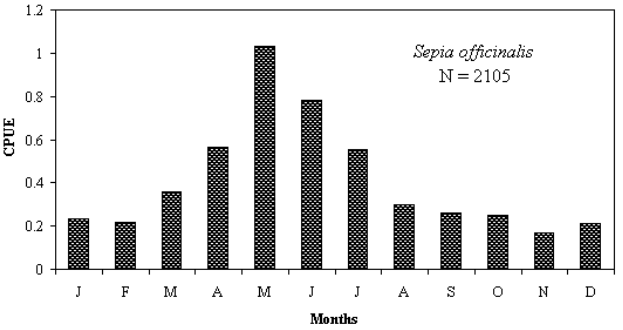

Fig. 2. *Sepia officinalis* - Frequency of occurrence (CPUE) in trammel bottom set catches.

Selectivity rate of trammel bottom sets : Preliminary data of selectivity rate of nets with different "maha" mesh-size were shown in Tab. 2. Calculated mean *ML* of cuttlefish are significantly different according to different mesh-size (*F* = 23.22, *Cv* 0 2.21, *p* > 0.05).

Table 2. *Sepia officinalis* - Preliminary data of trammel bottom set selectivity.

Mesh - size (mm)	N	*ML* (cm)		*W* (g)	
		Range	$\bar{x}$ ± SD	Range	$\bar{x}$ ± SD
24	364	6.5 – 21.0	11.03 ± 2.9759	35 - 1050	200.6 ± 172.56
28	1304	7.0 – 25.5	11.46 ± 2.7076	35 - 1800	209.4 ± 175.62
30	114	8.2 – 21.7	12.49 ± 2.7261	65 - 872	254.2 ± 161.15
32	67	8.5 – 21.3	12.70 ± 2.6136	60 - 976	251.9 ± 158.18
35	214	8.2 – 24.5	12.78 ± 2.5711	40 - 1335	257.2 ± 191.77
40	42	11.5 – 22.0	15.38 ± 2.8393	190 - 985	426.1 ± 216.34

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GROWTH OF PANDORA, *PAGELLUS ERYTHRINUS,* FROM THE MONTENEGRIN SHELF

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Abstract

The growth parameters of Pandora, *Pagellus erythrinus* (Linaeus, 1758) were estimated for the Montenegrin coastal area, as this is one of the most important species of trawling fishing. The estimates were made separately for Boka Kotorska Bay and the open sea of Southern Adriatic.

Keywords: Growth, Teleostei, Montenegrin shelf, South Adriatic

Pandora, *Pagellus erythrinus* (Sparidae, Percoidei) is only economically interesting species which biology and population dynamics has been studied in details in the Montenegrin coastal area. Among the others, growth parameters of this species have been studied too,(1) estimated growth parameters of Pandora in this area from the data obtained in the period from 1964 to 1965. These estimates apart, the only data on Pandora's growth for the Eastern Adriatic coast are those from the channel of the Middle Adriatic in the period 1957/58 (2). Therefore, the recent results given in this paper can be compared with these previous data.

Material and methods

Material was collected during the period from May 1997 to May 1999, with commercial trawlers in depth of 50-300 m. Thirty trawl hauls were analysed in total. In Boka Kotorska Bay 10 hauls were performed, and 20 at the open sea (Fig.1). The length and weight of 3201 individuals of *Pagellus erythrinus* were measured. The total weight of analysed individuals was 362.39 kg. Of that number, 2093 individuals (310.99 kg) were from Boka Kotorska Bay, while 1108 individuals (51.4 kg) have been taken at the open sea. Collected material was almost entirely processed on board Total length (TL), from the peak of mandible to the stretched ends of the caudal fin was measured with the one mm precision. The age of the fish was determined through rings on scales taken immediately above the lateral line. The age was read with the help of binocular lens "WILD" that enlarges 25 times. The estimate of growth parameters in the von Bertalanffy's function (3,4) is done with the method of smallest squares of non-linear functions. In order to calculate this, programs FISAT (5) and TRAWLAN (6) were used. The parameters L_∞, K and t_0 are being estimated after the various transformations, in different ways, based on a long row of data about age (t) and length of fish (L). The ratio $\frac{L_{max}}{L\infty}$ was also calculated (7), as the mass growth in the function of time (3,4).

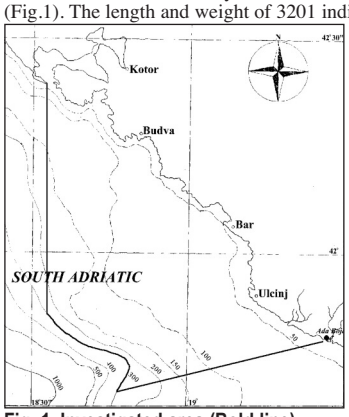

Fig. 1. Investigated area (Bold line).

Results

The results of estimate of growth parameters are shown in Table 1 as well as graphically in Figure 2 and Figure 3. Table 2 shows the estimated values of length-weight ratio (8), growth and maximum weight of individuals, gathered both through this estimate and the earlier estimates for Boka Kotorska Bay, for year 1964/65 (1) and the channels of Midlle Adriatic from year 1957/58 (2).

Table 1. Growth parameters of von Bertalannfy's growth function, by method of estimation of sum smallest squares of non-linear function.

	L_∞	s.e.	c.v.	K	s.e.	c.v.	t_0	s.e.	c.v.	r
Bay	37.741	0.457	0.0121	0.162	0.0065	0.0399	-1.227	0.0979	-0.045	0.993
O. sea	32.755	2.592	0.0791	0.202	0.0494	0.2445	-0.568	0.4548	-0.801	0.990

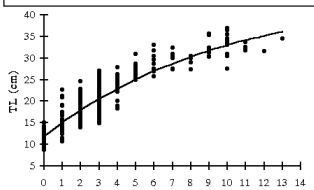

Fig. 2. Graphical explanation of growth parameters estimated for Boka Kotorska Bay.

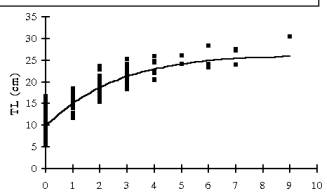

Fig. 3. Graphical explanation of growth parameters estimated for open sea.

Discussion

Estimation of growth parameters by the method of smallest squares of non-linear functions gave following results: for the Bay L_∞ = 37.741, K = 0.162 and t_0 = -1.227, for the open sea L_∞ = 32.752, K = 0.202 and t_0 = -0.568. Rijavec (1) got following values: for Boka Kotorska Bay L_∞ = 30.92 cm, K = 0.239 and t_0 = -1.639. The results of present estimate show larger values of the asymptote for Boka Kotorska Bay L_∞ = 37.741, but smaller growth rate K = 0.162, while t_0 =-1.227. The most probable explanation of this difference is the increase of trophic base in the bay as well as the increase in this species' biomass. Therefore, it may be assumed that the intraspecific competition has increased too, so the individuals grow slower but attain larger final size. The parameters that indicate the levels of eutrophication (nutrients, oxygen saturation, BOD, etc.) were not systematically measured in the Boka Kotorska Bay. Therefore, it is difficult to estimate the time of the beginning of anthropogenic eutrophication, and to assess its level. The only reliable indicator of human induced eutrophication of the Bay is the regular appearance of the summer maximum instead of usual spring and autumn maxima of phyto and zooplankton (9). However, until the beginning of seventies, there were no summer maxima of both phytoplankton (10) and zooplankton (11) in the Adriatic. They appeared for the first time with the beginning of anthropogenic eutrophication of Adriatic.It is not possible to compare these data with data from Rijavec (1), as he does not present data of estimates of growth parameters for the open sea. The only existing data which may be compared with ours are given for the channel area of Midlle Adriatic, Zupanovic and Rijavec (2) have compared the material collected in season 1957/58 and find out that L_∞ = 37.88 and K = 0.20. The value of K in the channel zone of the Midlle Adriatic matches the value of K for the open sea of Montenegin sea coast, while L_∞ matches the value for Boka Kotorska Bay. These data point to the conclusion that the ecological conditions of channels in Midlle Adriatic in season 1957/58 were similar to the present ecological conditions of Boka Kotorska Bay. The discovered difference between the asymptotes and the temporary growth rates in Boka Kotorska Bay and the open sea, supports the theoretical hypothesis that, the quicker growth rate is, the smaller are the asymptotic lengths, means that, K and L_∞. are oppositely correlated. On the other hand, Zupanovic and Rijavec (2) have find out that at the relatively high values of temporary growth rate, the asymptote is large, too. This disagreement with the theory can be explained in two ways. As the channel area of Midlle Adriatic belongs to the naturally euthrophic zones (12), while the trawling fishing as well as the other ways of fishing were intensive even then, it is possible that Pandora grew faster due to suitable trophical conditions on one hand, and the decreased intraspecific competition on the other hand. The other explanation is, that perhaps those are two different populations of *Pagellus erythrinus*, one living in channel area of Midlle Adriatic and other from Montenegin shelf.The calculated Hohendorf's index shows that the specimens from the bay have a better growth potential (0.962) than those on the open sea (0.930). Considering the ecological conditions and the greater amount of suitable food, the difference in values of this index is clear. The calculated values of final growth W_∞ for the bay are now at 559.95 grams, similar to the values for channels of Midlle Adriatic 679.74 gr (2). This fitting of values supports the already explained similarity of ecological conditions in these two areas. On the other hand, the almost identical values for the open sea now 326.28 gr and Boka Kotorska Bay 313.84 gr in the period 1964/65 (1) speak in favor of the smaller trophical base, i. e., insignificant eutrophication of the Bay in previous period. Nowadays, the value of W_∞ for Boka Kotorska Bay is almost twice bigger than in the season of 1964/65, and this also points to the intensive anthropogenous eutrophication of Boka Kotorska Bay.

Table 2.- The estimatied values of length-wight ratio, growth and maximal weight of specimens in present and previous research.

	W_∞ (gr)	L_∞ (cm)	a	b
B.K..Bay 98/99.	559.95	37.741	0.0146	2.907
Open sea 98/99.	326.28	32.755	0.0216	2.758
B.K.Bay 64/65.	313.84	30.92	0.0220	2.787
Midlle Adriatic 57/58.	679.74	37.88	0.0134	2.981

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COMMON OCTOPUS (*OCTOPUS VULGARIS*, CUVIER 1797) COASTAL FISHERY, DURING THE PEAK OF SPECIES REPRODUCTION

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Abstract

The present paper studies the catchability of fyke-nets and pots used in *O. vulgaris* fishery in the Thracian Sea. The analysis of variance showed that the catch per unit effort and the average mantle length of specimens caught by the two gears were similar. The by-catch species are referred.

Keywords : Octopus, fishery, Aegean Sea, traps

Introduction

Octopus fishery is widespread in the Thracian Sea, North Aegean Sea. Octopus catches are shared among three fishing gears, trawls, fyke-nets and pots. FRI was funded by the region of Eastern Macedonia-Thrace to study the catches of fyke-nets and pots at the peak of the reproductive period for the species *Octopus vulgaris*. The aim of the study was to support a new legislation on the use of these gears.

Materials and methods

During May to July of 1999, eleven cruise were conducted in the main octopus fishing grounds in the Thracian Sea. The survey was restricted to the depth zone of 30-35 m. The substrata were sand with mud and posidonia meadows. Data were collected by on board sampling on professional fishing vessels using fyke-nets and pots (Fig. 1). Fyke-nets exist in pairs which are bound together with a gillnet; 36-40 mm full mesh, 50 cm high and 3-4 m long. Pots were made from plastic material with volume 5 liters and opening 9-13.5 cm diameter. A fleet of fyke-nets usually enumerate 250-450 pairs, while a fleet of pots enumerate 800-1200 pots. Both gears were usually set for 5-10 days. Species abundance was recorded in number and weight. Individuals were measured in mantle length and weighted. The gonad maturity was recorded in three stages according to Sanchez (1). The by-catches and the food remains in the gears were also recorded.

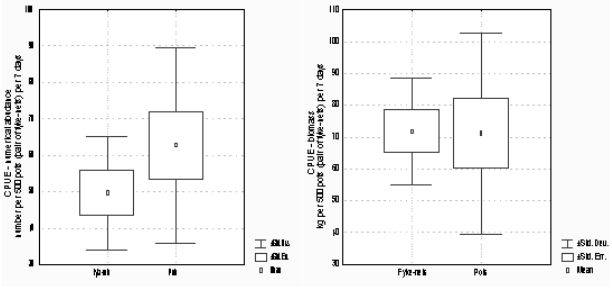

Fig. 1. CPUE values expressed in number and biomass for the two gears, fyke-nets and pots.

Statistical analysis was based on catch per unit of effort (CPUE) values and mantle length frequencies. CPUE values were calculated in terms of individuals or biomass per 500 pots (or pair of fyke-nets) per 7 fishing days. The mean CPUEs and mean mantle lengths were compared between the two gears, using one-way analysis of variance. The *Chi*-square test was used to examine the preference of females to stay in pots gluing their eggs.

Results - Discussion

Using 14280 traps in total, 3700 fyke-nets and 10580 pots, 1096 individuals of the species *O. vulgaris* were caught. The majority of them, 99.45 %, were recorded at the third maturity stage. The ovaries of females were very large with plenty of eggs, while the spermatophores were visible in the spermatophoric sacs of males. Considering that a pair of fyke-nets operates like a trap, ANOVA indicates no statistical difference (p>0.05) between the mean CPUEs (either expressed in individuals or biomass) for the two gears (Fig 1). However, the values of standard deviations for the two gears indicate that the CPUE of fyke-nets varies less than pots. This is because the fyke-nets work like trap while pots catch-ability is highly dependent on octopus diel activities. Comparing the mean mantle lengths of the octopus caught in the two gears, ANOVA shows no statistical difference (p>0.05). The *Chi*-square test denotes that there were no significant difference between the male-female ratio in the two gears.

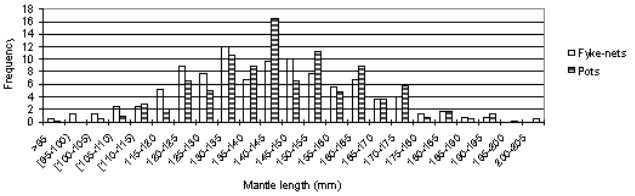

Fig. 2. *Octopus vulgaris* mantle length frequencies for the catches of the two gears.

The only by-catches in pots were gobids of the species *Gobius niger* and glued eggs of it inside the pots. From the remains of the preys which were found inside the pots were identified mainly crabs, *Liocarcinus depurator* and *Goneplax rhomboids* and less frequent the species *Gobius* niger, *Ophidion barbatum, Conger conger, Cepola rubescens, Scyliorhinus canicula* and *Eledone moshata*. We also found bivalves and gasteropods. During the last sampling in the total of 1050 pots 5 octopus males were found as preys of females, and it was denoted that both sexes were mature, third stage. In the fyke-nets as by-catches were recorded the species *L. depurator, G. rhomboides, Homarus gammarus, Palinurus elephas, C. conger, Spicara flexuosa, P. physis, Mulus surmuletus, Muraena elena, Diplodus annularis, Scorpaena porcus, Scorpaena notata, S. canicula, Trachurus trachurus, Raja miraletus, E. moshata* and *Sepia officinalis*. Also eggs of the species *Loligo vulgaris* were stack outside the trap.

From ourresults it seems that fyke-nets are traps which at the beginning catch fishes and crabs (due to the existence of gill-nets which drive them inside) and furthermore they attract octopus. These sequential catches explain why the gear is efficient after 5-10 days of setting. On the other hand, pots offer a shelter to the octopus in no rocky places. However, the variability of weather conditions, in relation to the stability of the light plastic pots to the current, affects the catches. It was also observed that during full moon the catches in pots were lower than the average. Stack octopus eggs inside pots were found only 4 times out of the total of pots used. However, it seems that the longer time the pots in the sea the more pots with stack eggs inside, because the better the adaptation of the animal to the new environment.

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GEOGRAPHICAL AND BATHYMETRICAL DISTRIBUTION OF *ARISTAEOMORPHA FOLIACEA* AND *ARISTEUS ANTENNATUS* (DECAPODA, ARISTEIDAE) IN THE GREEK IONIAN SEA

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Abstract

Aristaeomorpha foliacea and *Aristeus antennatus* have been found for first time in the Eastern Mediterranean (Greek North Ionian Sea). A total of 18.227 specimens of *A. foliacea* and 1807 individuals of *A. antennatus* were collected during three experimental trawl surveys mainly in the depth range 500-900 m. The spatio-temporal distribution of both species in the study area is discussed.

Keywords : distribution, Decapoda, Deep water, Ionian Sea

Introduction

Aristaeomorpha foliacea and *Aristeus antennatus* are commercially very important decapods in the Western and Central Mediterranean. However, they are almost unknown in the Eastern Mediterranean and only scarce data exist on their distribution [1, 2, 3] and biology [3] in the Greek waters. The present work aims to study the geographical and bathymetrical distribution of the two species in the Greek waters of the North Ionian Sea.

Material and methods

Three seasonal surveys (April, July and September 2000) were carried out along the Greek coasts of the North Ionian Sea, between Othoni Island and the Island of Zakynthos, (Fig. 1a, b) in depths ranging from 300 to 1200 m. Stratified sampling was used and a total of 60 hauls were carried out during each survey. A commercial 159 tons vessel, with 923 Hp engine was hired, equipped with a trawl of 40 mm stretched mesh size in the cod-end. 13426 and 1476 specimens of *A. foliacea* and *A. antennatus*, respectively, were sexed, measured (CL, mm) and weighted (gr).

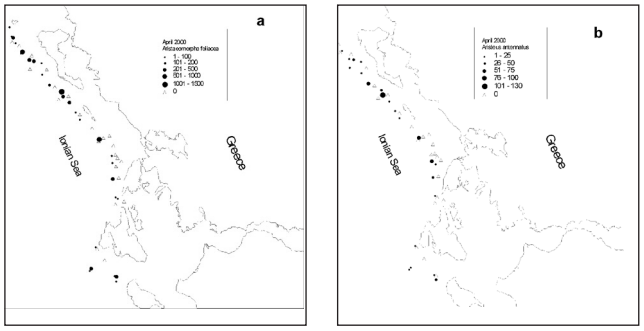

Fig. 1. Abundance (N/h) of *A. foliacea* (a) and *A. antennatus* (b) in April 2000 per sampling station in the study area

Results and discussion

Aristaeomorpha foliacea was found for first time in important quantities in all the experimental surveys (289-259 N/h). *A. antennatus* was also caught for first time in the study area but in lower numbers (50-25 N/h). The presence of both species showed a spatial continuity in all the study area, however, their abundance picked in some of the sampling stations (Fig. 1a, b). This significantly lower abundance of *A. antennatus* comparing to *A. foliacea* has been found also in the Sicilian Channel [4], while in the Italian Ionian Sea the opposite has been observed, attributed to different oceanographic and ecological factors [5].

A. foliacea and *A. antennatus* were found in depths ranging from 487 to 1047 m. and from 504 to 1171 m, respectively. *A. foliacea* was more abundant in the depth zone 500-700 m, whereas the abundance of *A. antennatus* did not differ significantly in the zones 500-700 and 700-900 m (Kruskal-Wallis test, P=0.38). Both species presented very low values in depths >900 m (Fig. 2a, b). Small specimens (<30 mm CL) of *A. foliacea* appeared almost exclusively in the depth zone 500-700 m., although some of them were also found in depths <500 m. (Fig. 2a). Larger individuals (>30 mm CL) appeared in both depth zones, however, they were very abundant between 500-700 m. *A. antennatus* specimens were found in three depth zones (500-700, 700-900, >900 m) but in very low numbers in depths >900 m (Fig. 2b). Large individuals (>45 mm CL) were more frequent from 500 to 700 m.

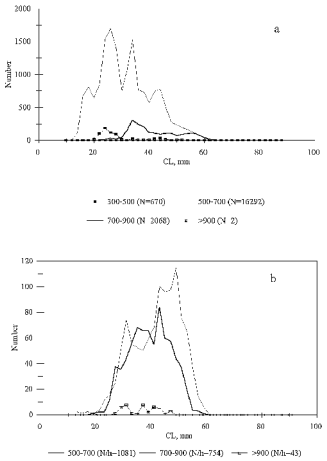

Fig. 2. Length frequency distribution of *A. foliacea* (a) and *A. antennatus* (b) in relation to depth

The examination of the length frequency distribution in relation to depth for *A. foliacea* did not show differences among the three sampling periods. Recruitment was observed mainly in April, as also mentioned in the Italian Ionian Sea [5]. A slight displacement of large individuals (> 30 CL mm) from the shallower depth zone to the deeper one was observed in July. This movement to the deeper grounds in summer, during the spawning period, was also observed in the Sardinian waters [6]. In *A. antennatus*, a more clear seasonal mobility pattern was evident during the three surveys. The main bulk of the population moved from the shallower depth stratum in April to the deeper one in July and the opposite from July to September. This is not in fully agreement with the distribution pattern of the species in the W. Mediterranean. In this area the species is found in deeper waters in winter-spring whereas in the shallower in autumn [7].

Red shrimp species were found in important quantities in the Greek Ionian Sea, fact hopeful for the development of deep-water fishery in Greece. A more detailed investigation on the biology of the two red shrimps in relation to environmental factors would improve our knowledge on their distribution pattern in the study area.

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OBSERVATIONS ON THE REPRODUCTION OF *ARISTAEOMORPHA FOLIACEA* (CRUSTACEA : ARISTEIDAE) IN THE SE. IONIAN SEA

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Abstract

The deep water shrimp *Aristaeomorpha foliacea* (Risso, 1827) is of high economic importance in the western and Central Mediterranean. In the present paper first data from a population in the SE. Ionian are presented. Compared to other Mediterranean stocks, shrimps showed an earlier reproduction peak (June), while mating activity was more pronounced and lasted for a longer period (ten months). GSI showed lower mean values (0.80, 1.09, 4.89, 6.63 for stages I-IV respectively).

Keywords : reproduction, decapods, Ionian Sea, Deep water

Introduction

The deep-water shrimp *Aristaeomorpha foliacea* (Risso, 1827), together with *Aristeus antennatus* (Risso, 1816), constitutes a commercially important resource for the Western and Central Mediterranean. Recently, new evidence from Greek waters suggested that it is adequate for exploitation [1, 2]. As opposed to the W. Mediterranean [4-8], few data exist for the E. Mediterranean [3]. The aim of this study is to present first data on the reproduction of *A. foliacea* in the SE. Ionian and contribute to a comparison along the Mediterranean.

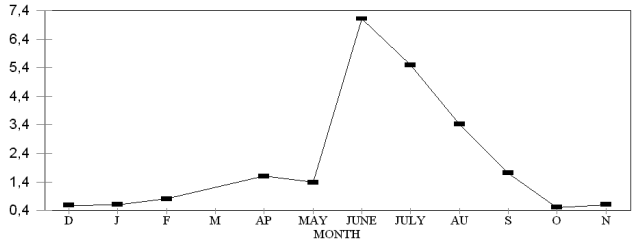
Materials and methods

The material was collected monthly between the Peloponnisos and Zakynthos Island (December 1996 - November 1997), in a depth range from 446 to 728 m, using a commercial trawl net (14 mm at the cod end). Female size (CL, mm) was measured to the nearest 0.01 mm and the presence of spermatophores was recorded. Body and ovary weight were measured to the nearest 0.0001 g. Gonad maturity was determined macroscopically [5] and the gonadosomatic index (GSI) calculated as 100*GW/BW.

Results and discussion

Mated females always constituted more than 75% of the female population, except for October and November (5% and 30% respectively). In May, June and September they actually dominated almost completely. The size of the smallest female bearing spermatophores was 25 mm CL, while the observed size at which 50% of the females had already mated, was 37 mm CL.

Spawning (ovarian stage III+IV) began in April and May (2.7% and 10.3% respectively), sharply increased in June (87.5%), continued in July and August (57.8% and 37.1% respectively) and ended in September (Fig. 1). The smallest mature female measured 37.5 mm CL. For a four-month period (October to January) almost all females showed inactive ovaries, entering the preparation for the new reproduction in February (>60% with maturing ovaries). An overlapping of female size according to the ovarian



maturation has been observed (Table 1).

Fig. 1. Temporal evolution of female maturity of *Aristaeomorpha foliacea.*

Table 1 : Gonadosomic index (GSI, %) and female size (CL, mm) of *Aristaeomorpha foliacea* in relevance to the maturity stage of the ovary.

STAGE	GSI	CL
	Mean ±SD	Mean ±SD
I	0.80±0.61	42.62±6.57
II	1.09±0.72	47.11±6.30
III	4.89±1.48	44.58±4.27
IV	6.63±2.27	46.37±4.19

Temporal variability of the mean GSI (Fig. 2) showed a distinct seasonal pattern : <1% for the period October to February, slightly increasing in April and May (1.6% and 1.4% respectively), peaking in June (7.1%) and gradually decreasing afterwards until September (1.7%). The mean GSI for each maturity stage is given in Table 1.

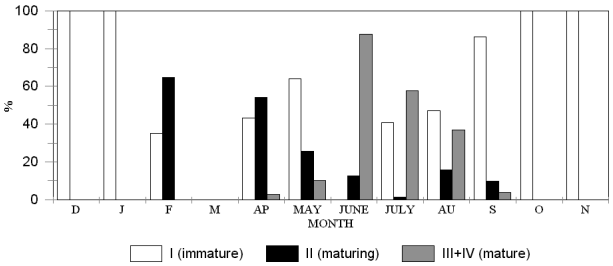


Fig. 2. Mean values of GSI of *Aristaeomorpha foliacea.*

From the above results, a preliminary comparison with other localities along the Mediterranean can be attempted. In the SE. Ionian, although the overall reproductive period coincides with that in Sardinia, Sicily and NW. Ionian [6,7,8], both the start and the peak of the reproductive activity was shifted for about one month earlier (regarding both mature ovaries and GSI). Moreover, mating activity seemed to be more pronounced (higher percentages of mated females) and lasting longer (ten months). The period of low mating activity is in accordance with that of the low male maturity [8].

Regarding GSI, the mean for each ovary stage was significantly smaller than that already reported [5, 9]. It could be tentatively attributed to population differences; nevertheless, methodological reasons cannot be excluded as frozen material was used in the present study. It is evident therefore, that a better insight in the biology of the species along the Mediterranean can be achieved only by applying common methods in parallel.

Acknowledgments

Dr. C. Papaconstantinou and G. Petrakis ('Deep Water Fisheries' project) are cordially thanked for providing the material.

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SMALL-SCALE GEAR COMPETITION AND OVERLAP FOR *DIPLODUS ANNULARIS* AND *SERRANUS CABRILLA*

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Abstract

In the present study, multivariate techniques were used to analyse competition and overlap between different fishing gears (gillnets : 22, 24, 26 and 28 mm bar length; longlines with hook sizes : 11>12>13>15), in terms of total length, weight and value, for *Diplodus annularis* and *Serranus cabrilla*. Cluster and multi-dimensional scaling analyses clearly indicated that gillnets with mesh sizes 26 and 28 mm and hook size 15, for *D. annularis*, and gillnets with mesh sizes 24, 26 and 28 mm, for *S. cabrilla*, caught larger individuals of higher value, the vast majority of which were sexually mature, than the remaining gears.

Keywords : fisheries, Aegean Sea

Introduction

Small-scale fisheries are of primary social and economic importance to Greece, accounting for 87.5% of the mean number of boats and 47.7% of the mean value of landings (1). In the present study, multivariate techniques were used to identify gear competition and overlap, in terms of total length, weight and value, between gillnets and longlines for *Diplodus annularis* and *Serranus cabrilla*.

Materials and Methods

Overall, 46 fishing trials were carried out in the coastal waters off Naxos Island (Cyclades), from October 1997 to October 1998, with gillnets (mesh sizes : 22, 24, 26 and 28 mm bar length; G_{22}, G_{24}, G_{26} and G_{28}, respectively) and longlines ("Mustad" round bent spade hooks of sizes 11>12>13>15; H_{11}, H_{12}, H_{13} and H_{15}, respectively). 1000 m of each mesh size and 250 hooks of each hook size were used. Fishing with all gears took place on the same day, at the same general area and at depths ranging from 4 to 90 m. Wholesale values are from reference 2, whereas market values were collected locally. Data were grouped in classes with different step per parameter (total length, TL : 0.5, 1, 2 and 3 cm; weight : 5, 10, 15, 20 and 25 g; wholesale and market value : 2, 5, 10 and 15 drh). The (number per class)¥(fishing gears) matrices were transformed to triangular matrices using the Bray-Curtis similarity index (3) and subjected to both clustering (group-average linking) and non-metric multi-dimensional scaling (MDS) techniques, using PRIMER (4).

Results and Discussion

Overall, 284 individuals of *D. annularis* and 466 individuals of *S. cabrilla* were caught. Both cluster (Fig. 1) and MDS (figures not shown) indicated the same groups per species for all parameters examined (weight and values : figures not shown), irrespectively of class step. Three groups (G_{22}+G_{24}; G_{26}+G_{28}+H_{15}; and H_{11}+H_{12}+H_{13}) were identified for *D. annularis* (Fig. 1a) and two (G_{24}+G_{26}+G_{28}; and G_{22}+H_{11}+H_{12}+H_{13}+H_{15}) for *S. cabrilla* (Fig. 1b).

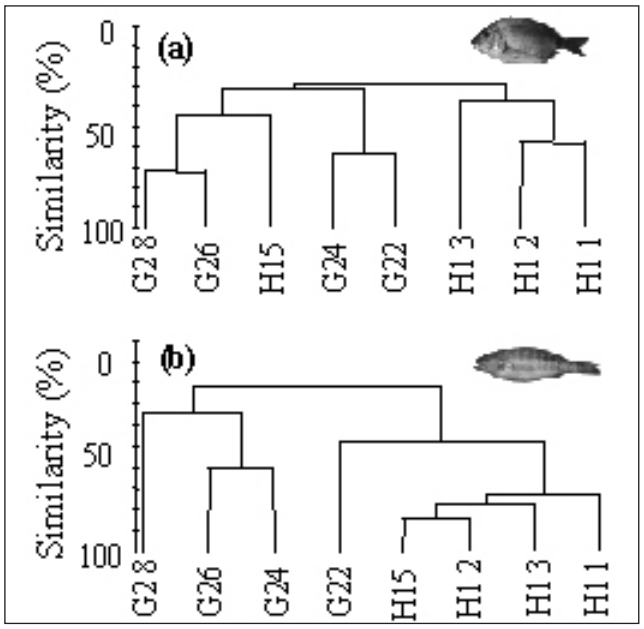

Figure 1. Dendrograms of group-average clustering for (a) *Diplodus annularis* and (b) *Serranus cabrilla*, using Bray-Curtis similarity matrices (based on length, step=1 cm), Cyclades 1997-1998. G_{22}, G_{24}, G_{26}, G_{28} : gillnets with mesh sizes 22, 24, 26 and 28 mm, respectively; H_{11}, H_{12}, H_{13}, H_{15} : longlines with hook sizes 11, 12, 13 and 15, respectively.

For *D. annularis*, group G_{26}+G_{28}+H_{15} generally caught larger individuals of higher value when compared to those of the remaining ones (Fig. 2). The greatest fishing pressure was expended on small sized and valued classes (Fig. 2). The percentages of individuals with TL<TL_{m50} (i.e., length at 50% maturity) caught in groups G_{22}+G_{24} and H_{11}+H_{12}+H_{13} were 35.3 and 15.0%, respectively, whereas that of group G_{26}+G_{28}+H_{15} was the lowest, 1.9% (Fig. 2).

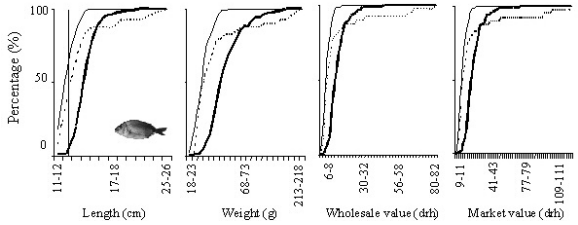

Figure 2. *Diplodus annularis*. Cumulative frequency distributions of total length, weight, wholesale value and local market value, for the groups identified by multivariate analysis : G_{22}+G_{24} (---------), G_{26}+G_{28}+H_{15} (----------), and H_{11}+H_{12}+H_{13} (- - -) (for symbols see Fig. 1), Cyclades 1997-1998. Vertical line indicates length at 50% maturity (L_{m50}=12.5 cm; from reference 5).

For *S. cabrilla,* group G_{24}+G_{26}+G_{28} caught larger individuals and of higher value when compared to group G_{22}+H_{11}+H_{12}+H_{13}+H_{15} (Fig. 3). Although both groups competed for some size classes (Fig. 3), group G_{24}+G_{26}+G_{28} caught considerably fewer individuals with TL<TL_{m50} than group G_{22}+H_{11}+H_{12}+H_{13}+H_{15} (21.6 and 58.0%, respectively).

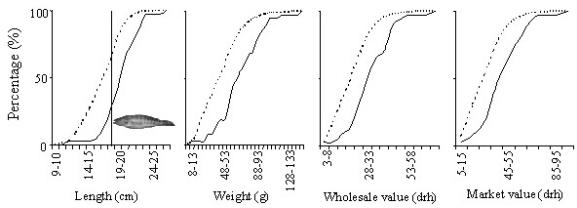

Figure 3. *Serranus cabrilla*. Cumulative frequency distributions of total length, weight, wholesale value and local market value, for the groups identified by multivariate analysis : G_{24}+G_{26}+G_{28} (---------) and G_{22}+H_{11}+H_{12}+H_{13}+H_{15} (- - -) (for symbols see Fig. 1), Cyclades 1997-1998. Vertical line indicates length at 50% maturity (L_{m50}=17.5 cm; from reference 1).

The results clearly indicated the strong multi-gear nature of the Greek small-scale fisheries, one of the main factors responsible for the failure of the technical regulations currently in force, and thus the importance of Marine Protected Areas as one of the most promising management tool (for an extended discussion see : 1, 6).

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ENVIRONMENTAL EFFECTS OF FISH FARMING IN THE MEDITERRANEAN

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Abstract.
A research project addressing the problem of environmental impacts of cage farming was carried out from 1995-1998 in Greek coastal waters, involving sampling of biogeochemical variables in the water column and the sediments at different spatio-temporal scales. The impacts found in the water column were low and the impacts on benthos were more easily detectable at silty sediments than at coarse sand sites. In all cases benthic effects did not exceed a distance of 25 m from the edge of the cages.

Keywords : aquaculture, geochemistry, plankton, zoobenthos, pollution

Introduction

The Mediterranean has experienced an exponential increase in fish farming production during the last 15 years, but only recently there have been some studies on the impact of fish farming on water quality and parasites (1), the effects on nutrients and plankton (2), the effects on seagrass (3), the dynamics of sediment accumulation beneath fish farm cages (4), the recovery process of the benthos after cessation of fish farming (5) and the effects on sediment geochemistry and benthic organisms (6, 7, 8).

Materials and methods

Sediment sampling for total organic C and N, redox, ATP content, Chl *a*, pheopigments, and macrofauna (>0.5 mm) was carried out during 3 seasonal cruises (July, November 1995, April 1996) aboard the RV *Philia*. Two fish-farms were visited in the Ionian and one in the Aegean Sea (Cephalonia, Ithaki and Sounion, respectively). Samples taken at 0, 5, 10, 25, 50 and 100 m from the edge of the cages were analysed as reported in (6). Water column was also sampled at different depth layers at the cages and at a control site. Samples were analysed for POC, PON, Chl *a*, nutrients and microplankton species diversity and community structure as described (2) .

Results

Benthic effects. A summary of the information (6) on impacts on the seabed beneath and close to the cages is given in Table 1. The Cephalonia fish farm showed typical signs of disturbance due to organic enrichment with low macrofaunal abundance dominated by the *Capitella* complex. The coarse sediment sites showed high macrofaunal abundance (10 times more than in the control sites) dominated by *Capitella* spp. in Ithaki and by *Protodorvillea kefersteini* and *Cirrophorus lyra* in Sounion. The associated geochemical variables, and particularly redox potential and total organic carbon (TOC) showed higher enrichment and low Eh in Cephalonia, almost negligible effects in Sounion and intermediate ones in Ithaki.

Area	Cephalonia	Ithaki	Sounion
macrofaunal diversity	<	<<	<
macrofaunal abundance	<	>	>
macrofaunal biomass	<	>10	>10
Capitella spp.	dominant	dominant	present
P. kefersteini - C. lyra	abundant	present	dominant
Tharyx heterochaeta	absent	absent	absent
Redox potential	<<	≈<	≈
ATP	x10	x10	x2
TOC	x2	x2	=
TON	x2	x2	=
Sediment type	muddy sand	coarse sand	coarse sand

Table 1. Effects up to 10m from the cages in comparison to the control sites

Water column. In two of the farms, no significant difference was found in any of the measured variables between the control sites and the water column in the cages. A significant increase in concentrations of phosphate and ammonium was detected within the cages over the control site in the third farm but without any significant effect on chlorophyll concentration. Plankton abundance for the major taxa (diatoms, flagellates, dinoflagellates, ciliates) and microplankton community structure were determined by the effects of season and location rather than by the presence of fish farming.

Discussion

At all three farms, the benthic assemblages in the immediate vicinity showed symptoms of disturbance. In Cephalonia there was only a change in faunal composition but in the coarse-sediment areas there were also pronounced changes in abundance and biomass. The coarse substratum in Ithaki and Sounion apparently allows for oxic sediment conditions and therefore the microbial processes related to the decomposition of sedimenting material do not result in severe chemical stress for the macrofauna. The identical patterns of spatial change found in the three areas (6) indicate that the benthic community approaches its normal characteristics at 25 m distance. The ecotone point may lie in this region because diversity was at maximum and the assemblage included species from both the polluted region and from the original community. Seasonal variability in geochemical and macrofaunal variables was always more pronounced at stations close to the farm (0 to 10 m) than at the control site or the stations at 25 m. This may be attributed to large differences in food supply to the farmed fish between warm and cold seasons, to increased oxygen supply to the sediments during winter or to H_2S toxicity, which is also affected by seasonal processes.

Water quality is an issue extensively used in the arguments regarding the impacts of fish farming on the usability of the coastal zone by other users. However, the scientific basis of these arguments is rather weak since there is little information relating aquaculture to water quality degradation. The inconsistency between nutrient enrichment and lack of a significant increase in chlorophyll *a* may be attributed to limited utilisation of the excretory wastes due to rapid flushing time, so that phytoplankton are not present long enough to capitalise on the high production of nutrients. Since site-selection for fish farming aims at excluding sites with low water renewal, it is unlikely that signs of eutrophication would be detected in the vicinity of fish farms. However, it is possible that under certain hydrographic conditions aquaculture effluents might affect adjacent coastal bays during certain periods of time.

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AGE ET CROISSANCE DU THON ROUGE (*THUNNUS THYNNUS* L. 1758) PECHE DE LA MER EGEE ET DE LA MER MEDITERRANEE EN TURQUIE

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Résumé

Dans ce travail, on a estimé les paramètres de croissance de Von Bertalanffy pour le thon rouge capturés par des sennes tournantes de la mer Egée et de la mer Méditerranée en Turquie entre janvier 1996 et juin 1998. Des valeurs paramétriques estimées de $L\infty$ = 315.493 cm, k=0.085 et t_o= -1.223 ans ont été dérivés jusqu'à l'âge 9.

Mots-Clés : Croissance, Mer Egée, Mer Méditerranée

La pêche du thon rouge en Turquie est l'une des pêcheries les plus importantes. Il est surtout capturé par des professionnels à l'aide de sennes. Après les années 1980, en fonction des développements dans les bateaux de senne tournante, il y a eu une certaine augmentation dans la quantité de pêche du thon rouge et on a commencé l'exportation de ce poisson. La quantité de thon rouge pêchée est tombée de 2230 tonnes en 1985 (FAO), 633 tonnes en 1996. Il y a peu de travaux sur cette espèce concernant les côtes de Turquie (1- 5). Nous apportons les premières données sur l'analyse de l'âge et de la croissance du thon rouge en Turquie dans ce travail.

Matériel et méthodes

Les échantillons de thon rouge ont été prélevés de la mer Egée et de la mer Méditerranée en Turquie entre janvier 1996 et juin 1998. Les poissons sont capturés à l'aide de sennes tournantes. Les données comprennent la longueur à la fourche en cm et le poids total en kg de 3577 individus. L'âge du thon rouge a été estimé à partir du premier rayon épineux de la nageoire dorsale (6). L'étude a été faite en utilisant 1526 échantillons (1-9 ans). A partir des clés âge-taille de thons rouges établies selon l'équation de Von Bertalanffy, nous avons analysé la répartition démographique des captures de la mer Egée et de la mer Méditerranée en Turquie. Chez le thon rouge, il y a quelques difficultés dans le calcul des groupes d'âge de $W\infty$ dans la détermination de la relation âge-poids tout en prenant de base la moyenne de taille des groupes d'âge mesuré. Par le procédé proposé par Beverton et Holt (7) ci-dessous, on a trouvé l'équation de croissance en poids de Von Bertalanffy : $W\infty = a \,.\, L(t)^b$; $W(t) = a \,.\, L\infty^{\,3}\,(1- e^{-k(t-to))b}$; $W(t) = W\infty\,(1- e^{-k(t-to))b}$;$W\infty = a.\, L\infty^{\,b}$

Résultats

La taille moyenne du thon rouge pêché par les sennes tournantes était de 118.40±0.37 cm de longueur à la fourche avec une longueur minimum de 59 cm et maximum de 275 cm, correspondant aux poids éviscérés de 31.60±0.34 kg, 3.5 kg et de 265 kg respectivement (Fig. 1). Les paramètres de la relation taille-poids du type $W = a.\, L^b$ sont les suivantes:

a	b	r
0.0000181	2.988	0.997

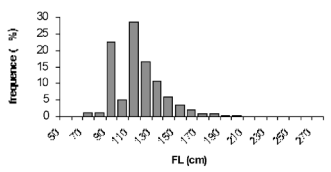

Fig.1. Distribution des tailles du thon rouge

On a constaté une croissance allométrique chez le thon rouge et une relation assez forte et positive entre les valeurs taille et poids (Fig. 2). Les paramètres de croissance de Von Bertalanffy obtenues pour le thon rouge sont:

$L\infty$ (cm)	k	t_o (ans)
315.493	0.085	- 1.223

$L\infty = 315.493\,[1-e^{-0.085(t+1.223)}]$

$W\infty = 586.153\,[1-e^{-0.085(t+1.223)}]$

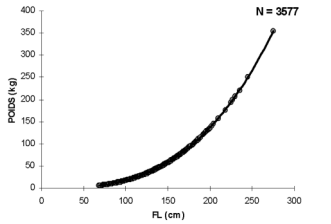

Fig. 2. Relation taille-poids du thon rouge

Les estimations des tailles moyennes obtenues à partir de la clé taille-âge correspondent aux estimations faites par rétro-calculs, étant donné qu'elles doivent être référées à la date de naissance au 1ère juin (6) (Tableau 1).

Discussion

Le thon rouge émigre vers le Bosphore et la mer Noire à partir du mois d'avril, y reste jusqu'à la fin d'août, bien qu'il soit le plus intense dans le mois de juillet et qu'il existe une migration de retour vers la mer Marmara et la mer Egée du mois d'octobre jusqu'à la fin de décembre (3, 5).

En Turquie, la pêche de thon rouge se fait intensément dans la mer Egée et dans la Méditerranée orientale. Une étude a signalé que les valeurs de longueur des thons rouges, pêchés au Bosphore et dans la Mer Marmara varient entre 120 à 330 cm et que la valeur de longueur moyenne est de 228.9±2.8 cm (2). En comparaison du résultat que nous avons trouvé, on constate que les poissons sont pêchés plus jeunes aujourd'hui et que leur longévité est plus courte. Les thons rouges en Turquie ont une croissance en taille comparable à celles d'autres pays méditerranéens, Espagne (6), France (8), Tunisie (9).

Tableau 1. Répartition des classes d'âge

FL (cm)	I	II	III	IV	V	VI	VII	VIII	IX
55-59	2	-	-	-	-	-	-	-	-
60-64	-	-	-	-	-	-	-	-	-
65-69	-	2	-	-	-	-	-	-	-
70-74	-	23	-	-	-	-	-	-	-
75-79	-	20	-	-	-	-	-	-	-
80-84	-	3	1	-	-	-	-	-	-
85-89	-	3	10	-	-	-	-	-	-
90-94	-	23	173	-	-	-	-	-	-
95-99	-	-	127	1	-	-	-	-	-
100-104	-	-	59	3	-	-	-	-	-
105-109	-	-	8	20	-	-	-	-	-
110-114	-	-	-	189	-	-	-	-	-
115-119	-	-	12	98	-	-	-	-	-
120-124	-	-	7	35	15	-	-	-	-
125-129	-	-	3	14	45	-	-	-	-
130-134	-	-	-	14	62	7	-	-	-
135-139	-	-	-	6	76	11	-	-	-
140-144	-	-	-	-	58	36	1	-	-
145-149	-	-	-	-	45	36	7	-	-
150-154	-	-	-	-	17	42	6	-	-
155-159	-	-	-	-	6	28	12	-	-
160-164	-	-	-	-	-	14	20	1	-
165-169	-	-	-	-	-	5	19	-	-
170-174	-	-	-	-	-	4	20	1	1
175-179	-	-	-	-	-	1	18	7	1
180-184	-	-	-	-	-	-	7	8	4
185-189	-	-	-	-	-	-	5	9	2
190-194	-	-	-	-	-	-	-	4	-
195-199	-	-	-	-	-	-	-	5	3
210-215	-	-	-	-	-	-	-	-	1
N	2	74	400	380	324	184	115	35	12
%	0.13	4.85	26.21	24.90	21.23	12.06	7.54	2.29	0.79

Chercheur	Pays	$L\infty$	k	t_o	$W\infty$
Farrugio (1979)	France	351.13	0.08	-1.087	-
Cort (1991)	Espagne	318.85	0.093	-0.97	615.90
Hattour (1994)	Tunisie	330	0.095	-0.366	579
Ce travail	Turquie	315.493	0.085	-1.223	586.153

En Turquie, il est interdit d'effectuer la pêche du thon rouge entre les mois de juin et de septembre et de pêcher les jeunes poissons (<90 cm). On a observé que les pêcheurs se conforment en majorité à cette interdiction.

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RELATIONSHIPS BETWEEN MAXIMUM GIRTH AND BODY LENGTH FOR SEVERAL MARINE FISHES

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Abstract

In the present study, we estimated the relationships between maximum girth (G) and total length (TL) for *Boops boops, Diplodus annularis, D. vulgaris, Merluccius merluccius, Mullus barbatus, M. surmuletus, Pagellus acarne, P. erythrinus* and *Trachurus mediterraneus*. G increased linearly with TL for seven out of the nine species examined, whereas for *D. vulgaris* and *M. barbatus*, G was a loglinear function of TL. The implications of such relationships for selectivity estimates are discussed.

Keywords : Aegean Sea, Cyclades Islands, biometrics

Introduction

The estimation of the relationship among various morphological characteristics (e.g. length, mouth and girth dimensions) is of primary importance for fisheries research (e.g. trophic ecology, selectivity estimates : 1-3). In this study, the relationship between length and maximum girth dimensions was determined for nine fish species in the Greek Seas.

Materials and methods

Sampling was conducted in the waters off Naxos Island (Cyclades), on a seasonal basis, from October 1997 to October 2000, with a commercial vessel. Samples were collected with gill nets (mesh sizes : 22, 24, 26 and 28 mm bar length), trammel nets (inner mesh sizes : 20, 24 and 28 mm bar length), and longlines (hook sizes No 11, 12, 13, and 15). All fish caught were measured for total length (TL) to the nearest mm. Maximum girth (G) was measured for a subsample to the nearest mm and consequently, the relationship between G and TL was estimated, using least – square regression.

Results and discussion

The relationships between G and TL for the nine fish species examined are summarized in Table 1 and Figure 1. The number of individuals examined per species ranged from 73, for *Merluccius merluccius*, to 234, for *Mullus surmuletus* (Table 1). G ranged from 5.7 cm, for *Boops boops* and *Pagellus acarne*, to 24.6 cm, for *P. erythrinus*, and was a linear function of TL for seven out of nine species, whereas it was loglinearly related to TL for *Diplodus vulgaris* and *M. barbatus*. All r^2 values were higher than 0.69 ($P<0.05$). The frequency distribution of G (not shown here) was unimodal for *B. boops, D. annularis, M. barbatus, M. surmuletus, P. acarne* and *Trachurus mediterraneus* and bimodal for *D. vulgaris, M. merluccius* and *P. erythrinus*.

Table 1. Relationships between maximum girth (G, in cm) and total length (TL, in cm) for nine marine fish species, in Greek waters. N : number of individuals examined; SE(b) : standard error of slope; and r^2 : coefficient of determination.

Species	N	TL range	G = a + bTL	SE (b)	r^2
Boops boops	188	11.5-26.3	G=-1.748+0.579TL	0.017	0.86
Diplodus annularis	221	9.8-17.8	G=-1.523+0.897TL	0.020	0.90
Diplodus vulgaris	110	9.9-29.4	Log (G)= -0.094+0.996Log (TL)	0.018	0.97
Merluccius merluccius	73	20.8-41.6	G=0.039+0.426TL	0.026	0.79
Mullus barbatus	103	13.1-22.8	Log (G)= -0.319+1.040Log (TL)	0.063	0.73
Mullus surmuletus	234	14.8-29.3	G=-1.384+0.642TL	0.016	0.88
Pagellus acarne	97	10.6-22.0	G=-0.270+0.598TL	0.024	0.87
Pagellus erythrinus	195	12.9-37.0	G=-0.740+0.676TL	0.008	0.98
Trachurus mediterraneus	192	18.3-33.7	G=-3.265+0.580TL	0.028	0.69

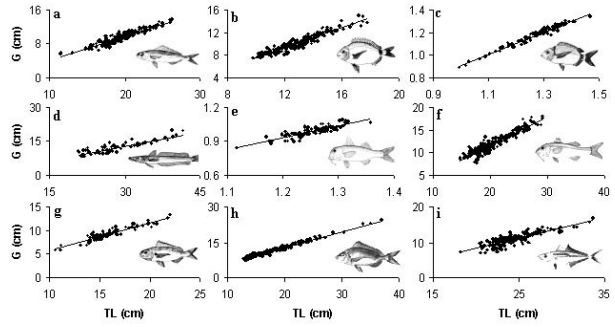

Figure 1. Relationships between maximum girth (G, in cm) and total length (TL, in cm) for nine fish species : (a) *Boops boops*, (b) *Diplodus annularis*, (c) *D. vulgaris*, (d) *Merluccius merluccius*, (e) *Mullus barbatus*, (f) *M. surmuletus*, (g) *Pagellus acarne*, (h) *P. erythrinus*, and (i) *Trachurus mediterraneus*. G and TL for (c) and (e) are log-transformed.

Various authors have also reported relationships between G and TL. For instance, Santos *et al*. [2] state that G is a linear function of TL for *Diplodus annularis* and *D. bellottii*. The same is also true of *Trachurus trachurus* [4]. Santos and Monteiro [5] report that G increases linearly with TL for *D. vulgaris, Pagellus acarne, P. erythrinus, Lithognathus mormyrus, Spicara smaris, Dicologlossa cuneata*, and *Microchirus azevia*, and exponentially with TL for *Mullus surmuletus*.

The catchability of fish and their size-selection by fishing gears are affected by factors related either to the characteristics of the fishing gear or of the fish [6, 7]. The probability of fish being captured depends on it encountering a gear, its ability to avoid it, which is related to the swimming capability and consequently to its length, and other body dimensions, such as girth [6, 7]. In general, the girth of fish caught is proportional to gill net mesh size [e.g. 4, 6, 7] and thus to length at 50% capture (L_{50}). Indeed, the estimated L_{50} for *Diplodus annularis, Pagellus erythrinus, Mullus surmuletus, Boops boops* and *Trachurus mediterraneus*, for the 22 and 24 mm gill nets (Stergiou and Erzini, unpubl. data) increase with a corresponding decrease in G (Fig. 2, $r^2 = 0.95$, $P<0.05$, for both 22 and 24 mm gill nets).

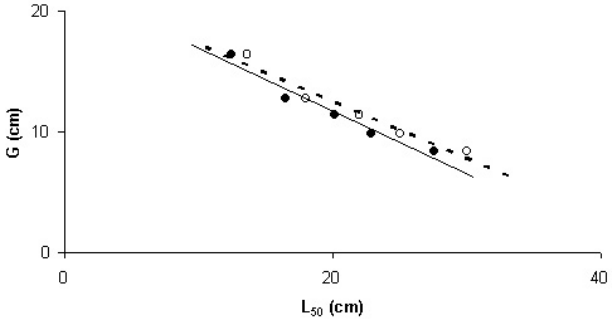

Figure 2. Relationship between maximum girth (G, cm, at 20 cm TL) (this study) and length at 50% capture (L_{50}, cm), for *Diplodus annularis, Pagellus erythrinus, Mullus surmuletus, Boops boops*, and *Trachurus mediterraneus*, for 22 (black circle) and 24 mm (open circle) gill nets (Stergiou and Erzini, unpubl. data).

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CADMIUM AND LEAD CONTENT IN MUSCLE TISSUE AND LIVER OF THREE FISH SPECIES FROM THE EASTERN PART OF MIDDLE ADRIATIC

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Abstract
Concentrations of harmful trace metals (Cd and Pb) were determined in edible tissue and liver of three commercially important fish species from the eastern Middle Adriatic. Levels found for cadmium and lead were not indicative of pollution. Cadmium concentration in fish tissues was lower, whereas lead level was in the range of values reported for other coastal areas of the Mediterranean. The edible tissue of the investigated species was not harmful for human health.

Keywords : Adriatic Sea, cadmium, lead

Introduction

The fish meat is an important component of the diet in the Croatian coastal region. In this connection we report lead and cadmium levels in muscle tissue and liver of three commercially important fish species (hake, *Merluccius merluccius*; red mullet, *Mullus barbatus*; and pandora fish, *Pagellus erythrinus*) from the eastern Middle Adriatic.

Methods

Fish samples were collected by the bottom trawl at 26 locations in coastal and open waters of the eastern Middle Adriatic (Fig. 1), during June and July of 1995. Sampling and pre-treatment of samples were performed according to UNEP/FAO/IAEA/IOC (1). After sample digestion (2), the analyses of Cd and Pb were performed by graphite furnace atomic absorption spectrophotometry (GF-AAS) on instrument Perkin Elmer 1100 B. The accuracy of analytical procedure was tested using certified reference materials (DORM-1, TUNA FISH, DOLT-1 and TORT-1).

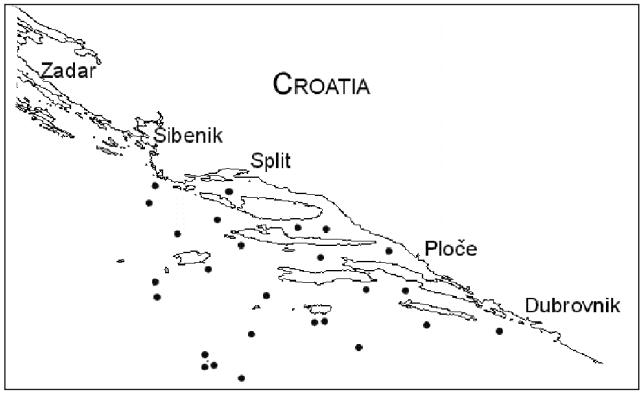

Figure 1. The eastern Middle Adriatic with geographical locations of sampling sites.

Results and Discussion

Cadmium concentration in the muscle tissue ranged from 4.2 to 18.8 μg kg^{-1} wet weight, while concentrations of lead ranged from 60 to 170 μg kg^{-1} w. wt. (Fig. 2), depending on the fish species. Values found for cadmium are lower than most values previously reported for the Adriatic and Mediterranean, whereas lead concentrations fall within the range of values reported for coastal areas of the Mediterranean (3, 4).

Cadmium and lead concentrations in liver (Cd : 10–408 μg kg^{-1} w. wt; Pb : 69–827 μg kg^{-1} w. wt.) are similar to the results of recent studies for the Mediterranean (5). Generally, liver has accumulated higher levels of trace metals than the muscle tissue. In addition, liver concentrations showed 2-3 times higher variation of values in comparison with the muscle tissue. Differences between trace metal concentrations in analysed tissues are the result of different physiological functions of muscles and liver (2, 6).

Overall cadmium levels in the edible tissue of investigated species are 8-12 times lower than the maximum permited value for fresh fish, whereas lead levels are 11-12 times lower in comparison to the maximum permited value (7) (Fig. 2). Since the average daily intake of Cd and Pb through this source in Croatia (8) constitutes a very small fraction of the Provisional Tolerable Daily Intake (9), we have concluded that eadible tissue of selected species is not harmful for human health.

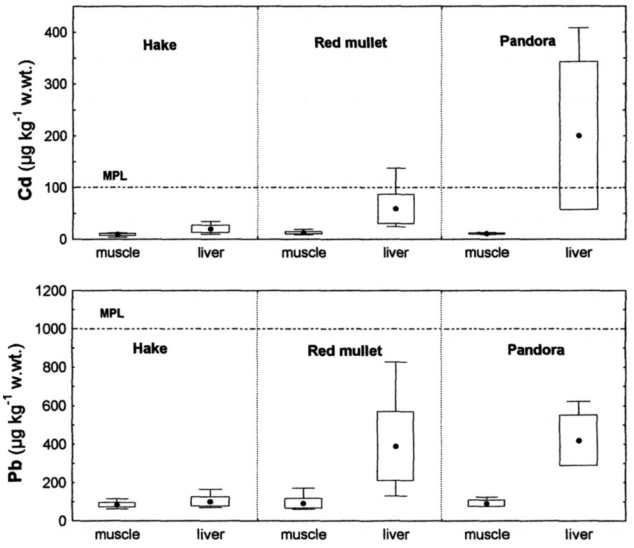

Figure 2. Trace metal content in selected tissues of three fish species from the Eastern Middle Adriatic. Dots represent average values; lower and upper box edges represent average ± 1 SD; outlier bars are minimum and maximum values. Dashed lines (– • –) present Maximum Permissible Levels for fresh fish in Croatia.

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INVESTIGATIONS ON THE EFFECT OF ECOLOGICAL METHOD FOR PROTECTION AGAINST ILLEGAL BOTTOM TRAWLING IN THE BLACK SEA – PRELIMINARY RESULTS.

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Abstract
Illegal bottom trawling for harvesting of Rapana thomasiana along the Bulgarian Black Sea shelf during the last decade has raised ecological concern with respect to the bottom communities and especially the mussel beds. Protected area against bottom trawling by specially designed concrete blocks was constituted near Varna Bay in 1999. The implementation of this protection method has resulted in an increase of the habitat diversity and development of new fouling communities dominated by the black mussel. The soft sediment communities in the protected area give evidence for increased biodiversity, abundance and biomass due to the rehabilitation of the natural mussel beds.

Keywords : Black Sea, zoobenthos, restoration, trawl impact, Mollusca

Introduction

Bottom trawling for *Rapana thomasiana* represents a significant hindrance to the recovery of zoobenthic communities along the Bulgarian Black Sea shelf, degraded due to the cultural eutrophication (2).

Rapana invaded in the Black Sea from the Sea of Japan during the 60-s. Its commercial harvest is a relatively new activity that has developed rapidly since 1990-1991. Till 1994 the snail was gathered manually by divers, but during the last 5-6 years the harvest has been increasingly accomplished by illegal bottom trawling. This activity has been localised on the mussel beds, where the predator snail concentrates to feed on *M. galloprovincialis*. Most impacted is the northern Bulgarian shallow shelf as it is evidenced by cases of mass mortality of benthic invertebrates and demersal fish in 1999-2000.

Methods

Protected area (PA) against bottom trawling by specially designed concrete blocks was constituted near Varna Bay in November 1999. An intensively trawled area at depth 18 m with surface of 65 ha was covered chess-like by 45 concrete pyramids with surface of 1,53 m^2 each, accommodated with metal spikes and oval concavities that provide shelter for juvenile marine organisms. Submersed buoys with surface 0.8 m^2 were fixed to part of the pyramids.

In November 2000 four 400 cm^2 samples from the concrete blocks and the buoys were collected by divers. Six samples were collected from the Protected Area (PA) and the adjacent Trawled Area (TA) by Van Veen grab (0.05 m^2). The laboratory processing was done by routine methods, dominant species were determined according to (1).

Results

One year after the submergence the fouling community covered only one fifth of the concrete blocks surface, while the buoys were covered evenly by *M. galloprovinvialis*. This difference is due to the buoys' position in the water column, which provides better trophic conditions for the filter feeding mussels. Therefore the growth rate of buoys' mussels was higher (mean length 19.2 mm) compared to that of the blocks' mussels (12.3 mm). as well the buoys mussels abundance and biomass (calculated on a squire metre) are 2,3 and 12 times higher respectively. No significant difference was observed in the accompanying species, the most common of which were the polychaetes *Nereis succinea, Polydora ciliata, Harmothoe reticulata, the barnacle Balanus improvisus* and the tunicates *Molgula euprocta, Ctenicella appendiculata*.

In PA 48 taxa were established : 15 Vermes, 13 Crustacea, 17 Mollusca, 2 Ascidiacea and *Phoronis euxinicola*. The species diversity in the TA was significantly lower with 30 species : 14 Vermes, 4 Crustacea, 10 Mollusca, 1 Ascidiacea, Ph. euxinicola. The number of Vermes species is not considerably different but the number of crustacean species is three times lower and the number of mollusc species is two times lower in the TA, where *M galloprovincialis* was not encountered (Fig.1).

The two areas differed greatly in the dominant species. Representatives of the epifauna dominated the PA : *M. galloprovincialis, Mytilaster lineatus, Molgula euprocta* and crustaceans, while TA was dominated by infauna representatives : *Chamelea gallina, Spisula subtruncata* and *Pitar rudis*.

The abundance is 1.6 times higher in the PA. The most significant difference was observed with respect to the abundance of Crustacea and Ascidiacea, which were five times less abundant in the TA (Fig.2).

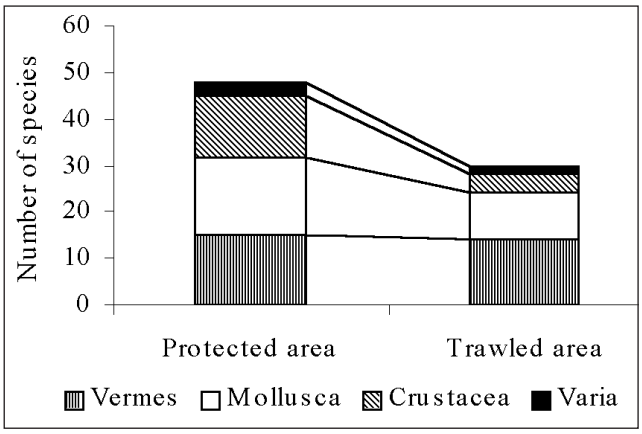

Figure 1.

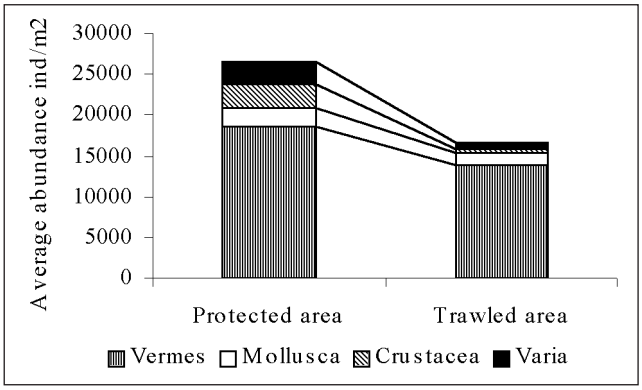

Figure 2.

The absence of *M galloprovincialis* in TA determined more than tree times lower biomass compared to PA biomass (338.255 and 1156.0 g.m^2 respectively).

The preliminary results of the study give evidence of the negative impact exerted by bottom trawling on the seabed communities. Degraded by the anthropogenic eutrophication these communities are particularly vulnerable to bottom trawling, which prevents them from recovery, despite the relative relaxation of the ecosystem regarding eutrophication. The results confirm the favourable ecological effect of the experiment : an increase of the habitat and species diversity, abundance and biomass due to the rehabilitation of the natural mussel beds.

Acknowledgements
We acknowledge Varna municipality for the financial support to the project accomplishment.

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MEGAFAUNAL COMPOSITION OF THE FINE SURFACE SANDS BIOCENOSIS IN NORTH AEGEAN SEA (COAST OF XANTHI)

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Abstract

Sampling of the megafaunal coexistance of the fine surface sands (FSS) was carried out at two stations along the Xanthi coast (NE Aegean Sea). Overall 16 species were identified. The analysis of 72 samples collected during summer and autumn 2000 showed that species composition at the two stations differed.

Keywords : Megabenthos, Donax, Echinocardium, Aegean Sea, Soft substratum

Introduction

Although the coexistance of the fine surface sands of the subtidal zone is considered to be one of the poorest in terms of species (1,2), some species, like *Donax trunculus*, have recently turned out to be worthy commercially (3). Thus biomonitoring of faunal communities are very important for understanding the consequences of overfishing (3). In this study,contacted within an E.U research programme, information is provided for the first time concerning the faunal composition of fine surface sand in place and time and especially during a period when fishing of *Donax trunculus* is not allowed (1st November-31st March).

Materials and Methods

The research was conducted at two stations, STA where fishing pressure is high and STB where fishing pressure is low, along the coast of Xanthi (NE Aegean Sea). Sampling took place across perpendicular sections (ST1 T1, ST2 T2) at three different depths (0.5, 1.5 and 2.5 m). A 50 x 50 x 15 cm metal frame was the minimum sampling surface used to estimate the spacial dispersion and density of the megafaunal populations (4). Overall, 72 samples were taken (6 samples per site and per two seasons, summer and autumn). The contribution of the various species was quantifing using presence (P), mean abundance (Am) and partial mean dominance (Dmp) (5).Two additional samples of microfauna were collected from each layer with a corer (4.5 cm diameter) penetrating 10 cm into the substrate (6). All samples were collected by SCUBA diving. Sediment samples (1 lt) were also collected from each place and their grain composition was analyzed. In addition, the total amount of organic matter in the sediment was estimated using the H_2O_2 compustion method.

The matrix comprised by the number of individuals per species, per replicates and depth of sampling, was analysed using multidimensional scaling (MDC) and the Bray-Curtis similarity index (4,7) (Figure1).

Results and Discussion

The granulometry showed that there are not important differences between STA and STB, since the 90% of the size of the grains taken from the two stations, was 500-250 _ and 250-125 _. At both stations the percentage of organic matter was <0.2% during summer in both stations whereas during autumn it was <1.43% at STA and <1.04 % at STB, the latter attributed to increased amount of incoming substances from a side river of the Nestos river which is located in the wider area of STA. In addition, the microfaunal species composition indicated that there are important differences not only among seasons but also among stations (Table 2).Thus juvenile bivalves (probably of D.T) mainly predominate in the summer samples. Nematode abundance was higher at STA whereas at STB there was a remarkably high number of Granulareticulosea during autumn. Copepods perdominated in high percentage only during summer in STA. Overall 16 species were found, which were already recorded as members of the FSS coexistance, from other similar areas of the Western Medittereanean (Table 1). *Donax trunculus* and *Echinocardium cordatum* exhibited remarkable presence (P) and abundance (Am, Dmp) that should probably be regarded as characteristic of the two stations. The number of species at both stations was lower during autumn and higher at STA compared to STB.The results of MDS indicated that samples ware separeted into groups reflecting the station effect with few exceptions (cases 5 and 8 for which 5 and 2 species were found, respectively, in very low abundances) (Table 1).

To sum up the two stations differ with respect to the megafaunal species composition. These differences are probably related to organic matter deposition that diffuses from STA towards STB rather than to the substrate composition. Group formation was not affected by depth and season of sampling . This can be attributed to similarities in the substrate and the distribution of organic matter as well as to the similar fishing presure expended at these areas in recent years.

Table 1 : Distribution of species in STA and STB during summer and autumn 2000.
P=presence, Am=mean abundance, Dmp=partial mean dominance.

Fauna / species	STATION A						STATION B					
	Summer			Autumn			Summer			Autumn		
	P	Am	Dmp	P	Am	Dmp	P	Am	Dmp	P	Am	Dmp
Donax trunculus	14	1.7	36.6	11	0.7	22	13	1.05	51.4	12	1.39	62.5
Donax semistriatus	4	0.2	4.87	3	0.2	5.08	2	0.17	8.11	3	0.17	7.5
Solen marginatus	3	0.2	3.65	1	0.1	1.7	0	0	0	0	0	0
Mactra sp.	1	0.1	1.22	0	0	0	0	0	0	0	0	0
Mactra corallina	1	0.1	1.22	0	0	0	3	0.33	16.2	2	0.11	5
Mactra corallina lignaria	1	0.1	1.22	2	0.1	3.38	1	0.06	2.1	3	0.17	7.5
Cyclope neritea	6	0.6	13.4	9	0.9	27.1	0	0	0	2	0.11	5
cyclope donovani	0	0	0	7	0.4	11.9	0	0	0	0	0	0
Diogenes pugilato	0	0	0	0	0	0	1	0.06	2.7	0	0	0
Circulus striatus	0	0	0	0	0	0	1	0.06	2.7	0	0	0
Astarte sulcata	0	0	0	0	0	0	0	0	0	2	0.11	5
Spisula su btruncata	1	0.1	1.22	0	0	0	0	0	0	0	0	0
Amyclina corniculum	0	0	0	1	0.1	1,69	1	0.05	2.7	0	0	0
Astropecten jestoni	0	0	0	0	0	0	1	0.06	2.7	0	0	0
Liocarcinus depurator	1	0.1	1.22	0	0	0	0	0	0	0	0	0
Echinocardium cordatum	16	1.5	34.1	10	0.9	27.1	4	0.22	10.8	2	0.16	7.5
Glycera tesselata	1	0.1	1.22	0	0	0	0	0	0	0	0	0
Number of species	11			8			9			7		
Number of individuals	82			59			37			40		

Table 2 : Distribution of microfaunal individuals in STA and STB during summer and autumn 2000.

Classes	Station A						Station B					
	Summer			Autumn			Summer			Autumn		
	P	Am	Dmp	P	Am	Dmp	P	Am	Dmp	P	Am	Dmp
Bivalvia	4	8.75	22.87	4	3	18.2	6	7.5	35.15	6	5.16	8.01
Copepoda	2	9.25	24.18	2	1	6.06	1	0.16	0.78	2	0.33	0.52
Granulareticulosea	2	1	2.61	4	2	12.1	6	5	23.44	6	44.8	69.5
Nematoda	3	28	18.3	4	5.5	33.3	5	3.33	15.625	6	11.2	17.3
Polychaeta	4	12	31.37	4	5	30.3	6	5.33	25	6	3	4.65
Number of individuals	152			66			128			387		

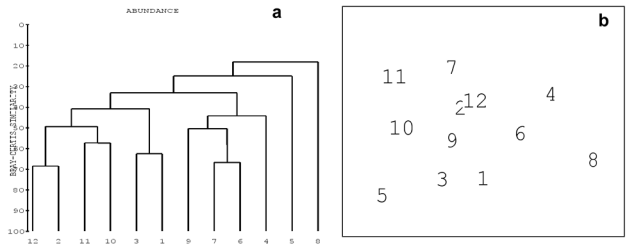

Figure 1. Results of (a) cluster and (b) multidimensional scaling (stress value = 0.129) basedon Bray-Curtis similarity index. 1-6 : samples during summer, 7-12 samples during autumn.

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SEASONAL OCCURRENCE AND SIZE DISTRIBUTION OF GREY MULLET FRY (PISCES, MUGILIDAE) IN STRYMONIKOS GULF (GREECE)

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Abstract

The seasonal occurrence and size distribution of mullet fry was studied in the two estuarine systems of Strymonikos Gulf (Northern Aegean Sea). Samplings were carried out on a monthly basis between September 1997 and December 1998 using a bag seine net. Five species of Mugilidae were caught : the common grey mullet (*Mugil cephalus*), the thick-lipped mullet (*Chelon labrosus*), the thin-lipped mullet (*Liza ramada*), the golden mullet (*L. aurata*) and the leaping mullet (*L. saliens*).

Keywords : Aegean Sea, Eastern Mediterranean, fishes, estuaries, migration.

Introduction

The five species of Mugilidae that occur in the Greek coastal waters are commercially important fish and constitute a significant part of the fish production in the Mediterranean, especially in lagoons.

The two estuarine systems where the study was carried out were those of Strymon and Rihios, which are the two main rivers flowing into the Strymonikos Gulf (Fig. 1). Strymonikos Gulf is located at the northwestern part of the Aegean Sea, occupying an area of 540 km^2. Strymon River, one of the three most important rivers in Northern Greece, originates from Bulgaria and flows to the northern part of the gulf. Rihios is a small river with a steady flow throughout the year that drains the lake Volvi.

Figure 1. Map of the study area.

Materials and methods

Samplings were carried out on a monthly basis from September 1997 to December 1998. Four sampling stations were selected, two in each estuarine system. A bag seine net of 20 m length and 2 mm mesh size was used for the collection of the samples.

Results

With respect to the Strymon estuarine systems, members of the Mugilidae family were among the most abundant species, accounting for 41.8% of the total catch [1]. In Rihios estuary, Mugilidae accounted for 29.1% of the total catch. A total of 3,515 juveniles of grey mullets were caught. The monthly size distribution of the juveniles is shown in Fig. 2. *Chelon labrosus* accounted for 5.4% of Mugilidae catch in Rihios and for 5.2% in Strymon estuary. The first appearance of the fry occurred in March 1998 but the smallest individuals were caught in May 1998 (SL= 15-66 mm). Fry catches continued till November 1998 when length reached 99 mm. *Mugil cephalus* percentage of the total Mugilidae catch reached 14% in Rihios and 13.9% in Strymon estuary. The juveniles first appeared in August 1998 but the smallest individuals were caught in October 1998 (SL= 17-29 mm) and November 1998 (SL= 17-41 mm). Fry catches continued till December 1998 but maximum standard length (41 mm) was observed in November 1998. *Liza saliens* exhibited the highest percentage in the total Mugilidae catch in Rihios system (45.8%) and the lowest in Strymon with 3.8% of the mullet catch. The first appearance occurred in July 1998 but the smallest individuals were caught in August 1998 (SL= 8-45 mm). The catch of *L. saliens* juveniles continued till December 1998. The biggest specimen was caught in November 1998 (78 mm). The percentage of *L. ramada* in the total Mugilidae catch in Rihios was 10.7% and in Strymon reached 17.4%. The smallest individuals were caught in December 1998 (SL= 14-20 mm). In 1997 the fry catches continued till the following September when juvenile length reached 112 mm. The percentage of *L. aurata* in the total Mugilidae catch in Strymon was the highest recorded in the present study (59.6%) and the second higher in Rihios system (24.4%). The smallest individuals were caught in October 1998 (SL=10-26 mm). In 1997 the first appearance of the fry occurred in November and fry catches continued till next July when standard length reached 75 mm.

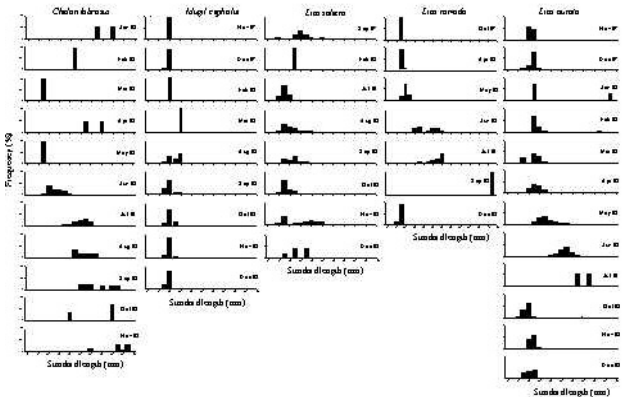

Figure 2. Size composition of the juveniles of the five Mugilidae species caught in Strymonikos Gulf between September 1997 and December 1998.

Discussion

The first appearance of each grey mullet species occurred in different months of the year but in general follows the same order in the Mediterranean with 1-2 months variation [2]. The first Mugilid species which appeared during the year near the coasts of Strymonikos Gulf was *C. labrosus* in March, followed by *L. saliens* in July, by *M. cephalus* in August and then by *L. aurata* in October. The juveniles of *L. ramada* appeared last, in November. Results from a similar study in another lagoon of Northern Greece [2], reported the same order of appearance shifted 1-2 months later in the year than in Strymonikos Gulf.

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THE FIRST RECORD OF BLUEFISH FINGERLING, *POMATOMUS SALTATOR* (LINNAEUS, 1766) (PISCES : POMATOMIDAE) IN THE SOUTHEASTERN ADRIATIC SEA

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Abstract

Bluefish are a rare species in the Adriatic. We captured the first fingerling specimens of this species in the Gornji Molunat Bay along the eastern shores of the Adriatic. The paper describes the morphological and meristic measurement features of captured specimens. Considering that this species is found in tropical and subtropical seas, the captured fingerlings point towards the possibility of their spawning and greater expansion in northern Adriatic waters.

Keywords : biometrics, biodiversity, Adriatic sea

Introduction

The bluefish (*Pomatomus saltator*, Linnaeus 1766) belong to the family of Pomatomidae. It inhabits tropical and subtropical seas, and is widespread throughout the entire Mediterranean, but it is rare in the Adriatic (1). This species is rarely caught in the waters of Dubrovnik, usually up to 20 adult specimens and most frequently during late summer and autumn (Kozul, unpublished data). Up until now, no data has been published on the biological and ecological characteristics of this species in the eastern Adriatic. This paper gives the first data on bluefish fingerling, and their morphological and meristic features.

Material and methods

Bluefish fingerlings were captured at the beginning of November 2000. The specimens were identified using the taxonomical key given by Soljan (2) and Jardas (1) (Figure 1). Two fingerling specimens were captured using a modified drag-net in the Gornji Molunat Bay (18º26'E, 42º27'N). During the sampling, the temperature was 19.6 C, the salinity was 36.9 % and the oxygen was 7.71 mgl-1. This is a sandy and shallow bay located on the eastern shore of the southern Adriatic, 17 n/m southeast of Dubrovnik. The surface of the bay is 2 km^2 and it is exposed to the southern winds characteristic of the southern Adriatic (3). The net used to catch the fingerlings was 50 m in length and 5 m in height in the middle, with a central bag. The diameter of the netting on the outside wings of the net was 8 mm, and in the central area of the net it was 4 mm. The net was dragged from the bay's entrance up to its end at a work depth of 0-4 m. The captured fish specimens were preserved in a 4% formaldehyde solution in preparation for laboratory work. In the laboratory, the total and standard lengths were measured with a precision of 0.1 mm, and the weight was measured with a precision of 0.01 g. The biometric measurements were taken in mm. The meristical characteristics contained ray fins in the dorsal, anal, pectoral and caudal fins. A decrease in length caused by formaldehyde preservation depends upon the initial specimen length and duration of preservation. An average of 5% is lost on total larvae and fingerling length due to formalin storage (4).

Results and discussion

Tabel 1 shows the dimensions (in mm) and the meristic measurements of captured fingerlings. The fingerlings had pronounced, sharp, conical teeth bent slightly backwards in both jaws, the second dorsal and anal fins were of equal length, and the belly and chest fins were also of almost equal length. There were no scales on either of the two specimens. A dark green to black color covered the top of the head and top of the back, while the bottom of the head and abdomen varied from silver to white.

No examples have been noted of bluefish fingerling in the Adriatic up until now, and according to Jardas (1) this species is infrequent in the Adriatic. Taking into consideration that the fingerlings were captured in early November 2000, and that this species spawns during spring and summer (1), we can conclude that bluefish also spawn in the southern Adriatic. The significant movement of bluefish noted towards northern Portuguese waters by Quero (5), as is the case with the Adriatic Sea. In recent years, more fish species that do no belong to the Adriatic are being caught, such as the white grouper *Epinephelus aeneus* (6). Besides this, we can now find species that were once characteristic of only southern Adriatic waters in the central and northern regions of the Adriatic. The dusky grouper (*Epinephelus marginatus*) is spreading northwards from the southern and central Adriatic (7). Usually, it concerns species that are tropical or subtropical. Along with adult specimens, pompano fingerling (*Trachinotus ovatus*) specimens were also caught (8). Some Mediterranean species that lived only in the southern Adriatic are now being caught in the north as well, *Trachypterus trachypterus, Epinephelus marginatus, Choryphaena hippurus, Plectorhinchus mediterraneus* and *Balistes carolinensis* (9). The same is happening with the amberjack (Seriola dumerili), which reached the central Adriatic 5-6 years ago. Now, adult and juvenile specimens are being caught in the northern Adriatic, while amberjack numbers in the traditional hunting grounds of the southern Adriatic have decreased significantly (Koĭul, unpublished data). The arrival of new species can affect the ecological conditions of our sea, or can endanger and push out autochthonous species. Greater attention should be paid to such occurrences as they have been growing increasingly frequent over recent years, and this could be a reflection of general climatic changes.

Table 1. Morphometric (in mm) and meristic data of bleufish fingerling,

Fing.	I	II		I	II
Total length	47.2	50.1	Body depth (max)	11.4	13.4
Standard length	37.3	43.3	Body depth (min)	6.1	5.3
Fork length	40.1	45.2	Head length	14.0	15.5
Predorsal length	17.5	17.5	Ocular diameter (horiz.)	4.5	5.3
Preanal length	24.3	28.4	Interorbital width	5.0	5.5
Preventral length	13.5	17.7	Preorbital length	4.5	5.3
Prepectoral length	17.2	15.5	Dorsal fin rays D1	VIII	VIII
Dorsal fin lengthD1	8.0	9.2	D2	I+2z	I+26
D2	10.1	10.5	Anal fin rays	II+24	II+25
Anal fin length	11.5	11.5	Pectoral fin rays	17	17
Pectoral fin length	8.2	8.7	Ventral fin rays	I+5	I+5
Ventral fin length	5.1	5.3	Caudal fin rays	28	28
Caudal fin length	10.2	11.3			

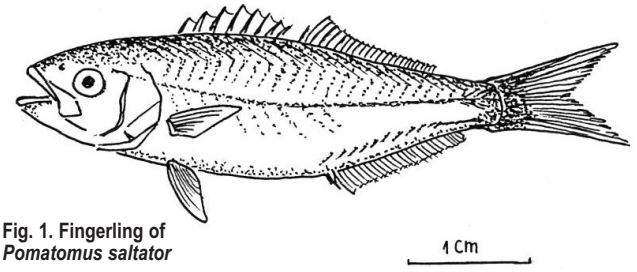

Fig. 1. Fingerling of *Pomatomus saltator* caught in the south estern Adriatic

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INFLUENCE DE LA TURBIDITÉ ET DES CONDITIONS ENVIRONNANTES SUR UN ÉLEVAGE PISCICOLE DANS UN ÉCOSYSTÈME MÉDITERRANÉEN MAROCAIN : LA BAIE DE M'DIQ

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Résumé

L'influence de la turbidité des eaux et du milieu environnant (houle, tempête et apports terrigènes) sur l'élevage de thon rouge dans l'écosystème méditerranéen marocain de la baie de M'diq a été étudiée au cours de deux campagnes océanographiques durant l'été 1997 et l'hiver 1999. Les résultats des aspects physico-chimique, biologique, sédimentologique et courantologique ont montré que le site d'élevage présente des taux élevés en matières en suspension pendant l'hiver et moindres durant l'été. Durant la saison d'hiver, leur impact sur le site d'élevage devient plus accentué par l'arrivée massive des apports terrigènes en provenance du continent et par le mode de circulation des eaux de la baie au moment des tempêtes. Cette situation provoque un déséquilibre de l'écosystème au niveau du site d'élevage.

Mots-clés : Aquaculture, courants, Mer d'alboran, processus côtiers et turbulence.

Introduction

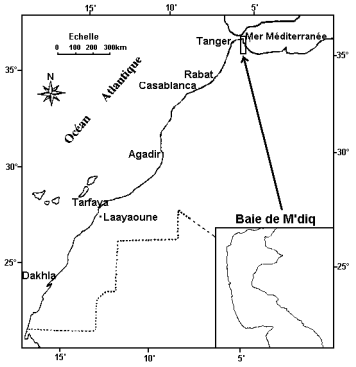

Figure 1 : Emplacement du site d'étude.

La baie de M'diq est une baie de longueur 23 Km, située dans la partie Nord-Ouest du Maroc Méditerranéen, entre Sebta au Nord et Cap Negron au Sud (Figure 1). Cette zone présente pendant l'hiver un grand écoulement des eaux des deux principaux Oueds Smir (OS) et Negron (ON) provoquant ainsi un impact direct sur l'élevage de thon rouge dans la baie. En hiver 1997, la zone d'élevage (ou ancien site d'élevage : ASE) a connu une élévation importante de la turbidité de l'eau sous l'effet de tempêtes, ce qui a engendré des mortalités importantes des géniteurs de thon rouge.

Les travaux les plus récents réalisés sur cet environnement méditerranéen ont porté sur les aspects géochimiques et de pollution de la marge méditerranéenne marocaine (1, 2, 3) Cependant, les travaux portant sur le fonctionnement de la baie sont peu nombreux. Afin de mieux appréhender le fonctionnement de cet écosystème et d'évaluer l'impact des apports terrigènes sur l'élevage, des études regroupant les aspects sédimentologique, physico-chimique et courantologique ont été réalisées par l'INRH dans la baie durant l'été 1997 et l'hiver 1999. Nous présentons dans cet article uniquement les résultats résumant les deux schémas de circulation idéalisés des eaux de la baie pendant ces deux périodes d'observations.

Matériel et méthodes

Les mesures des paramètres physico-chimiques et biologiques ont été effectuées sur un total de 43 stations, couvrant quasiment toute la baie de M'diq. Les analyses physico-chimiques et biologiques ont été effectuées en surface et au fond et analysées selon les méthodes suggérées par Aminot et Chaussepied (4). Les courants ont été mesurés à l'aide de courantomètres RCM7 Aanderaa, respectivement au Nord de la baie (ASE ou C1) et au milieu de la baie (C2) (Fig. 2).

Résultats et conclusion

Les principaux résultats ont pu mettre en évidence un ensemble de processus (5). Le courant de marée dans la baie est de direction Sud-Sud-Est. L'ASE se trouve dans une zone hydrodynamiquement instable caractérisé par des eaux de surfaces turbides. Le NSE se situe dans une zone calme et ce sont donc les eaux du fond qui sont plus riches en MES témoignant ainsi de la stabilité du site. Deux périodes ont pu être identifiées :

1- durant la période normale (mai-octobre), les vents dominants sont d'origine Nord-Est. Les décharges de l'OS qui sont permanentes toute l'année, avec un débit relativement faible, sont drainées vers le Sud de la baie par les courants Sud-Sud-Est.

2- en période hivernale (cas de tempête durant les mois d'octobre à février), les houles dominantes de direction Est (4 à 5m de hauteur), une fois diffractées par le Cap Negro, entraînent un déplacement des eaux du Sud vers le Nord (Figure 2). Dans les conditions de fortes précipitations et des apports fluviaux importants, l'ASE reçoit donc toutes les décharges issues de l'ON qui est proche de la zone d'élevage. La turbidité de l'eau au niveau de l'ASE s'accentue et constitue ainsi un risque sur les géniteurs du TR.

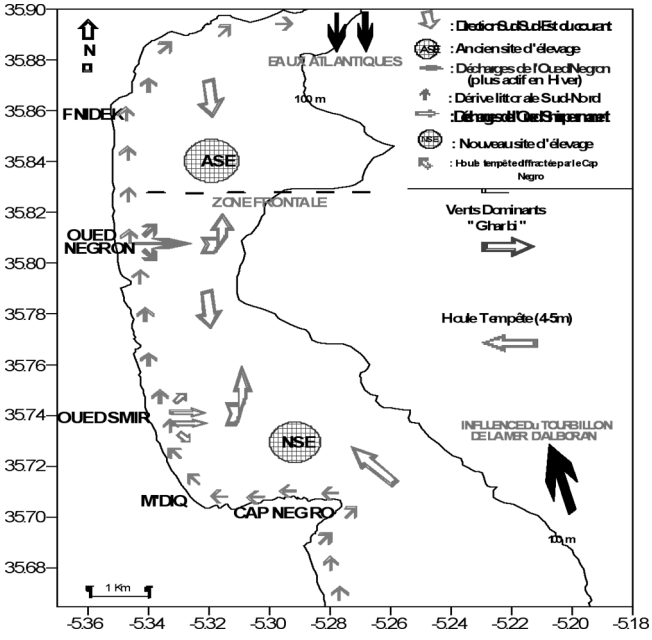

Figure 2 : Circulation idéalisée des eaux de la baie M'diq en situation exceptionnelle de tempête.

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BIODIVERSITY OF THE MARINE PLANKTON IN LEBANESE WATERS AND LEVANTINE BASIN (EASTERN MEDITERRANEAN)

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Abstract

Planktonic fauna and flora of the Levantine basin is a Mediterranean temperate type with certain subtropical affinity. Studies carried out since 1965 showed a high taxonomic diversity in comparison with other regions of the Eastern Mediterranean. To date, 400 taxa of phytoplankton have been recorded, including 151 diatoms belonging to 46 genera, 227 dinoflagellates with 33 genera, 5 silicoflagellates and 2 ebriidae. Zooplankton subcommunity comprises all the known Mediterranean groups; with 200 microzooplankton species and 600 mesozooplankton, including 171 species of copepods. Several species are of Indo-Pacific origin and considered as "Lessepsian". The spatio-temporal distribution and the abundance of the species are affected by hydrographic conditions, namely temperature, salinity, nutrient concentration, phytoplankton standing crop and current regime. The oligotrophy of the Levantine basin affects the primary production and the plankton biomass .

Keywords : Plankton., Biodiversity, Lebanon, Levantine Basin

Introduction

The Levantine Basin and the Red Sea are both characterized by a heavy oligotrophy, a high temperature, and saliniy. However the plankton of the Levantine Basin belong to Mediterranean temperate fauna and flora, with certain subtropical affinity. 69% of planktonic taxa inhabiting the Eastern Mediterranean are present in the Western basin and only 33% are common with the plankton of Red Sea (1, 2). The opening of the Suez Canal in 1869 to navigation, has accelerated the migration phenomenon allowing colonization of the Eastern Mediterranean by many Indo-Pacific elements (3, 4). The plankton of the Lebanese water is unknown untill the seventies (5). Phytoplankton data and primary production study made in Lebanese waters confirm the oligotrophy characterizing the Levantine Basin (6,7). However this poverty of the plankton contrasts with a high taxonomic diversity. Four hundred phytoplankton species were identified from the inshore and offshore Lebanese waters (8). Zooplankton community displays a low in biomass, and a high species diversity (9). In a recent study on the biodiversity of marine flora and fauna of Lebanon (10), we focused on the endangered taxa and menaced species. In the present paper, we give a general aspect of the biodiversity of the plankton community from the Lebanese water.

Material and methods

Qualitative and quantitative surface and vertical samples of both phytoplankton and zooplankton were collected since 1968 from inshore and offshore waters along the coast of Lebanon :33º52'N-35º29'E and 34º30'N-35º5'E Hydrological parameters including T° C, S‰, O_2, Chl.*a*, PO_4,NO_3 and Secchi were accompainying plankton sampling. Identification of taxa was made up to species

Results

The majority of the species occurring in the Eastern Mediterranean are present in the Western basin. However some differences in the abundance and distribution are recorded between the two areas. Several Indo-Pacific species that were introduced through the Suex Canal ,are confined only to the Levantine Basin..41% of the Diatoms present in the East Mediterranean are also present in the Red Sea and 54% of the dinoflagellates are common for the two basins (1,2). Diatoms constitute 75% of the total standing crop and 40% of the total phytoplankton species, while Dinoflagellates, although more diversified constitute only 15-20% of the abundance .The total number of taxa is given in Table 1.

Table1- Taxonomic distribution of phytoplankton community from Lebanese waters

Groups	Nb. Families	Nb. Genera	Nb. Species
Bacillariophyceae (Diatoms)	15	46	151
Dinoflagellata	14	33	227
Silicoflagellata	3	3	5
Ebriidae	2	2	2

The phytoplankton bloom, is recorded always in spring (April-May).This maximum of standing crop corresponds with a low species diversity; while the highest diversity is computed in January-February when the density is low. During the long and hot period summer, the phytoplankton is poor standing crop is the lowest; the dinoflagellates are more important than diatoms. 18 potentially toxic species are reported in coastal and estuarine waters : including 7 diatoms and 11 dinoflagellates (11).

Zooplankton is highly diversified ; all zoological groups are represented from the microzooplankton up to the prochordates. The most important groups are represented. In addition to the microzoplankton we have : *Cnidaria, Ctenaria, Polychaeta, Crustacea, Chaetognatha, Mollusca, Apendicularia, Tunicata, Meroplankton larvae*; *Eggs* and *Fish larva*e. The number of species so far recorded in the Lebanese waters amounts to 790 species, including 242 protozoans(10) Total number of taxa is given in Table 2.

Table 2- Distribution of zooplankton groups from Lebanese seawater.

Groups	Nb.Species	Groups	Nb Species
Foraminifera	12	*Mysidaceae*	4
Actinopoda	66	*Cirripedia larvae*	4
Tintinniidae	121	*Décapoda larvae*	106
Hydromedusa	68	*Chaetognatha*	10
Scyphozoa	5	*Pteropoda*	9
Siphonophora	28	*Heteropoda*	4
Copepoda	173	*Polychaeta* (larvae)	8
Cladocera	6	*Polychaeta* (adults)	4
Ostracoda	6	*Appendicularia*	15
Amphipoda	25	*Thaliacea*	6
Euphausiaceae	5	*Eggs & Fish larvae*	84

Out of the 68 species of **Hydromedusae** reported from Lebanese waters (12),11 are considered as tropical forms of Indo-Pacific origin. Among the **Scyphomedusae** the largest Mediterranean species *Rhopilema nomadica*, a recent Lessepsian migrant is a dominant element in summer.in (13). Out of 28 found **Siphonophores**, 18 species are also present in the Red Sea. The bigest group **Copepoda**, includes 109 calanoids from whom, 8 are Lessepsian; (14,15). Among the 50 indo-Pacific species of fish found in the Levantine basin, five larval species were recorded (16), In spite of the oligotrophy characterizing the waters of Eastern Mediterranean and the low primary production striking the Levantine Basin, planktonic community shows a high taxonomic diversity. The biodiversity of the plankton is improving with the allochtonic tropical species mostly coming through the Lessepsian migration.

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NEW RECORD OF *GALITEUTHIS ARMATA* (CEPHALOPODA : CRANCHIIDAE) IN THE MEDITERRANIAN SEA

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Abstract

The occurrence of *Galiteuthis armata* Joubin, 1898 (Cephalopoda : Cranchiidae) in the Eastern Ionian Sea, off the NW Greek coast, is reported. One specimen was caught during a deep-water international trawl survey in September 1999. The squid was collected during daylight hours at a depth of 1015 m and sized 231mm DML. Previous Mediterranean records of *G. armata* are reviewed. This finding confirms the presence of the species in the Ionian Sea and extends its eastern longitudinal distribution in the Mediterranean Sea.

Keywords : Cephalopods, Ionian Sea, Mediterranean Sea

Introduction

The family of Cranchiidae is highly diversified and generally poorly known (1). In the Mediterranean Sea only two species of the subfamily Taoniinae, *G. armata* and *Teuthowenia megalops* are known (2). Joubin's original specimen of *G. armata* was from Nice (3), but the species is widely distributed in the North Temperate, North Subtropical and Tropical regions to ~10° S of Atlantic Ocean and in the Mediterranean Sea (4). Records of the species in the Mediterranean Sea have been reported mainly for the western part [Alboran Sea (5), SW Mediterranean (6,7,8), Catalan Sea (9,10), Ligurian Sea (7,11), Tyrrhenian Sea (12), Strait of Messina (7,13,14,15)] and only a single larva for the Central Mediterranean (8). A new record of *G. armata* in the Mediterranean Sea is reported and discussed in this note.

Materials and methods

The present specimen was collected during a deep-water trawl survey carried out in September 1999 in the northeastern Ionian Sea, in the framework of the project "Interregional environmental studies in the Ionian Sea (INTERREG II)". A professional trawler of 78 tons gross tonnage was used, equipped with a bottom trawl-net with stretched mesh of 20 mm in the cod end. Hauls lasting from 30 to 60 minutes, were performed during day-light at a total of 34 sampling stations distributed in four depth strata : 300-500, 500-700, 700-900 and 900-1200 m.

The species was identified following the keys in Mangold and Boletzky (16). The weight (in grams) and the morphometric measurements (in millimeters) were taken after fixation in 5%. formalin solution

Results and discussion

The specimen found was in fairly good condition. Despite its tentacular clubs were cut, in one of the remaining tentacles had one hook which, together with the leaf-shaped fins ending to a long gladial tail, enabled us to clearly identify it as *Galiteuthis armata*. It had a dorsal mantle length of 231mm and weighed 8.2 g. The measurements (in mm) of the arms and the beaks were : Arm I (right and left) length = 30; right arm II length = 41; left arm II length =38; arm III (right and left) length = 46; right arm IV length = 51; left arm IV length =55; maximum diameter of arm suckers = 1.15; upper hood length = 7.05; upper crest length = 8.21; upper rostral length = 2.44; lower hood length = 2.82; lower crest length = 5.77; lower rostral length = 1.99.

G. armata was caught off the western coasts of Kerkyra island (39° 29'N; 19° 42' E) at a depth of 1015 m. This is the second finding of the species in the Central Mediterranean after that of Roper (8), confirming its occurrence in the Ionian Sea. The present specimen is one of the largest collected in the Mediterranean Sea. Large individuals of *G. armata* (ML >100mm) have been more frequently caught by bottom trawls (5, 9) than by mid-water sampling gears (8), due probably to their higher concentration near the bottom. Sub-adults of this species have been shown to live in deep water below 600 m, whereas early stages (ML< 30mm) have been taken from subsurface to 1000 m (4, 9), indicating that the species exhibits ontogenetic descent (16) as most of cranchids (1).

The relatively greater frequency of *G. armata* occurrence in hauls below 900 m and its high percentage in the stomach contents of swordfish fished in the Ligurian Sea (11), make us suspect a considerable abundance of the species in the deep-water basins of the Mediterranean Sea, although more sampling in the bathypelagic and abyssopelagic zone is needed for confirmation.

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ELEDONIDS EXPLOITED IN THE THRACIAN SEA : PRELIMINARY ANALYSIS OF STOCK STRUCTURE BASED ON TRAWLERS LANDINGS

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Abstract

Eledone moschata and *Eledone cirrhosa* are by-catches of demersal trawling for fishes in the Thracian Sea. Trawl landings of the two species were recorded for the fishing period October 1998 - May 1999, during which the proportion of *E. moschata* was generally higher. A single cohort, consisted mostly of immature individuals, was present in *E. cirrhosa* landings. In the population of *E. moschata* two peaks of recruitment in October '98 and April '99, were observed. Males have been shown to reach maturity earlier than females in both species.

Keywords : Cephalopods, fisheries, Aegean Sea

Introduction

Eledone moschata and *Eledone cirrhosa* are an important component of cephalopod catches in the Thracian Sea (1). This resource is exploited almost exclusively by trawlers and less than 1% of *Eledone moschata* is landed by beach-seiners (2). Both eledonids, are commercialized under the same common name, thus it is impossible to assess catches of each species from official landings.

The monthly contribution of the two species in landings was studied for the first time in the framework of an E.U. funded project on "Analysis and evaluation of the fisheries of the most important cephalopod species in the Mediterranean Sea".

Materials and methods

Landings of the two species were reported for trawlers on a fortnight basis (the last three days of each fortnight), by an observer at the auction of Kavala. The period June-September is a closed season for trawlers according to the Greek legislation, thus data were collected for the 8month fishing period : October 1998 - May 1999. During this period biological samples of trawlers landings were bought every month. Records of mantle length (in mm), weight (in gr), sex and maturity stage were taken from freshly caught or frozen specimens.

Results and discussion

E. moschata constituted the major part (69-96%)of eledonids landings from November '98 to March '99 and in May '99 (Fig. 1). Experimental trawl surveys carried out in the Thracian Sea (1992-1993) had shown that *E. moschata* and *E. cirrhosa* represented respectively the 14.2% and 26.7% of the cephalopod biomass estimated for the bathymetric zone 10-400m (1). The dominance of *E. moschata* in trawl landings could be related to the small individual weight of immature *E. cirrhosa* during the sampling period, as well as, to the greater concentration of trawlers activity in lower depths near the coasts, especially in winter time, where *E. moschata* is more abundant (1).

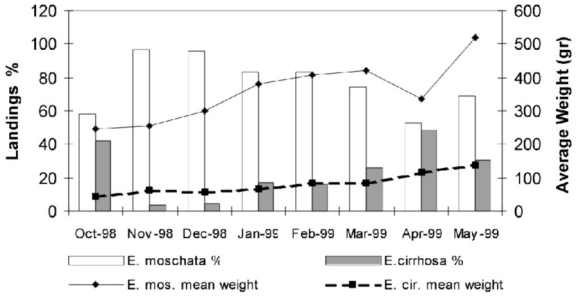

Figure 1. Monthly percentage and mean individual weight of *E. cirrhosa* and *E. moschata* in the Thracian Sea from October 1998 to May 1999.

A single cohort is present in *E. cirrhosa* landings, with a common modal length for both sexes, increasing from 6cm in October to 8cm in May (Fig. 2). The presence of one year class in the catches of *E. cirrhosa* has also been reported for other areas (1,4) and it could be related to the short life span of the species (about 1 year) (4) and the seasonality in the reproductive cycle of the species (5).

Length frequency distributions indicate two peaks of recruitment for *E. moschata*, occuring in October '98 and April '99 (Fig. 2). A wide recruitment period has been shown for *E. moschata* also in the southern Aegean Sea (6).

Sexual maturation follows different time courses for the two sexes in both species. Immature individuals dominate (74% - 100%) in the population of *E. cirrhosa* till March, whereas only males attain maturity within the sampling period. According to previous investigation in the study area, it is assumed that the period of female maturity in the Thracian Sea occurs from early summer till mid of autumn (7).

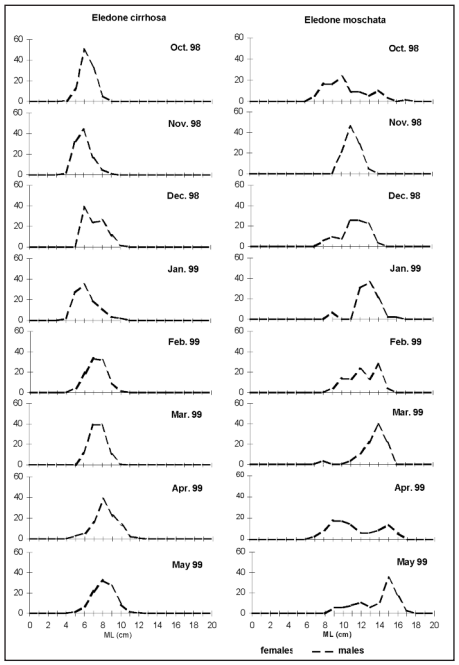

Figure 2. Monthly length -frequency distributions of *E. cirrhosa* and *E. moschata* in the Thracian Sea from October 1998 to May 1999.

Mature females of *E. moschata* (11/98 - 3/99 : 4-14%, 4/99 : 23%, 5/99 : 52%) show an apparent increase from April onwards whereas high percentages of mature males appear from February (69%). The relatively low percentage of mature females (31%) in October indicates that these are probably the last to mature and spawn from a year class which began spawning in early spring, This suggestion is in agreement with the model of the species life cycle proposed by Mangold (8).

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TIME SCALE OF APPENDICULARIAN ABUNDANCES IN THE OFFSHORE SOUTHERN ADRIATIC

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Abstract
Appendicularians were collected during 44 cruises, May 1996-1997. High abundances, especially for the juvenile specimens, were registered. Results show their importance in the secondary production at the oligotrophic waters. Appendicularians assemblages and vertical distribution respond to the influence of coastal and southern Adriatic oceanic features and changes of temperature.

Keywords : mesozooplankton, vertical distribution, Adriatic Sea

In spite of the unquestionable importance of appendicularians to marine ecosystem (1, 2, 3), their populations is poorly known in many regions of Mediterranean Sea. Objective of the present paper is contribution to undrestanding of seasonal populations density and vertical distribution of appendicularians community at the oligotrophic offshore station (100-m depth) in the Southern Adriatic (42°38'N, 18°03'E).

Plankton material was collected during 44 daytime cruises from May 1996 to May 1997. Appendicularians were sampled with 200 μm (54 cm in diameter) and 53 μm (45 cm in diameter for juvenile specimens) Nansen nets, equipped with a closing system, and in the following depth layers : 0-25 m, 25-50 m, 50-90 m. Temperature was measured using inverted thermometer at 0, 10, 20, 25, 50, 75 and 90 m depth. Chlorophyll *a* concentration (Chl *a*) was analysed fluorometrically by standard methods.

During warmer months a typical thermocline was formed in the surface layer until 20 m depth. Vertical gradient weakened during autumn and isotherm (19.1°C) was noted till 75 m depth. Salinity values are tipically oceanic with a moderatly influence of coastal waters (range 36.9-38.9 psu). Mean Chl *a* concentrations in the 25-50 m and 50-90 m layers were significantly higher than in the 0-25 m ($p<0.001$; one-way ANOVA). Annual range per water column was 0.004-0.680 μgl^{-1}, average 0.085±0.096. The highest concentrations were noted during spring.

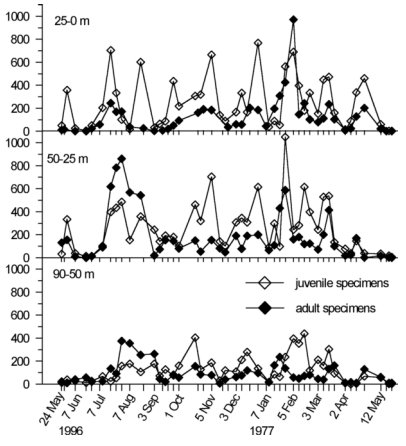

FIGURE 1. Seasonal and vertical variations of appendicularians population densities during 1996-1997 in the offshore southern Adriatic.

A high number of juvenile apendicularians were registered throughout the year in the upper and middle layers (Fig 1). Quantities often surpassed densities of 600 ind.m^{-3}, followed by slow or abrupt decreased to values less then 50 ind.m^{-3}. A maximum of 1050 ind.m^{-3} was noted in the middle layer at the end of January. A total number of adults specimens was 3.2 times less than of juvenile specimens. However, if compared with juvenile specimens, variations of adults population densities were similar (Pearson coefficient correlation, r=0.52, p<0.001). Increased adult values were recorded at the 25-50 m in July with maximum of 861 ind.m^{-3}, and from the end of January to the beginning of February with maximum of 972 ind.m^{-3} at surface layer (Fig. 1). Species *Oikopleura longic*auda and *O. fusiformis* dominated during summer high values, while *O. longicauda* and *Fritillaria pellucida* in winter. In general, *O. longicauda* was the most abundant species with an annual average of 39% to total appendicularians populations densities, followed by *O. fusiformis* (22%), *F. pellucida* (18%), *F. borealis* (10%), *F. haplostoma* (3%), *O. dioica* (3%), *F. megachile* (2%), *O. parva* (1%). Species, *Pelagopleura haranti, O. albicans, O. graciloides, O. mediterranea, Appendicularia sicula, F. formica, F. tenella, F. venusta*, were present sporadicaly, mostly below 50 m depth, indicating a high influence of open water currents. Among rare species, *Kowalewskia tenuis* was present in the surface layer only during summer.

Significantly higher densities of *Oikopleura juvenile* and adult specimens were found in the layers above the 50 m depth, while a marked aggregations of *Fritillaria* specimens were found at the 25-50 m and 50-90 m layers (Table 1). The temperature influenced adult vertical distribution during strong thermal stratification (6-8°C), most specimens were noted below the thermocline. Appendicularian communities exhibit characteristic shifts of species composition with depth (2) and was almost identical to those described off Villefranche-sur-Mer (4). Whether this feature is a consequence of physiological adaptations to temperature or something else is still uncertain.

Table 1. Comparison of the vertical distribution of abundant appendicularian species and their juvenile between 0-25 m (A), 25-50 (B) and 50-90 m (C) layers (Kendall's coefficient of concordance).

taxon	Probability	Sequences of abundances
Oikopleura juv.	<0.001	A=B>C
Fritillaria juv.	0.001	B>C>A
Oikopleura cophocerca	0.26	
Oikopleura dioica	0.05	A=B>C
Oikopleura fusiformis	<0.001	A=B>C
Oikopleura longicauda	0.01	A=B>C
Oikopleura parva	0.05	
Fritillaria borealis	0.02	B=C>A
Fritillaria haplostoma	0.01	B=C>A
Fritillaria megachile	0.25	
Fritillaria pellucida	0.01	B>C>A

When compared with other numerous mesozooplankton groups in the same samples collected with 200 μm net (Lucic, unpublished), calanoid copepods were 3.4 times more abundant than appendicularians, while appendicularian abundances were 2.1 times higher than that of cladocerans. Appendicularians growth rates are typically much greater than those of copepods at the same temperature (3) and our results appeared to an inevitable appendicularians importance in the secondary production at the oligotrophic waters. There were no meaningful relationship between Chl *a* estimates and appendicularian abundances. The lack of any significant temporal and spatial Chl *a*-appendicularians relationship and appendicularians specific feeding rate (3) suggest that phytoplankton must not be the factor modulating their production and vertical distribution. Presumably, it is regulated by its predators. A high positive correlations between total appendicularian specimens and planktonic cnidarians were noted (Pearson coefficient correlation, r=0.36, p<0.01). However, the observed appendicularian assemblages, their changes towards the seasonal species succession and vertical distribution, responded to the progressive influence of coastal and southern Adriatic oceanic features and annual changes of temperature.

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COMPARISON OF DISCARDED, ESCAPED AND LANDED FISH USING DIAMOND AND SQUARE MESH CODENDS

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Abstract
We compared 20 mm diamond-shaped codend with 20 mm square-shaped codend. Sampling was conducted with a chartered commercial trawler in the Gulf of Lion during July and August 2000. The codend covered method was used. Number and weight landed, discarded and escaped of twelve commercially important species were studied. Our results suggested great differences between the two codends in the number and weight of fish escaped and discarded. Landed weight only differed between 0.01 and 8.0 % for all species studied, excluding under-sized fish sold.

Keywords : trawl codend selectivity, square mesh, diamond mesh, fisheries, Gulf of Lions

The total annual catch in Catalonia (Spain) is approximately 50,000 t, 70 % of which is caught by bottom trawl fishery. Catches have been decreasing since 1994 and now mainly consist of under-sized fish. The multi-specific character of this fishery makes it difficult to manage, but some size selectivity experiments with diamond and square mesh codends suggest that changing the shape of the mesh codend could aid the escape of under-sized fish and (also very important) reduce the number of discards (1,2).

The aims of this study were :

1) to evaluate the number and weight of discarded, escaped and landed fish, and

2) to compare the selectivity of diamond and square mesh codends.

Sampling took place in the Gulf of Lions between July and August 2000 in a chartered commercial trawler. We made eight hauls with every mesh codend at depths between 50 and 350 metres. The hauls lasted between 3 and 4 hours and the towing speed was 3.8 knots. Codend selectivity was calculated through the covered codend method (3).

Catches were sorted for every mesh codend and separated into three categories : landed, discarded and escaped fish. Each category was sorted by species. The total number and weight per species and individual lengths (to the nearest mm) were recorded. In this paper, we describe the results for twelve commercially important species : *Merluccius merluccius, Micromesistius poutassou, Trisopterus minutus capelanus, Mullus barbatus, Sardina pilchardus, Engraulis encrasicolus, Scomber scombrus, Trachurus trachurus, Trigla lyra, Eutrigla gurnardus, Phycis blennoides* and *Lepidorhombus boscii*.

The analysis of every category suggested that, with diamond mesh, discards were between 20.0 and 75.8% of the total number retained, and between 4.2 and 47.3% of the total weight retained. Square mesh reduced the number of discards in both total number and weight retained to 0-13.3% and 0-7.3 %, respectively.

In other words, the number of escapes with square mesh was over 50 % more than with diamond mesh.

Total number and weight landed with diamond mesh were 12.0-72.7% and 39.2-96.1%, respectively; and with square mesh, 5.3-63.6% and 15.7-94.0%. We observed that less fish were landed with square mesh, but if we took away the under-sized fish landed with diamond mesh, and then compared the diamond-mesh fish again with the fish landed with square mesh, the difference was only about 5% for the total weight landed.

Comparison of the under-sized fish landed with every type of mesh showed big differences for the most commercial species like hake (*Merluccius merluccius*) and red mullet (*Mullus barbatus*). The total number of under-sized hake landed was 60.2% with diamond mesh and 13.6% with square mesh, whereas the weight of under-sized hake landed was 11.0% and 5.3%, respectively. The total number of under-sized red mullet landed was 54.0% with diamond mesh and 10% with square mesh; and the weight of under-sized red mullet landed was 11.4% with diamond mesh and 5.2% with square mesh.

The results of the present study show that :

(1) square mesh allows significantly more individuals to escape through the mesh;

(2) consequently, the number of individuals discarded decreases with a square mesh codend;

(3) the weight of fish landed is similar for the two types of mesh when the under-sized fish landed are excluded; and

(4) the under-sized fish sold decrease if we use the square mesh codend.

Acknowledgements

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SIGHTINGS DISTRIBUTION AND VARIABILITY IN SPECIES COMPOSITION OF CETACEANS IN THE ADRIATIC SEA ECOSYSTEM IN ONE DECADE OF STUDY

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Abstract

Since 1988 the "Adriatica" shipping company and the R/V *Salvatore Lo Bianco* have carried out cetacean visual surveys in the waters of the Adriatic Sea. Collected data take account of the number of sightings and their geographical and temporal distribution, the number of individuals per sighting, and, finally, the species composition. The data processing points out which areas could be considered at high risk for the abundance of cetaceans, the presence of more than one species, or the sporadic presence of rare species. These areas should be taken in consideration in relation to fishing and other human activities.

Keywords : Adriatic Sea, Cetacean, Sampling methods

The sightings represent an efficient parameter, if repeated for a relevant number of years such as a decade, to assess the occurrence of cetaceans in a given sea body [1]. Information about the occurrence, the amount, the species composition, and so on, of cetaceans in the Adriatic Sea could aid the management and the conservation of these marine mammals. As a matter of fact several areas of the Adriatic Sea are interested by an intense human activity ranging from fishery to tourism, from oil drilling to maritime trade [2][3]. A certain number of these areas are "hot spots" because they are at high risk for the cetaceans and, therefore, should be particularly cared.

Material and methods

The data on cetacean sightings in the Adriatic Sea for a period of ten years long, from 1988 to 1998, come from two different sources : the "Adriatica" shipping company and the R/V *Salvatore Lo Bianco*. With regard to the "Adriatica", all the sightings have been performed from the ships in transit on the Adriatic Sea along the commercial routes followed regularly all the year round. The data obtained by R/V *Salvatore Lo Bianco*, instead, were collected during two acoustic surveys carried out each year from 1988, from July to October [4]. During these surveys trained personnel visually monitored the marine mammals. All the data have been processed in a particular geographical context in which the terrestrial coordinates, latitude and longitude, have been translated in Cartesian coordinates, X and Y. Each elementary cell of this raster map is one square mile and the cetacean sightings have been referred to 50 square blocks of 30x30 elementary cells.

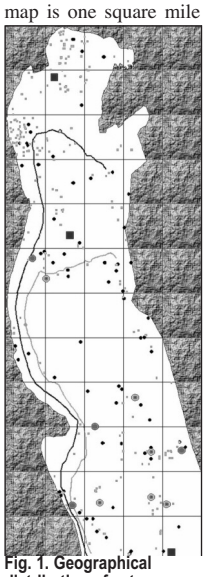

Fig. 1. Geographical distribution of cetacean sightings in all Adriatic sea in the decade 1988-1998.

Results and discussion

The geographical distribution of cetacean sightings during the decade 1988-1998 has been analyzed for North Adriatic, South Adriatic, and all Adriatic Sea (Fig. 1) in which they are divided per season only for the species belonging to the Delphinidae Family. Considering the mean number of individuals in a herd, per Delphinidae species, it's possible to highlight that both striped and bottlenose dolphins form larger herds in winter than in summer; on the other hand, the herds of common dolphins are larger during summer period than in winter. Table 1 shows the number of sightings and individuals for each species, also not identified and rare species, visually surveyed all the year round and during summer (May–October) and winter (November-April) period. The next step dealt with the analysis of the trend of the sightings and the number of the individuals in the space of these ten years for North Adriatic Sea, South Adriatic Sea, and, finally, the whole Adriatic Sea (Fig. 2). At the same time, the species composition visually surveyed during each year has been pointed out, once again for the North, South and the whole Adriatic Sea (Fig. 3). Although there is a relevant fluctuation on yearly basis in sightings and individuals' number for North and South Adriatic Sea separately considered, all the Adriatic Sea evidences a fairly constant trend with regard to the sightings with a less emphasized shrinkage between 1991 and 1993, probably due to the civil war in the ex-Yugoslavia. The number of cetaceans is more fluctuating during this decade, but it's an undependable parameter because subject to a lot of mistakes. The trend of species composition reflects this situation with the most of unidentified species concentrated during the central years of ex-Yugoslavia' troubles. However, it seems quite constant, except for the North Adriatic Sea in which occurs a considerable change for *Tursiops truncatus* and *Stenella caeruloalba*. Figure 4 shows the percentage of identified cetaceans and its species composition within the decade 1988-1998.

Table 1. Number of sightings and individuals for each species during 1988-1998.

Species	Yearly		During summer period (May-October)		During winter period (November-April)	
	Sightings	IndividuNals	Sightings	Individuals	Sightings	Individuals
Not identified delphinidae	110	1417	100	1118	10	299
Bottlenose dolphin	111	1710	66	969	45	741
Striped dolphin	50	487	31	285	19	202
Common dolphin	17	164	13	136	4	28
Sperm whale	4	16	3	15	1	1
Fin whale	3	15	1	13	2	2
Risso's dolphin	6	19	4	16	2	3
Total	301	3828	218	2552	83	1276

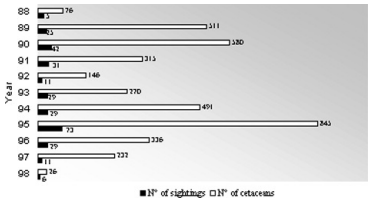

Fig. 2. Trend of sightings and cetacean numbers visually surveyed during the decade 1988-1998 in the whole Adriatic Sea.

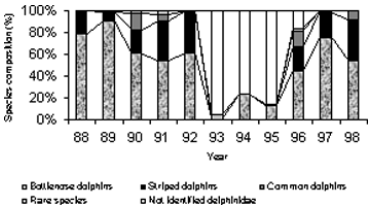

Fig. 3. Trend of species composition visually surveyed during the decade 1988-1998 in the whole Adriatic Sea.

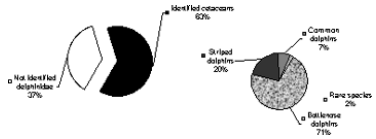

Fig. 4. Species composition of the identified cetaceans fraction.

The 66% of them have been identified and the bottlenose dolphins represent the majority, i.e. 77%. Only the 2% is formed by rare species that only occasionally frequent the Adriatic Sea. Once gained all these data, we have laid out the raster maps of sightings number and species composition yearly and seasonally surveyed. These maps point out which areas are at high risk due to either the considerable amount of cetaceans referred to the uniform distribution or the presence of more than one species. Also those areas in which it has been found the sporadic presence of rare species (for the Adriatic Sea) should be considered at high risk.

Conclusions

A relevant result of this work is that bottlenose dolphin seems to be the most abundant and most variable species, followed by the striped dolphin, considering either separately North or South Adriatic and the whole Adriatic Sea. The bottlenose dolphins move to South Adriatic during winter season, while striped dolphins tend to aggregate into the Central Adriatic in the same season. With respect to the "hot spots", about the 50% of the all analyzed blocks results to be at risk (high or mean) for the yearly or seasonally occurrence either of a significant amount of cetaceans or of more than one species or both of them. In certain cases also the sporadic presence of rare species represents an index of risk for the protection of these mammals.

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THE BIOLOGY OF THE GREATER WEEVER (*TRACHINUS DRACO* L., 1758 – OSTEICHTHYES, TRACHINIDAE) IN THE SOUTHERN ADRIATIC SEA : A PRELIMINARY NOTE

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Abstract

Preliminary information on some biological features of *Trachinus draco* L. in the Southern Adriatic Sea are reported. Minimum lengths at maturity of 21 and 20 cm were found for male and female specimens respectively. Length-at-age mean values of 13.9, 17.5, 18.7 and 22.4 cm were estimated for age classes 1, 2, 3 and 4 respectively.

Keywords : Teleostei, Reproduction, Growth, South Adriatic Sea.

Introduction

The greater weever (*Trachinus draco* L.) is widely distributed in the eastern Atlantic from Norway to Morocco and it is very common in the Mediterranean (1). In spite of this, scientific information on the species is scanty or generic (2-5) and sometimes targeted to the venom organs (6).

In the present paper, preliminary information on some biological features (reproduction, growth) came from data collected in the southern Adriatic Sea.

Materials and methods

Samples of *T. draco* came from international trawl surveys (MEDITS Project, funded by E.U.) carried out from 1998 to 2000 in the southern Adriatic basin (7) and from national trawl surveys (years 1998-2000) carried out in the western side of the same basin (Italian waters) (8).

The collected specimens were measured by sex (total length, mm) and macroscopic maturity stage was pointed out (9). Somatic weight (g), as well as the weight of the female gonads was recorded also. Otoliths (sagittae) were removed in order to age the specimens. Each otolith was read at stereomicroscope by three different observers and the coincident readings were accepted only.

Gonado-somatic indices (females), length-weight relationship and length-at-age mean values were calculated.

Results

Greater weever was collected at 26-140 m depth range, and sixty-three specimens were analysed in the 1998-2000 period. The survey's seasons corresponded to the referenced reproductive period in the Mediterranean (4, 5), so macroscopic maturity stages and gonado-somatic indices (% gonad weight/somatic weight) could be useful to specify the length at maturity. With regard to male specimens, stage four (ripe) of Nicolsky's scale occurs at a minimum of 21 cm total length, while females at the same stage were recorded at 20 cm total length. Gonado-somatic indices (Fig. 1) confirm this last result.

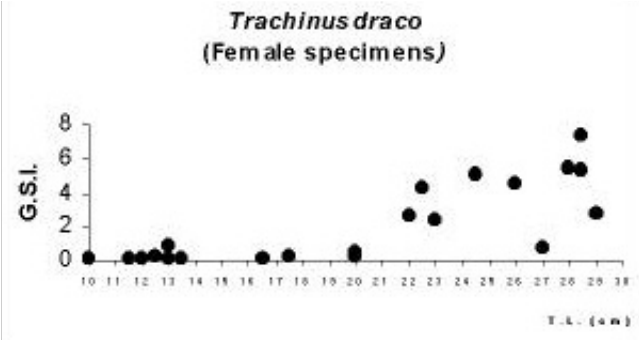

Fig. 1 . Gono-somatics indices per length.

Length-weight relationship was computed on the whole sample (Fig. 2), since no significant difference was found between sexes (parallelism test).

Otoliths readings were accepted for 56 specimens of the whole population, and length-at-age mean values of 13.9, 17.5, 18.7 and 22.4 cm were estimated for age classes 1, 2, 3 and 4 respectively (Tab. 1). Due to the low number, bigger individuals (TL>25 cm) were discharged.

In view of the obtained results, individuals older than 3 years could be considered potential spawners.

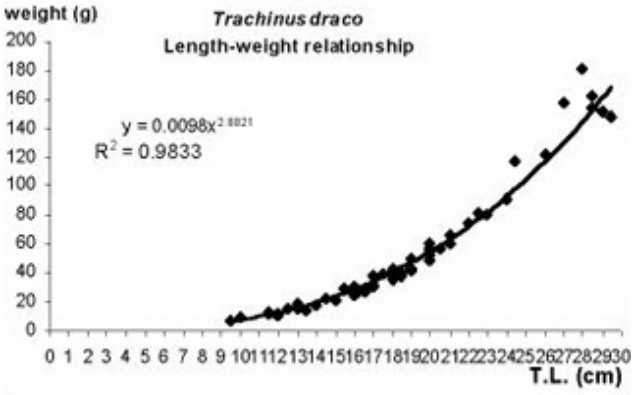

Fig. 2. Length-weight relationship (whole sample).

Tab. 1; Age-at-length mean values

age (year)	1	2	3	4
mean length (cm)	13.91	17.53	18.71	22.43
st. dev.	1.7	2.9	2.5	3.9
n° of specimens	11	17	21	7

Discussion and conclusion

The reported data adds information on the *T. draco* biology in the Mediterranean (at least for the southern Adriatic Sea), although it needs improvements. In fact, the low number of analysed specimens prevents the estimation of the maturity L50% or to fit a growth curve, and we hope to make it the next future.

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BATCH FECUNDITY OF ANCHOVY, *ENGRAULIS ENCRASICOLUS*, IN THE NE AEGEAN SEA

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Abstract
Adult samples collected onboard the purse-seine fleet, as well as a research vessel by means of a pelagic trawl, were used to estimate batch fecundity of anchovy in the NE Aegean Sea during June 1993 and June 1995. Relative fecundity differed significantly between years which seemed to be associated with differences in the adult feeding environment. In June 1993 waters were colder, less saline and richer in zooplankton. Adult condition, egg size and batch fecundity were higher in 1993 than in 1995.

Keywords : Reproduction, Aegean Sea

Introduction

Batch fecundity is a parameter of the Daily Egg Production Method (DEPM), an ichthyoplankton-based method being used increasingly around the world to estimate biomass of small pelagic stocks (1). Besides biomass estimation, batch fecundity is an important biological variable of fish stocks, which can improve our insight into the reproductive biology of multiple spawning fishes, particularly when it can be compared between species and stocks (2).

In the present communication we present the first estimates of batch fecundity of anchovy of the NE Aegean Sea and relate them to the biotic and abiotic conditions of the pelagic environment.

Materials and methods

Adult samples were collected on board both the commercial purse seine fleet and the R/V "PHILIA" by means of a pelagic trawl in June 1993 and June 1995. The location of sampling stations is shown in Fig. 1. Sampling was carried out from 22:00 to 05:00 local time. Fish were fixed onboard immediately after collection, using 15 l jars filled with 10% buffered formalin. Each sample consisted of random collection of 1,5-2 kg of anchovies.

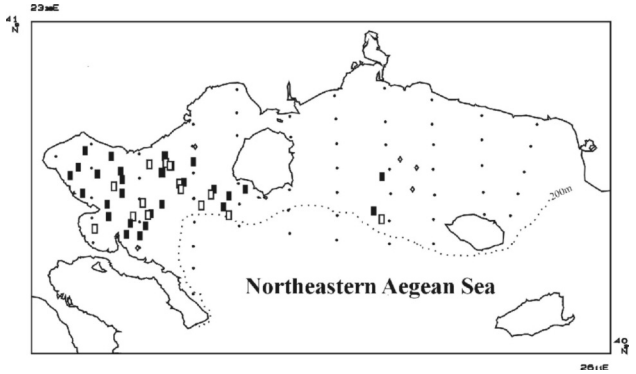

Fig. 1. The location of adult and planktonic/hydrographic sampling sites. Black squares : purse seine stations in 1993. Open squares : Purse seine stations in 1995. Open triangles : Pelagic trawl stations in 1995. Dots : Bongo-net and CTD

In the laboratory, all macroscopically detected hydrated or running females were weighted and their gonads weighted and preserved in formalin. The hydrated oocyte method was used for batch fecundity measurements (3). Only gonads with fully hydrated oocytes but no postovulatory follicles were used which had previously been tested through histological analysis of one of the two ovaries. Hydrated oocytes were counted in 40-60 mg subsamples (containing 100-200 eggs) per fish, taken from the anterior, middle and posterior part of the gonad.

For each year, data on the number of eggs per batch and the ovary free weight recorded for the hydrated females were used to fit a linear model. The regressions were forced through zero since the intercepts were not significant at the 0.05 level.

Relative condition factor of females (4), egg size, sea temperature and salinity and zooplankton biovolumes were also examined. Plankton and hydrographic data were available from a research survey made concurrently with the adult sampling (Fig. 1).

Results and discussion

The upper water column was generally cooler and less saline in 1993 than in 1995 (Table 1). Mean zooplankton displacement volume (ZDV), measured from the catch of the 0.250-mm mesh net, was significantly higher in 1993 than in 1995 (Table 1).

Table 1. Mean values for environmental and anchovy reproductive parameters being significantly different between 1993 and 1995 (P<0.05).

		1993	1995
Temperature (°C)	5 m	21.20	23.55
	0-40m	16.74	18.93
Salinity (psu)	5 m	32.49	33.65
	0-40m	34.70	36.18
Zooplankton displacement volumes (ml/m^2)		24.31	18.72
Egg size (mm^3)		0.206	0.195
Relative condition factor (100*W/L^b)		0.550	0.526
Relative fecundity (eggs/g)		563	325

Hydrated females were found only in samples collected before 02:00 a.m. (n=2 and n=5 in 1993 and 1995 respectively). Batch fecundity was measured for a total of 25 females in 1993 and 70 females in 1995. The slope of the fecundity-on-gonad free weight equation (relative fecundity, Fig. 2) was significantly higher in 1993 (95% confidence intervals : 518-608 eggs/g) than in 1995 (298-353 eggs/g).

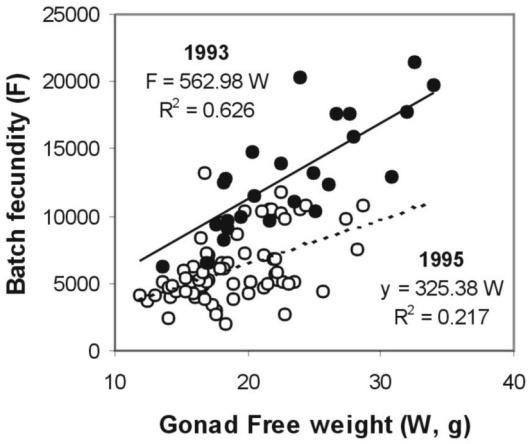

Fig. 2. Batch fecundity models. Black circles : 1993. Open circles : 1995.

The relative condition factor of females and mean egg size were significantly higher in 1993, when zooplankton biovolumes were also higher and temperature and salinity were lower (Table 1).

These results suggest an enhancement of adult condition and reproductive traits (fecundity and egg size) when zooplankton abundance is higher, i.e. in a superior trophic environment for the spawners. Higher zooplankton abundance in the NE Aegean Sea during June 1993 might have been due to a severe winter during that year (5).

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THE OCCURRENCE OF *OCTOPUS VULGARIS* CUVIER, 1797 ON THE BATHIAL GROUNDS OF THE EASTERN IONIAN SEA

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Abstract

The finding of *Octopus vulgaris* on the bathyal zone of the Ionian Sea is reported in this poster. The octopod was a male, sized 9.0 cm ML. It was collected during daylight hours at a depth of 560 m , during an experimental deep-water trawl survey carried out in September 2000 in the North-eastern Ionian Sea. This is the deepest record of the species so far.

Keywords : Cephalopods, Ionian Sea, Mediterranean Sea.

Octopus vulgaris Cuvier, 1797 is a cosmopolitan species, common in different habits of the neritic coast. The species is generally distributed up to 200 m in depth, although it has been occasionally caught on deeper grounds in the Mediterranean Sea1 and in the Atlantic Ocean 2. In this note is reported the deepest catch of the species so far.

The specimen was collected during an experimental deep-water trawl survey carried out in September 2000 in the North-eastern Ionian Sea. A professional trawler of 159 tons gross tonnage was used equipped with a bottom trawl-net with stretched mesh of 20 mm in the cod end. A total of 29 hauls was performed during day-light, between 300 and 1200 m of depth. The species was identified and the main morphometric data were recorded.

The specimen of *Octopus vulgaris* was caught in the Eastern Ionian Sea at a distance of 10.5 nautical miles off the NW coasts of Lefkas Island (38o 52 N; 20 o 25 E) and at a depth of 560 m. It was a maturing male, sized 9.0 cm DML and its weigh was 350 g. This specimen was alive and appeared stone-blind.

Previous findings of *O. vulgaris* on the slope have been reported for Mediterranean areas 3,4 where the sea bed drops abruptly. This could explain the present record in the Ionian deep-water basin.

Figure 1. *Octopus vulgaris* collected during deep-water trawl survey (560 m) carried out in September 2000. This specimen was alive and appeared stone-blind.

Figure 2. Octopus collected together with other deep species (red shrimps and other species).

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UN GROUPE DE *STENELLA COERULEOLBA* DANS UN PORT !

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Résumé
Une bande de 7 *Stenellas* fréquente étrangement un port du sud de la France, du 24 septembre au 13 octobre 2000. Ils repartent progressivement mais deux individus restant voient leur comportement changer et se montrent de plus en plus apathiques et indolents.

Mots-clés : Cetacea, Behaviour

Description du phénomène

Dans la nuit du 23 au 24 septembre 2000, un groupe de sept Dauphins bleus et blancs investit le port de l'île des Embiez (Var, France) pour une période de vingt jours.

Ces dauphins regagnent progressivement le large : le 28 septembre il en reste cinq, le 2 octobre deux, et le 5 une seule femelle subsiste. **L'étude est réalisée sur les deux derniers individus (Z1 et Z2, du 2 octobre au 13 octobre)**. L'autopsie de Z2, retrouvé mort le 9 octobre, n'a révélé aucun reste de proies classiques dans l'estomac. Faits exceptionnels, Z1 accepte du poisson mort de la main de l'homme et se voit retirer un hameçon profondément planté dans la gencive vestibulaire sans se débattre. Il montre divers symptômes pathologiques et disparaît le 13 octobre au soir après un léger regain d'activité.

Matériels et méthodes

Les observations ont été réalisées tous les quarts d'heures, à l'oeil nu et du quai :

- positionnement des individus dans le port, sur un plan divisé en vingt-sept secteurs.

- taux de vocalisation par individu, concerne les sifflements rauques émis, en surface, par l'évent. Du 2 au 4 octobre, les données sont divisées par deux pour être ramenées à un taux individuel.

- taux de plongée, ne concerne que Z1 une fois seul. L'effort d'observation est réparti sur toute la journée sauf pour les 9 et 11 octobre (sur la soirée) et 10 octobre (sur la matinée).

Evolution du comportement des deux derniers individus

1- Le positionnement des individus dans le port est fonction des tranches horaires (graphique 1). **De jour : jusqu'au 9 octobre** les dauphins restent cantonnés dans la moitié Ouest du port et s'y reposent. **A partir du 10**, Z1 élargit son secteur vers la partie S-E. **Le soir et de nuit**, le quart S-W reste le lieu de prédilection mais les dauphins chassent devant la capitainerie et à l'extérieur du port.

2- L'augmentation du taux de vocalisation. Ce taux reste faible tant que les animaux sont deux (0 à 15 % des observations révèlent un sifflement) puis augmente régulièrement jusqu'à un pic de 70 % le 12 octobre. Le 13 octobre, le chiffre de 14 % traduit avec un regain d'activité.

3- La diminution du taux de plongée et donc l'augmentation du taux d'exposition au soleil. Les quatre premiers jours, le taux d'émersion évolue de 35 % à 89 % et coïncide avec le développement de plaies sur les nageoires caudale et dorsale trop exposées au soleil. Les cinq jours suivants révèlent une légère augmentation du taux d'immersion. Aucune immersion le 12 octobre, jour où l'animal semblait le plus apathique. Le 13, Z1 atteint un pic de 44 % de taux de plongée, ce qui coïncide avec le regain d'activité observé ce dernier jour.

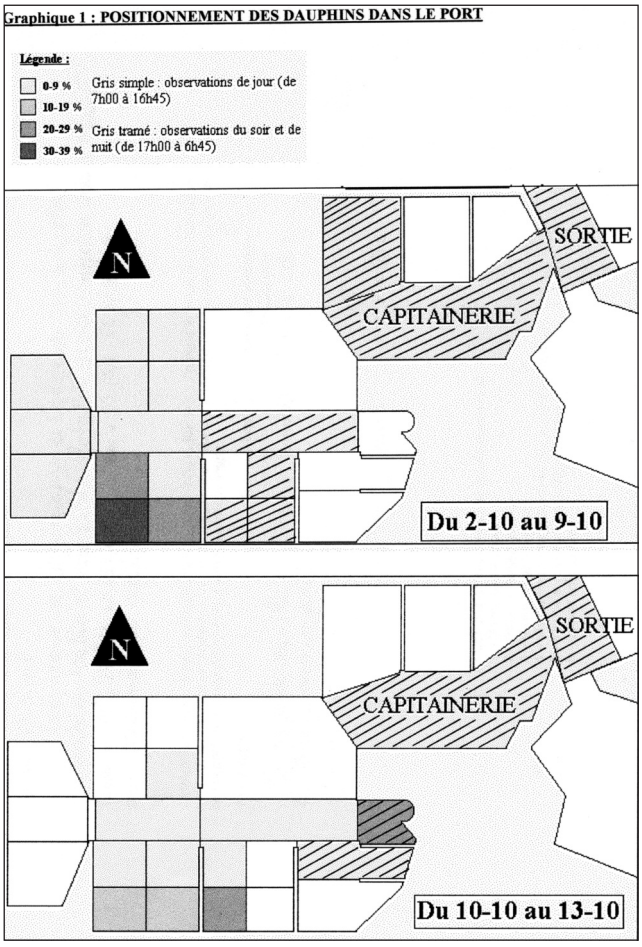
Conclusion

Différentes hypothèses expliqueraient l'intrusion de ces animaux dans le port. Des tirs de mines, effectués la veille par la Marine Nationale, ont pu les effrayer ou blesser. Il se peut aussi que le groupe ait choisi d'accompagner certains individus malades.

Après la disparition de Z2, Z1 a changé progressivement de comportement. La diminution du taux de plongée, l'apathie croissante, l'état de maigreur avancé, des convulsions et les variations d'occupation de l'espace ont probablement une origine neurologique. L'augmentation des vocalisations pourrait provenir d'une souffrance physique ou répondre à un besoin de communication.

L'indolence croissante de Z2 fut ponctuée par un regain d'activité précédant sa disparition : il a consommé quelques poissons vivants. Cela l'a peut-être aidé regagner le large dans la nuit du 13 au 14 octobre puisque son corps n'a jamais été retrouvé.

Graphique 1 : POSITIONNEMENT DES DAUPHINS DANS LE PORT



Remerciements

Je remercie les personnes qui m'ont aidé pour cette étude : Mme Michel (S.A. Paul Ricard), N. Vicente, F. Dhermain, M. Corbeille, O. Nicolas, R. Menegolla, Fred, B. Prosnier, D. Rebillard, L.Revillod, F. et A. Fauck, et P. Beaubrun.

UNUSUAL OCCURRENCE OF THE MICROFLAGELLATE HERMESINUM ADRIATICUM ZACH. IN THE NORTHERN ADRIATIC SEA IN 1998 AND 1999

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Abstract

Hermesinum adriaticum Zacharias (Incertae sedis) is a rare heterotrophic microflagellate that has been described for the first time in the northern Adriatic in 1906, but since then it wasn't recorded in this region until the summer of 1998 and summer and autumn of 1999.

Keywords : plankton, Adriatic Sea

Hermesinum adriaticum Zach. species has uncertain taxonomic position (Incertae sedis; 1) due to the presence of a siliceous skeleton inside its cells, two unequal flagella and a nucleus with condensed chromosomes similar to that of Euglenophyceae.

H. adriaticum is known both as a tropical and temperate species. Highest known concentrations (up to 380,000 cells/L) were associated with a marked chemocline at the H2S boundary in the Narragansett Bay (USA; 2) and in the Lake Rogoznica (small salty lake on the central eastern Adriatic coast; 3) in summer. In the northern Adriatic Sea, since 1906 (4), *H. adriaticum* has not been reported, although the Centre for Marine Research in Rovinj continuously collected phytoplankton data since 1972. The Hermesinum species was found only in the western coastal part of the Otranto Strait (5) and in the offshore southern Adriatic along "profile" Dubrovnik-1000m isobath (3), when its appearance was correlated with the inflow of eastern Mediterranean waters with temperatures above 13.8°C and salinity above 38.6‰, providing evidence of subtropical microplankton winter migration into Adriatic. Immigration brought by natural anomalies in the current transport is a frequent reason for the appearance of new species in plankton communities, as already observed in the northern Adriatic (6).

Seawater samples for analysis of microphytoplankton composition were collected from 1/1/1998 to 31/12/1999 on 11 stations, using Van-Dohrn bottles, and preserved with Lugol solution (neutralised with sodium-acetate). On 7 stations additional samples were taken and preserved with 2% neutralised formaldehyde solution. Cell counts were performed by the Utermöhl method (7). The investigated region included open waters as well as coastal belt of the northern Adriatic including Limski kanal (Fig. 1).

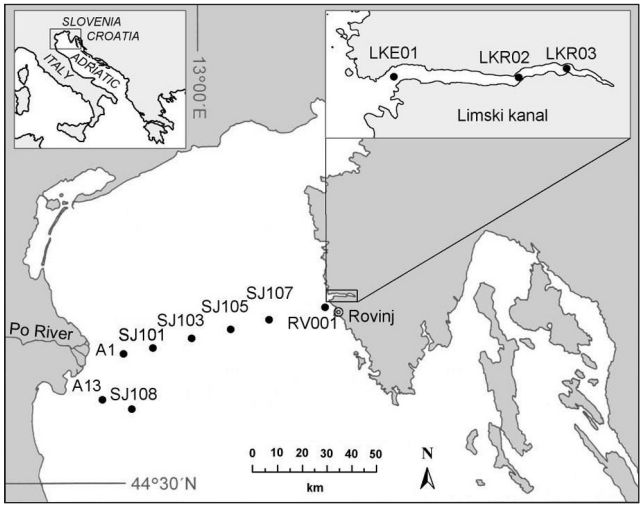

Figure 1. Map of the study area with sampling stations.

H. adriaticum species was found in summer and autumn months (Tab. 1), mostly in the 0-10 m layer, in low concentrations, ranging generally from 40-800 cells/L. Higher values (up to 6400 cells/L) were found on August 24th, 1999 in the surface layer of the area 22 km south-east off the river Po delta.

Table 1. Records of *Hermesinum adriaticum* in the Northern Adriatic in 1998 and 1999.

Date	Station	depth/m	cells/L
09/06/98	SJ107	10	200
17/08/98	SJ108	10	400
10/06/99	SJ107	0	740
24/08/99	SJ108	0	800
24/08/99	SJ108	5	6400
24/08/99	SJ108	10	3200
24/08/99	SJ108	20	800
01/09/99	LKE01	10	400
01/09/99	LKE03	10	40
01/09/99	LKE03	16	200
08/09/99	SJ107	20	200
18/12/99	A13	24	370

The hypothesis that the appearance of *H. adriaticum* in the northern Adriatic in 1998 and 1999 was due to higher than usual northward advective transport of oligotrophic southern Adriatic waters was verified principally from higher salinity and transparency, as well as minimum values of plankton abundance and oxygen production and consumption in 1998 and 1999. It may also indicate an intrusion of eastern Mediterranean water masses into Adriatic. This inflow appeared to be more intensive in 1999 than in 1998.

Assuming that the origin of the observed *H. adriaticum* are coastal environments in the warmer and saltier eastern Mediterranean (3), this species could be used as an indicator of enhanced intrusions of these waters in the Adriatic, up to its northernmost part.

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EXPERIMENTAL INFECTION OF EUROPEAN SEA BASS (*DICENTRARCHUS LABRAX*) WITH *ANISAKIS SIMPLEX* THIRD-STAGE LARVAE (NEMATODA : ASCARIDOIDEA)

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Abstract

Infective larvae of *Anisakis simplex* were experimentally administrated to a cage reared European sea bass (*Dicentrarchus labrax*). First positive findings were noticed five days after the first forced feeding with the third – stage larvae. The larvae showed high viability and vigor, even if they were isolated from an unusual and accidental fish host and from a non-predilected site.

Keywords : Dicentrarchus labrax, Anisakis simplex, experimental infection

Introduction

A. simplex matures in the stomach of whale, while its infective third–stage larvae can be found in the viscera and occasionally the flesh of over 70 species of fish. The species is highly pathogenic to men, wherever raw, marinated, (under) cooked fish meat is consummated.

Materials and methods

A cage-reared European sea bass from the fish farm were held in two tanks of 5 m^3 in running sea water (temperature 20°C, salinity 35‰). Third-stage larvae of *A. simplex* were isolated from Atlantic horse-mackerel (*Trachurus trachurus*) an thoroughly washed in 0.9 % NaCl solution. Before the administration, larvae were measured under the light microscope. After acclimatization period of two weeks, fish were anaesthetized with benzocain and forced fed with the plastic catheter. From 20 to 30 larvae were administrated in one feeding, which was performed on the day 1, 3, 5. and 10. In the mean time, fish were fed on standard commercial diet. Twenty- four hours after the feeding, a random fish sample was taken, and autopsied. In the second tank, the control group of fish was held, and fed only on commercial diet.

Results

After the first and second feeding (day 1. and 3, respectively), fish showed nematodes in stomach, but not in the intestine or under visceral serosis. Stomach was almost empty, with only a small amount of transparent mucus, without erosions on the mucosa. The pyloric caeca were filled with the large amount of tick, yellowish content. The same was found in the intestine. Fish autopsied one hour after the forced feeding, were found to contain live, vigorously moving larvae.

The day after the last forced feeding (day 10), all of the remaining fish were autopsied, and found with the live larvae under different parts of visceral serosis.

The larvae isolated from infected fish were alive and showed no difference in the body length.

The relation between the mean weight of the fish and isolated larvae from viscera, is given in figure 1. That correlation is – 0,161.

The localization and the number of isolated larvae is shown in table 1.

The autopsied control group showed no larvae.

Discussion

The attempts to transmit experimentally infective stage of Ascaroid nematods has been studied to elucidate questions regarding their migration patterns during life cycle. Køie (1) succeeded to transmit *Contracaecum osculatum* to various fish species, exposing them to ensheated third-stage larvae, infected copepods or via infected intermediate fish host. She concluded that larvae migrating into wall of the pyloric caeca reached mesentery, and those penetrating the intestinal wall, reached liver via the blood vessels. Smith et al. (2) infected rainbow trout (*Oncorhyncus mykiss*) with *C. osculatum* and *Pseudoterranova decipiens* and monitored the development of the larvae, concluding that they grew within 270 days 10.2 (mean value) in length. When Moser et al. (3) tried to infect striped bass (*Morone saxatilis*) with *A. simplex* larvae, he obtained only two from six positive bass, with the number of one to four larvae per fish, respectively.

The present study indicates that even European sea bass is not a usual host of *A. simplex*, the infection is possible, while the migrations from the stomach to different sites takes 5-10 days post infection.

The unusual site of localization of the larvae and their high viability, indicate the huge adaptation possibilities of this nematode, even the growth of larvae was not noticed, because of very short period which they passed in fish body.

The largest number found in mesenteric fat suggest that the fat acts only as a way trough which the passing is made, in attempt to reach other more convenient site.

The correlation between the number of isolated larvae and the fish weight is negative and insignificant, meaning that the success in penetration of the gastrointestinal tract in this case does not depend on fish size.

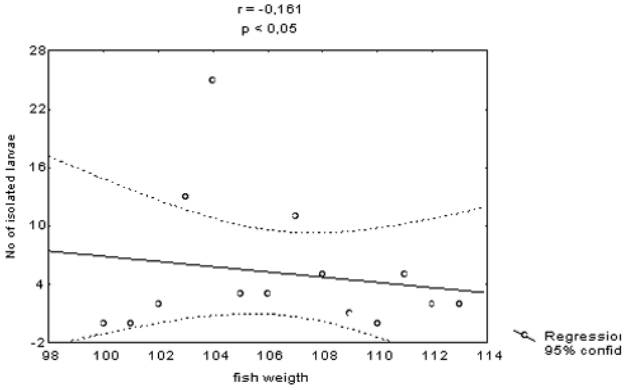

Figure 1. Regression scatterplot of correlation between the mean weight of fish and number of isolated *A. simplex* larvae.

Table 1. The localization and the number of isolated larvae of *A. simplex* from European sea bass.

Localization	No
mesenteric fat	52
stomach serosis	7
esophagus serosis	5
mesentherium	5
liver serosis	1
pyloric caeca serosis	1
swim bladder	1

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BIO-ECOLOGIE DE *ARISTEUS ANTENNATUS* (RISSO, 1816) ET DE *PARAPENAEUS LONGIROSTRIS* (LUCAS, 1846) DES COTES ALGERIENNES

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Résumé

Aristeus antennatus et *Parapenaeus longirostris*, crevettes profondes d'intérêt économique, sont très fréquentes et très abondantes en Algérie. Une synthèse des travaux sur l'écologie et la biologie de ces crevettes permet de déterminer leurs répartitions optimales. Ces espèces fréquentent des fonds chalutables; *A. antennatus* est abondante sur des fonds de vase très peu sableuse à *Isidella elongata,* aux profondeurs de 400 à 600 mètres de jour et entre 200 et 300 mètres de nuit alors que *P. longirostris* est abondante sur les fonds de vase plus ou moins sableuse à *Funiculina quandrangularis*, entre 150 et 350 mètres de profondeur.

Mots-clés : Aristeus antennatus, Parapenaeus longirostris, Shrimp fishery, Bioecology, Algeria

Introduction

En Algérie, parmi les groupes d'animaux marins présentant un grand intérêt économique et des possibilités réelles d'exploitation se situent les crustacés, groupe au sein duquel les crevettes (représentées par environ 90% des captures) tiennent une large part.

Selon les statistiques officielles entre 1980 et 1999, les apports en crevettes sont en moyenne de l'ordre de 3000 tonnes par an, représentant environ 4% de la production totale annuelle. Malgré ce faible apport relatif en quantités débarquées, la valeur économique des crevettes est assez élevée : elle représente environ 10% de la valeur globale. Parmi ces crevettes, *Aristeus antennatus* (Risso,1816) et *Parapenaeus longirostris* (Lucas,1846), par leur qualité et leur abondance, constituent la quasi-totalité des captures. Ces espèces ont fait l'objet de travaux en Algérie (1, 2).

Matériel et méthode

Les données de la pêche commerciale de la région algéroise, de 1980 à 1994, ainsi que celles effectuées en 1998 et 1999 dans le cadre d'un projet (Analysis of the Mediterranean, including North Africa, deep-sea shrimp fishery : catches, effort and economics) ont permis la détermination des paramètres biologiques et d'exploitation. L'étude écologique a été effectuée à partir des données des campagnes de prospection effectuées sur l'ensemble de la côte algérienne en 1982 et dans l'est algérien en 1984. Une synthèse des résultats des travaux effectués en Algérie contribue à la connaissance de ces espèces, permettant ainsi une meilleure exploitation.

Résultats et discussion

Aristeus antennatus (Risso,1816) fréquente des profondeurs allant 260 à 820 mètres de jour et de 80 à 650 mètres de nuit. De jour, l'optimum d'abondance se situe entre 400 et 600 mètres alors que de nuit cet optimum est entre 80 et 550 mètres. Cette espèce semble préférer des températures de l'ordre de 13°C sur des fonds de vase très peu sableuse à *Isidella elongata* (Esper, 1785). La taille moyenne (en longueur céphalothoracique) des femelles est de 37 mm ; les mâles, plus petits en général, ont une taille moyenne de 27 mm.

La période de reproduction définie à partir de l'évolution des stades ovariens s'étale d'avril à septembre, avec des maxima de mai à août. Le pourcentage de femelles est de l'ordre de 85% et la taille de première maturité sexuelle est de 23 mm. La fécondité relative moyenne est estimée à 8000 œufs /g. de poids corporel.

Les paramètres de croissance obtenus sont : L• = 65 à 70 mm avec K (par an) = 0.33 à 0.37 pour les femelles et L• = 35 à 40 mm avec K (par an) = 0.40 à 0.45 pour les mâles.

Parapenaeus longirostris (Lucas,1846) fréquente des profondeurs allant de 50 à 650 mètres. L'optimum d'abondance se situe entre 100 et 300 mètres. Cette espèce semble préférer des températures de l'ordre de 13,5°C sur des fonds de vase plus ou moins sableuse à *Funiculina quadrangularis* (Pallas, 1774) et Octocoralliaires (3). La taille moyenne des femelles est de 26mm; celle des mâles est de 24,5 mm.

La période de reproduction définie à partir de l'évolution des stades ovariens met en évidence trois périodes de ponte par an : printemps, été et automne. La taille de première maturité sexuelle est de 19 mm. Pour cette espèce, le sex-ratio est proche de 1.

Les paramètres de croissance obtenus sont L∞ = 44.35 mm avec K (par mois) = 0.0454 et to (en mois) = 0.629 pour les femelles et L∞ = 35.45 mm avec K = 0.0475 et to = -0.908 pour les mâles.

Ces résultats sont en accord avec ceux des différents travaux méditerranéens (notamment 4, 5, 6, 7, 8 et 9 pour *A. antennatus*). Tenant compte de la répartition bathymétrique, *P. longirostris* se trouve bien exploitée en Algérie, car elle se situe sur les zones de pêche les plus fréquentées (entre 200 et 400 mètres de profondeur). En dehors de ces zones, d'autres plus profondes et riches en *A. antennatus* restent inexploitées en raison de leur position éloignée (donc dangereuse en période de mauvais temps) et du manque de moyens (comme les longueurs de câbles limitées pour l'ensemble des chalutiers). Du point de vue exploitation, bien qu'en Algérie les rendements en crevettes (en moyenne de 20 Kg par heure de pêche) sont meilleurs que dans d'autres secteurs de la Méditerranée, il serait intéressant d'orienter l'effort de pêche sur ces zones profondes.

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FACIES CARACTERISTIQUES ET NATURE DU FOND DE *HELICOLENUS DACTYLOPTERUS DACTYLOPTERUS* (DELAROCHE,1809) DES CÖTES ALGERIENNES

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Résumé

Une synthèse de travaux antérieurs et d'observations personnelles a permis de déterminer les facies caractéristiques et la nature des fonds chalutables de différents secteurs algériens de la Méditerranée. La fréquence et l'abondance de *Helicolenus dactylopterus dactylopterus* sur ces fonds indiquent que cette espèce fréquente différents types de facies, et principalement les fonds à *Funiculina quadrangularis* et à *Isidella elongata*. Pour la nature du fond, *Helicolenus dactylopterus dactylopterus* présente une certaine préférence pour les fonds de vase très peu sableuse.

Mots-clés : Helicolenus dactylopterus, Ecology, Mediterranean Sea, Algeria

Introduction

En Algérie, nos résultats sur la répartition bathymétrique de la rascasse de fond *Helicolenus dactylopterus dactylopterus* (Delaroche, 1809) indiquent que ce poisson fréquente des fonds allant de 50 à 650 mètres, avec un optimum d'abondance entre 175 et 375 mètres. Cette répartition, déjà signalée par Dieuzeide *et al*. (1) et Siblot-Bouteflika (2) qui notent respectivement la fréquence de cette espèce sur les fonds chalutables entre 100 et 200 mètres ainsi qu'un maximum de prises entre 200 et 400 mètres, est en fait liée à la nature du fond et les facies caractéristiques.

L'analyse de la fréquence et de l'abondance de *Helicolenus dactylopterus dactylopterus* sur les fonds des différents secteurs algériens (3, 4, 5, 6, 7, 8 et 9) permet de mettre en évidence l'influence de ces facteurs écologiques.

Matériel et méthode

Les données utilisées proviennent de la campagne du navire océanographique *Thalassa* effectuée en 1982 sur les côtes algériennes et la méthode utilisée est identique à celle effectuée sur l'étude de *Parapenaeus longirostris* (Lucas, 1846) (10). Pour les secteurs où le nombre de stations est représentatif, la fréquence (en nombre de stations) et l'abondance (en nombre d'individus pêchés par heure) de *Helicolenus dactylopterus dactylopterus* sont indiqués par type de facies et la nature du fond est déterminée sur l'ensemble des stations qui correspondent à la répartition bathymétrique de l'espèce.

Résultats

L'étude a été effectuée pour les secteurs où le nombre de stations est représentatif : Ghazaouet-Beni Saf (Secteur I), Bou Ismail (Secteur II) et Annaba (Secteur III). Dans le Secteur I, les types de fonds sur lesquels les individus de *Helicolenus dactylopterus dactylopterus* ont été pêchés sont caractérisés par :

- les fonds de vase peu ou pas sableuse à Octocoralliaires et Annélides où *Helicolenus dactylopterus dactylopterus* n'a été capturée qu'en une seule station avec 40 individus / heure.
- les fonds à *Leptometra* et *Ophiotrix* sur lesquels 4 stations ont rapporté *Helicolenus dactylopterus dactylopterus* avec respectivement 40, 16, 8 et 4 individus.
- les fonds à *Funiculina quadrangularis* (Pallas, 1774) sur lesquels 12 stations ont rapporté *Helicolenus dactylopterus dactylopterus* (de 2 à 40 individus).
- les fonds à *Isidella elongata* (Esper, 1785) où *Helicolenus dactylopterus dactylopterus* a été capturée à 3 stations avec 27, 21 et 4 individus.

Pour le Secteur II, les mêmes types de fond se retrouvent que précédemment. Sur les fonds à Octocoralliaires, 2 stations ont ramené *Helicolenus dactylopterus dactylopterus* avec 44 et 6 individus. Cette espèce a été pêchée à 6 stations sur les fonds à *Funiculina* (de 1 à 12 individus) et à 5 stations (de 2 à 26 individus) sur les fonds à *Isidella*.

Dans le Secteur III, *Helicolenus dactylopterus dactylopterus* n'a pas éte pêchée sur les fonds à Octocoralliaires, cependant elle se rencontre en 6 stations (1 à 72 individus) sur les fonds de sable grossier du large mêlé de roches. Sur les fonds de vase profonde sableuse sa fréquence est de 2 stations (avec 7 et 15 individus) alors que sur les fonds à *Funiculina* et à *Isidella,* sa fréquence est respectivement de 6 stations (5 à 49 individus) et de 4 stations (1 à 20 individus).

La fréquence (valeurs en gras), ainsi que l'abondance (valeurs entre parenthèses) reportées par secteur et par type de fond (Tableau 1) indiquent que *Helicolenus dactylopterus dactylopterus* est présente sur différents types de faciès et principalement sur les fonds à de *Funiculina quadrangularis* et à *Isidella elongata*.

Pour la nature du fond, les résultats obtenus (Tableau 2) montrent que *Helicolenus dactylopterus dactylopterus* se trouve sur tous les fonds, sauf sur les fonds très durs, avec une certaine préférence pour les fonds de vase très peu sableuse.

Tableau 1 - Répartition de *Helicolenus dactylopterus dactylopterus* sur les différents faciès.

Type de faciès	a	b	c	d	e	f	Total
Ouest		**1** (40)	**4** (68)		**12** (134)	**3** (52)	**20** (294)
Centre		**2** (50)			**6** (27)	**5** (74)	**13** (151)
Est	**6** (100)			**2** (22)	**6** (123)	**4** (29)	**18** (274)
Total	**6** (100)	**3** (90)	**4** (68)	**2** (22)	**24** (284)	**12** (155)	**51** (719)

***a** : Sable grossier du large, **b** : Vase à octocoralliaires, vase détritique à alcyonaires,*
***c** : Détritique du large, Ophiotrix et Leptometra, **d** : Vase profonde sableuse,*
***e** : Vase profonde à Funiculina quadrangularis, **f** : Vase profonde à Isidella elongata*

Tableau 2 - Relation de *Helicolenus dactylopterus dactylopterus* avec la nature du fond

	SG	VS	VPS	VTPS	Total
Nombre de stations retenues (a)	7	19	17	63	106
Nombre de stations avec *H. d. dactylopterus* (b)	1	8	9	50	68
Nombre d'individus de *H. d. dactylopterus* (c)	1	92	70	866	1029
Effectif moyen de *H. d. dactylopterus* (c/b)	1	11.5	7.8	17.3	15.1
Fréquence de *H. d. dactylopterus* (b/a en %)	14.3	42.1	52.9	79.4	64.1

***SG** : Sable grossier, **VS** : Vase sableuse, **VPS** : Vase peu sableuse, **VTPS** : Vase très peu sableuse*

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THE STRIPED DOLPHINS, *STENELLA COERULEOALBA*, OF THE LIGURIAN PELAGIC SANCTUARY : MAIN BIOLOGICAL CHARACTERISTICS.

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Abstract

Stranding data (1986-1997) were used to assess the population parameters of *Stenella coeruleoalba* in the Ligurian Sea, in comparison with those regarding all Italian coasts. Sizes and growth characteristics resulted similar; male mortality appeared higher; density of population, in particular of young individuals, was remarkable in the Ligurian Sea.

Keywords : Stenella coeruleoalba, stranding, Ligurian Sea, population parameters

Introduction

The Ligurian Sea, the core of a future international Sanctuary (fig.1), represents an area densely populated by Cetaceans : *Stenella coeruleoalba* is the most abundant species, with a density of population estimated at 0.43-0.56 individuals/km^2 (1, 2), that is, in the figured study area (fig. 1), a total of about 16000 dolphins. Many field observations concerning this population are available, but the assessment of the main population parameters in the area is still lacking. In non-harvested populations, stranding is a precious source of information and its use, in Italy, was planned since the eighties. Our aim is to describe some biological parameters of the striped dolphin in the future Sanctuary on the basis of stranding data.

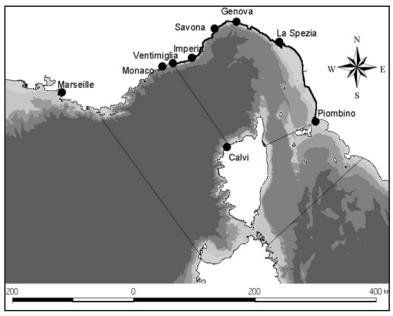

Figure 1. The Ligurian sanctuary and, in the middle, the study area.

Materials and methods

Since the eighties the Centro Studi Cetacei (Società Italiana di Scienze Naturali) established a network along the coasts of Italy to recovery stranded carcasses of Cetaceans for study; from 1986 annual reports are available (3). In the period 1986-1997, an average of about 65 *S. coeruleoalba* per year have been recorded in Italy and in the years 1990 and 1991 this figure raised to 106 and 329, due to a morbillivirus epizootic. In 12 years stranded dolphins were 1054; 908 measures of length without notation of uncertainty are available; 663 individuals were sexed and measured according to a more detailed protocol. More than 200 individuals were collected in our study area. Length was measured in a straight line from the tip of the lower jaw to the caudal notch. Frequency distributions of total length per sex were prepared for : 1) the total obtained on Italian shores; 2) the individuals collected on the Ligurian coast. Stranded specimens were classified as babies (up to 130cm TL), juveniles (131 - 179 cm TL) and adults (from 180cm TL onward).

Results and discussion

The Ligurian sample is composed of 197 individuals, 61 females, 91 males and 45 of unknown sex or imprecise measure (fig. 2a). This yields a male/female ratio of 1.5, with a clear dominance of males. Considering the total stranded along the Italian coast (N = 663), the sex ratio was 1.24. A more relevant mortality affecting males was also recorded in the French Mediterranean (male/female ratio = 1.21 in the GECEM reports) and on the coasts of Valencia (Catalonia) Balearic Islands (4) during the morbillivirus epizootic (1.13). Plotting the sex ratio against size, it was shown that males outnumber females from birth to the size of 210cm TL, where females prevail, given their longevity (5).

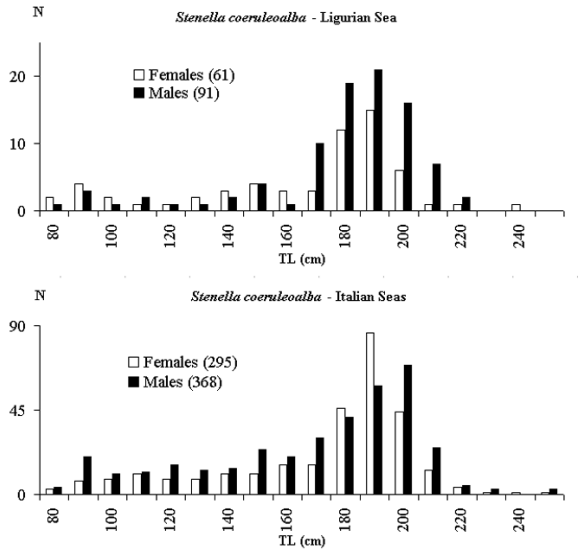

Figure 2. Size/frequency distributions of striped dolphins stranded along the Ligurian and Italian coasts

Why in the Ligurian area the male mortality is so important remains unknown. Probably when a danger occurs, males are more exposed, to protect the weaker members of the group. The Ligurian sample include those years (1986-1990) in which several instances of killing of marine mammals were recorded in relation to the swordfish fishery by gillnets.

The size composition of the two groups of striped dolphins presented in fig.2 is remarkably similar. A main gaussian group occurs on the right side : these are the adult individuals, with a mode, in the largest sample, at 190cm TL in females and at 200 cm TL in males, a sexual dimorphism typical of those mammalian species in which the male has a defensive role. A small gaussian group occurs on the left at 90cm TL : this point represents the neonatal mortality. A second small mode can be appreciated at 150cm TL. According to the growth models proposed for the Mediterranean, this size corresponds to age 2 (6,5), or to age 3 (7). Therefore it could represent the end of the lactating period or simply the end of the link between the juvenile dolphin and the adults and their protection.

In the Ligurian sample adult females are represented with the same size recorded along the total Italian shores. On the contrary the largest males (200cm TL) are under-represented. The prevalence of young adult males in respect of full grown individuals, suggest the possibility that the rich trophic area of the Ligurian Sea is preferentially left to females and young individuals. In any case the growth model proposed for Italian waters (5) appears to be acceptable for the Ligurian Sea : it is

Males : $L(t) = 200-[(200-90)\ e^{(-0.375\ t)}]$;
Females : $L(t) = 190-[(190-90)\ e^{(-0.430\ t)}]$

In the total measured stranded dolphins (N = 908), 171 individuals were babies and 221 juveniles. The 19% of both these young individuals were found in our study area. If the stranding events would have been evenly distributed the Ligurian coast would have produced, in respect of the total Italian coasts, the 4.5% of stranding. Of course, the causes of such concentration can be of different origin (oceanographical, biological or related to human activities, including the intensity of monitoring the shore). A combination of causes can be also hypothesised. Only during spring the Ligurian percentage of babies (Table 1) is close to that expected. During summer it becomes three times more important, suggesting that the Ligurian Sea is an important calving ground. Newborn babies were collected from July to October, with a maximum during August, in coincidence with the highest annual surface temperatures. The calving period results therefore anticipated in respect to the Spanish coast, where the maximum of births (95%) was located in October (8).

Table 1. Ligurian records of stranded *S. coeruleoalba* as percentage of total Italian records.

	SPRING	SUMMER	FALL	WINTER
Total in Italy (N)	*213*	*406*	*139*	*160*
Ligurian babies (%)	4.9	15.6	50.0	33.3
Ligurian juveniles (%)	14.1	10.1	36.0	38.9
Ligurian adults (%)	20.8	21.3	34.8	22.5

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AGE ET CROISSANCE DE *SYMPHODUS* (*CRENILABRUS*) *CINEREUS* (BONNATERRE, 1788) DES COTES DE LA REGION DU GOLFE DE GABES (TUNISIE)

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Résumé

Dans ce travail, nous avons étudié par scalimétrie l'âge et la croissance du Crénilabre cendré *Symphodus* (*Crénilabrus*) *cinereus* des côtes de la région du golfe de Gabès. A cet effet, les équations relatives à la croissance linéaire ont eté établies ainsi que les relations taille-masse.

Mots-clès : Teleostei, growth, Gulf of Gabes.

Introduction

Le Crénilabre cendré *Symphodus* (*Crénilabrus*) *cinereus* khodhir est un poisson Labridé présent en Tunisie et notamment dans la région du golfe de Gabès (1). Dans cette zone, il est classé parmi les poissons très rares, capturés occasionnellement et essentiellement au printemps, surtout par le "Kiss" à Sidi Mansour et "Chrafi" (pluriel de charfia) dans les îles Kerkennah. La biologie de cette espèce n'a pas été étudiée, à notre connaissance, dans la région. Dans ce travail, nous présentons l'étude relative à l'âge et la croissance de cette espèce.

Matériel et méthodes

L'étude étalée sur huit ans environ a porté sur 375 individus dont la longueur totale est comprise entre 69 et 136 mm. Pour chaque poisson nous avons relevé la longueur totale (Lt) en millimètre, les masses du poisson entier (Mp) et éviscéré (Mev) en gramme. Nous avons en outre prélevé, sous la nageoire pectorale, et préservé les écailles. Pour chaque individu, nous avons retenu en moyenne huit écailles. Après nettoyage et montage entre deux lames, la lecture a été effectuée à la loupe binoculaire munie d'un micromètre oculaire. 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 différentes stries d'arrêt de croissance. Nous avons supposé que l'apparition de la première strie d'arrêt de croissance se situe à 12 mois. 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 : ($Lt = a R^b$) pour les deux sexes séparés. A partir de cette équation, et par la méthode de rétro calcul, 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 (3) à ces données de longueurs par âge dont l'équation s'écrit de la façon suivante : $Lt = L\infty(1 - e^{-K (t - to)})$. Lt : longueur du poisson à l'instant t ; L∞ : Longueur asymptotique correspondant à un taux de croissance nul ; K : constante de vitesse de la croissance et t_o : l'âge théorique auquel la longueur est nulle.

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 (2). Nous avons également établi les relations liant la masse du poisson entier et la masse du poisson éviscéré à la longueur totale du poisson ($M = a L^b$).

Résultats et discussion

Croissance linéaire

La lecture des écailles du *S* (*C*). *cinereus* nous a permis de calculer les paramètres de croissance linéaire et de dresser les courbes de croissance de cette espèce (Fig 1(a,b)). Cette croissance a été ainsi étudiée à base des tailles moyennes par âge. nous constatons que la limite d'âge chez les mâles de *S* (*C*). *cinereus* des côtes de la région du golfe de Gabès est de 6 ans alors que celle des femelles est de 5 ans. Le tableau.1 montre que la relation entre la longueur du poisson et le rayon de l'écaille est assez bonne. Les valeurs des longueurs totales théoriques en fonction de l'âge sont très proches de celles déterminées par le calcul rétrospectif (Tabl.2) le modèle de Von Bertalanffy s'applique bien à la croissance de *S* (*C*). *cinereus*. Le calcul des paramètres de l'équation de Von Bertalanffy conduit aux expressions suivantes :

femelles : $Lt=116,4 (1 - e^{- 0,4488 (t +0,5887)})$;
mâles : $Lt= 140,7(1 - e^{- 0,2647 (t + to1,371)})$;

Tableau 1. Relation entre la longueur totale (Lt) et le rayon de l'écaille (R) chez *S* (*C*). *cinereus*.

($Lt = a R^b$) femelles	Effectif	r	($Lt = a R^b$) mâles	Effectif	r
$Lt = 37,834R^{0,8052}$	70	0,89	$Lt = 43,180R^{0,7335}$	305	0,89

Tableau 2. Tailles (Lt en mm) calculées par scalimétrie et par application du modèle de Von Bertalanffy, en fonction de l'âge de *S* (*C*). *cinereus*.

Age (ans)	1	2	3	4	5	6
Lt.Scalimétrie (femelles)	59	81	93	100	108	
Lt.Von Bertalanffy (femelles)	59,352	79,986	93,159	101,568	106,936	
Lt.Scalimétrie (mâles)	65	84	97	106	113	122
Lt. Von Bertalanffy (mâles)	65,561	83,025	96,714	106,714	114,608	120,666

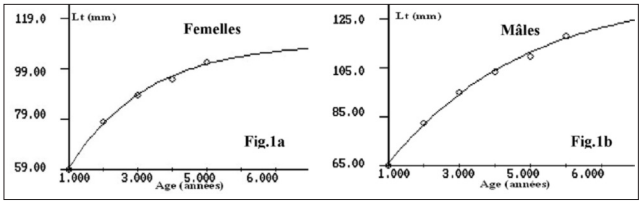

Fig. 1 (a,b) : Croissance linéaire chez *S* (*C*). *cinereus* des côtes du golfe de Gabès (modèle de Von Bertalanffy).

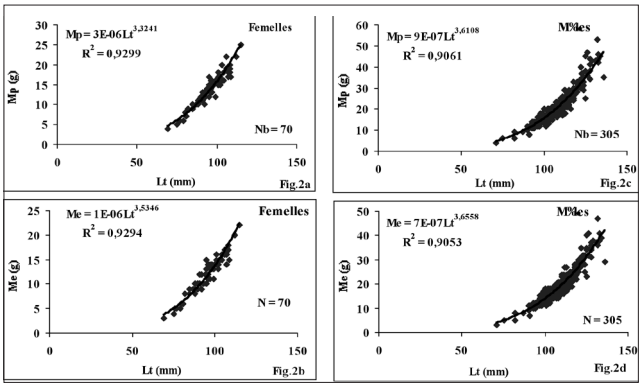

Fig. 2 (a,b,c,d) : Relation taille-masse chez *S* (*C*). *cinereus* des côtes du golfe de Gabès

Croissance massique

Les relations taille-masse de l'animal plein et éviscéré sont représentées graphiquement par le figure. 2 (a, b ,c, d). Nous constatons une bonne corrélation entre la longueur totale du poisson et sa masse pleine et éviscérée (r* 1).

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DOLPHIN BYCATCH IN THE SWORDFISH DRIFTNET FISHERY IN THE AEGEAN SEA

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Abstract

Dolphin bycatch in the swordfish driftnet fishery was examined in the Aegean Sea coast of Turkey, in May and June, 1999 and 2000. In 1999, total 10 bycatches were examined, which were *Stenella coeruleoalba* (7 individuals), *Tursiops truncatus* (2) , *Grampus griseus* (1). In 2000, total 9 bycatches were examined, which were *S. coeruleoalba* (6), *T. truncatus* (2) and *G. griseus* (1).

Keywords : Cetacea, Conservation, Aegean Sea

Introduction

The swordfish is one of the commercially important fish species in the Turkish waters. It is caught by longlines, gill nets and harpoons (1). Tokac et al. (2) studied the swordfish fishery in the North Aegean Sea, but did not give information on the driftnets. At present, some 50-60 fishing vessels are known to use driftnets for swordfish in the Turkish Aegean Sea.

Dolphins are considered as globally threatened species in spite of some national and international protection measures. In the Mediterranean, one of the threats is the driftnet due to its non-selectivity, i.e. it entangles any species which are larger than the mesh size (3, 4). In the Aegean Sea, the swordfish driftnet fishery is a relatively new problem for cetaceans and very little studied (5, 6). Thus the aim of our study is to collect basic data and accurate information on the swordfish driftnet fishery and dolphin bycatches in the Turkish Aegean Sea, so that more effective protection measures can be implemented.

Materials and Methods

Monitoring of the bycatch was made on five vessels of 9-14 m in length, in May and June, 1999 and 2000, in the Aegean Sea coast of Turkey, between Marmaris and Fethiye (Fig. 1). The details of fishing trips were recorded and all the bycatches were examined for species, sex and body length.

Fig.1. The study area for the swordfish driftnet fishery in the Turkish coast of the Aegean Sea

Results and Discussion

Driftnets are set at 18-20 hrs and retrieved at 4-5 hrs in the next morning. The fishing season lasts only two months, May and June. Mesh size of the driftnet used for the swordfish is 240-260 mm and the net is made of nylon polyfilament. The total length of the net is 1000 -1500 m on average and the depth is 4 m. In both 1999 and 2000, 20 boats were counted as operating swordfish driftnet fishery in Fethiye - Marmaris area. The fishing areas were 300- 2500 m deep and 5-9 nmiles from the coasts. The driftnet is set in the depth of 6-7 m in general.

Table 1 shows the list of dolphins incidentally caught by the swordfish driftnet. In 1999 and 2000, 10 and 9 dolphins were caught, respectively.

Table 1. The species, sex, and body length (BL) of the dolphins incidentally caught in the swordfish driftnets in the Agean Sea.

Year	Species	Sex	BL (cm)
1999	*Stenella coeruleoalba*	Male	103
	Stenella coeruleoalba	Female	140
	Stenella coeruleoalba	Male	173
	Stenella coeruleoalba	Male	-
	Stenella coeruleoalba	Female	-
	Stenella coeruleoalba	Male	-
	Stenella coeruleoalba	Female	-
	Tursiops truncatus	Male	210
	Tursiops truncatus	Unknown	-
	Grampus griseus	Female	300
2000	*Stenella coeruleoalba*	Male	150
	Stenella coeruleoalba	Unknown	-
	Stenella coeruleoalba	Female	200
	Stenella coeruleoalba	Male	150
	Stenella coeruleoalba	Unknown	-
	Stenella coeruleoalba	Female	180
	Tursiops truncatus	Female	220
	Tursiops truncatus	Unknown	-
	Grampus griseus	Male	250

These data showed that *S. coeruleoalba, T. truncatus* and *G. griseus* were bycatch dolphin species in the swordfish driftnet fishery and *S. coeruleoalba* was the most influenced species of all. These three species are shown as being under the impact of driftnet fishery in the Mediterranean (4). Our result also reflects the fact that the most common species in the Mediterranean is *S. coeruleoalba* (4). Due to our small sample size, we cannot discuss neither sex nor body length of the bycatch animals.

This is the first and basic study on the bycatch of the swordfish driftnet fishery and we understood that there was a considerable threat for dolphins in the Turkish Agean Sea coast, although dolphins are under the legal protection and no direct catch is permitted in Turkey. Therefore, special protection measures should be prepared, for example, an education program for fishermen for rescue and release live animals from the net. As banned in the Barcelona Convention, large-scale driftnets exceeding 2.5 km should be forbidden and appropriate measures should be taken by the relevant authorities.

Acknowledgement

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CUTTLEFISH TRAMMEL NET 'METIER' IN GREECE

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Abstract
The cuttlefish metier was studied in Greek waters with observations on a professional vessel during 1996-1997. Trammel nets with mesh size of 60 mm in the inner net and of 240 in the outer net were used. Cuttlefish composed 31% by number and weight of the catch. *Symphodus tinca* was the dominant by catch species (32% by number and 23% by weight). Cuttlefish presented the highest mean CPUE (4 Kg/100 fathoms of netting) with ML ranging from 85 to 235 mm. Most cuttlefish were entangled in the middle part of the net. The commercial/total catch ratio was about 0.80 by number and weight in 1996 and 0.48 by number and 0.62 by weight in 1997.

Keywords : cuttlefish, trammel nets, Greek waters

Material and methods

In the framework of the project "Selectivity of fixed gears in Mediterranean" the *Sepia officinalis* (cuttlefish) 'metier' has been studied in Greek waters. Sampling took place during April 1996 and April 1997 on a professional small scale fishery vessel in Patraikos Gulf. The duration of each mission was one week and 17 stations were sampled. The depth of the stations ranged from 2 to 12 m. A trammel net with nominal mesh size of the inner net 60 mm and nominal mesh size of the outer net 240 mm was used (full mesh). The twine of the inner net was multifilament PA 210/2 and of the outer net was multifilament PA 210/4. The height of the net was 2.5 m. The fishing practice consisted on setting the nets on the bottom 2 hours before sunset and hauling them 2 hours after sunrise (soaking time about 17.5 hours). The Catch Per Unit of Effort is expressed as number or weight of the catch per 1000 fathoms of netting.

Results

A total of 1794 specimens were caught belonging to 45 species. *Sepia officinalis* composed 30.85% or 31.15% of the total catch in terms of numbers and weight respectively (Fig. 1). Dominant by catch species was *Symphodus tinca* which composed 31.99% by number and 22.77% by weight of the catch. Other important species were *Scorpaena porcus* in terms of number (9.85%) and *Octopus vulgaris* in terms of weight (11.59%).

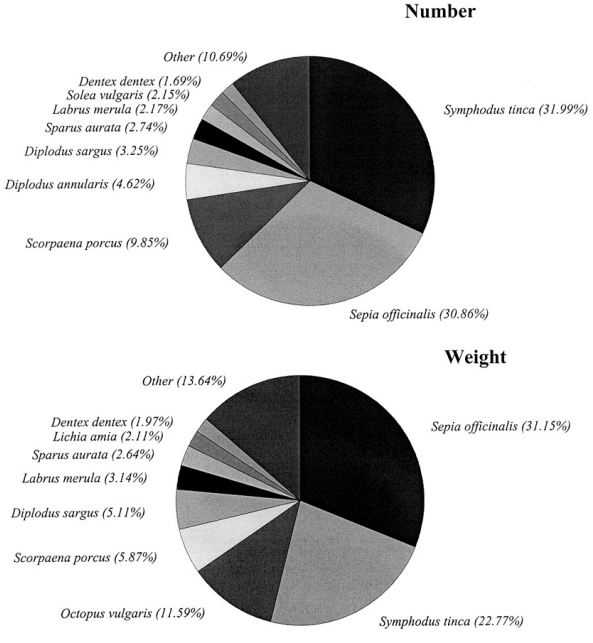

Fig. 1. Combined catch composition in cuttlefish metier (Patraikos Gulf 96-97).

Cuttlefish, *S. tinca* and *S. porcus* were caught in all stations, whereas *O. vulgaris* presented a frequency of occurrence of 64.7% (Table 1). Cuttlefish presented the highest mean CPUE by weight (4.11 Kg/1000 fathoms), while by number, it ranged second (22 specimens/1000 fathoms) with a small difference from *S. tinca* coming first (23 specimens/1000 fathoms).

The lengths of cuttlefish ranged from 85 to 235 mm (ML) in 1996 and form from 85 to 205 mm in 1997. In both years, the mode appeared at 105 mm (Fig. 2). The lengths of *S. tinca* ranged between 175 and 265 mm (mode at 215 mm) and between 115 and 285 mm (mode at 205 mm) in 1997.

Table 1. Mean CPUE (number and Kg per 1000 fathoms of netting) and frequency of occurrence of main species in cuttlefish metier. Numbers in parentheses show the Standard Deviations.

Species	By Number	By Weight	Occurrence (%)
Sepia officinalis	22.27 (18.50)	4.11 (3.16)	100
Symphodus tinca	23.08 !21.05)	3.00 (2.51)	100
Scorpaena porcus	7.11 (6.90)	0.77 (0.65)	100
Octopus vulgaris	0.94 (0.85)	1.53 (1.52)	64.7
Total catch	72.16 (24.41)	13.19 (4.48)	

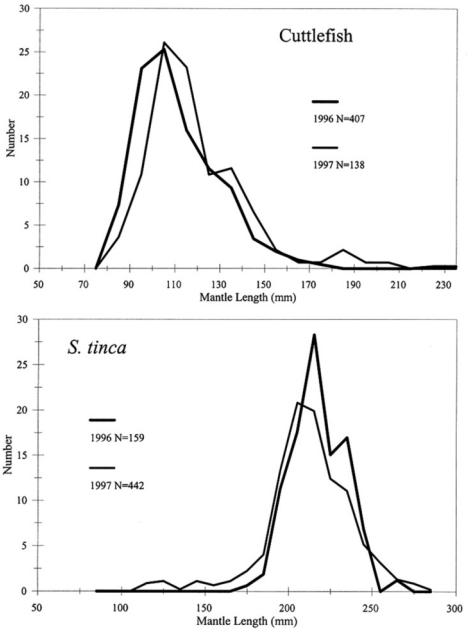

Fig. 2. Length frequency distribution of the two more abundant species in the cuttlefish metier.

The commercial/total catch ratio in 1996 was high both in terms of number and of weight (0.79 and 0.82 respectively), but in 1997 it was lower (0.48 and 0.62 respectively). The difference between the two years was due to the decrease of the catch of cuttlefish and to the increase of that of S. tinca during the second year.

In the middle part of the panel of the net, 100% of cuttlefish, 90% of *S. tinca* and 28% of *S. porcus* were caught, whereas in the lower part, 10% of *S. tinca* and 72% of *S. porcus*. Cuttlefish and *S. porcus* were mainly caught entangled (97% and 71%, respectively) whereas *S. tinca* gilled (71%).

Discussion

Cuttlefish metier can be considered species selective since the 5 more abundant species composed about 80% in terms of number and weight of the total catch. Moreover the marketable part of the catch composed a high proportion comparing with bottom trawl fishing (1), whereas it was similar to the sole trammel net metier and hake gill net metier (2). The main non commercial species was *S. tinca* which was mainly caught gilled opposing to cuttlefish that was caught entangled. Subsequently, the discarded part could be reduced, without important losses in the commercial part, by a small increase of the mesh size.

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TROPHIC INTERACTIONS AMONG GROUPER (*EPINEPHELUS MARGINATUS*), OCTOPUS (*OCTOPUS VULGARIS*) AND RED LOBSTER (*PALINURUS ELEPHAS*) IN THE WESTERN MEDITERRANEAN

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Abstract

In the present paper a first evaluation of the trophic interactions between grouper, octopus and spiny red lobster in the western Mediterranean is presented. The efficiency of octopus preying on lobsters is also estimated from trap catches. Grouper and octopus base their diet on the same major taxonomic groups and this is reflected in the values of diet overlap. Trophic diversity of grouper and octopus is also very similar. The estimation of the octopus efficiency preying on lobsters shows that 23.5% of the attacks are successful.

Keywords : diet composition, trophic diversity, diet overlap, predation efficiency

Introduction

Long-line fishermen know that octopus makes a good bait for catching groupers, and the prevalence of this prey in the diet of groupers has been corroborated by scientific works. Fishermen also know that octopuses are active predators of lobsters because they produce damages in the fisheries for this crustacean. Thus, grouper (*Epinephelus marginatus*), octopus (*Octopus vulgaris*) and spiny red lobster (*Palinurus elephas*), all three species of high commercial interest, interact closely in the food webs of the continental shelf. The main objective of this work was to carry out a first assessment of the trophic interactions between the three species. To this end, diet composition, diet overlap, trophic diversity and predator-prey size relationships were analysed. The efficiency of a predator in catching its prey is an important input in the Lotka-Volterra predator-prey model but it is a difficult parameter to estimate in field studies. From a set of predator attacks to its prey, this parameter tells us the probability of capture. An additional objective of this work was to estimate the efficiency of octopus preying on lobsters from trap catches.

Materials and methods

Groupers were caught by commercial long-lines off the Balearic Islands, while octopuses and lobsters were collected in trap surveys conducted in the Columbretes Islands Marine Reserve, both in the north-western Mediterranean. All specimens were measured [grouper: total length (TL, cm); octopus : mantle length (ML, cm); lobster : carapace length (CL, cm)] and their stomach contents were analysed to the lowest possible taxonomic level.

To study diet composition and overlap, the following indices were used: A) Occurrence Index (OCI) : the ratio between the number of stomachs with one type of prey and the total number of stomachs with food, each stomach being counted as many times as the different type of prey it contained; B) Trophic diversity, using the Shannon-Weaver index (H´)[1]; C) Diet overlap, using Schoener's similarity index (C)[2], calculated by prey species and also by major taxonomic groups. Inputs to this analysis were preys that contributed 2% or more in terms of OCI. Following Langton [3]: C=0–0.29 (low overlap), C=0.3–0.59 (moderate overlap), and C>0.6 (high overlap).

The relationship between predator size and prey size was determined for grouper versus octopus and for octopus versus lobster. The size of octopuses preyed by groupers was calculated from the beaks present in the stomachs [4], while the size of the lobsters preyed by octopuses was obtained from dead individuals found in the traps.

The octopus predation efficiency on lobsters was calculated by the nº of dead lobsters/nº of interactions x 100. Interactions were defined as hauls where octopus and lobster (alive and/or dead) appeared plus hauls where dead-emptied lobster but not the octopus were found (the predator abandoned the trap after eating the prey).

Results and discussion

The diet composition by major taxonomic groups of the three species is in Fig. 1. Lobster diet consists mainly on molluscs (gastropods and bivalves) and sea urchins. Grouper and octopus share a preference for osteichthyes and brachiurids, although groupers also consume large quantities of cephalopods, mainly octopus (OCI=12%). Lobster OCI in grouper diet was low (1%).

Trophic diversity indices (H´) of grouper and octopus were very similar, 1.30 and 1.28 respectively, while that of lobster was slightly higher, 1.44. However, the diversity indices of grouper and octopus were underestimated because fishes are the most important prey in both predators and their determination at the species level in stomach samples is very difficult.

Similarity of grouper and octopus diets is reflected in the values of their diet overlap index. On the basis of the major taxonomic groups presented above, the degree of overlap appears to be high (0.79), but decreases to moderate (0.42) when overlap is examined at the species level. This is due to the fact that, although they prey on the same zoological groups, they do not consume the same species. Grouper-lobster and octopus-lobster diet overlap were low, both at the level of major groups (grouper-lobster : 0.29; octopus-lobster : 0.27) and at the species level (grouper-lobster : 0.14; octopus-lobster : 0.20).

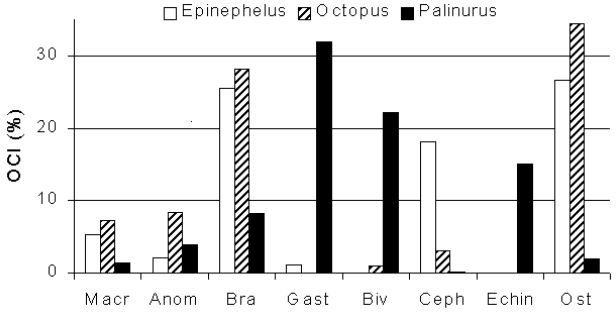

Figure 1. Diet composition of *E. marginatus*, *O. vulgaris* and *P.elephas* expressed in Occurrence Index (OCI) of major taxonomic groups. Major groups are Macrura, Anomura, Brachiura, Gastropoda, Bivalvia, Cephalopoda, Echinoidea and Osteichthya.

The estimated efficiency of octopus predation on lobster was 23.5%. This value probably overestimates predation efficiency in natural conditions, because a lobster's capacity to refuse the attack of an octopus is presumably higher in a natural cave than in a trap. This is presented as a first estimation as it provides an approximation to the efficiency that occurs in nature.

Predator-prey size relationships are in Fig. 2. In general, the larger the grouper the larger the octopus consumed although middle sized groupers may also eat large octopuses. The octopus-lobster size relationship shows the same tendency of increasing size of prey with size of predator. It also appears that while small octopuses do not prey on large lobsters, larger octopuses do not reject small lobsters.

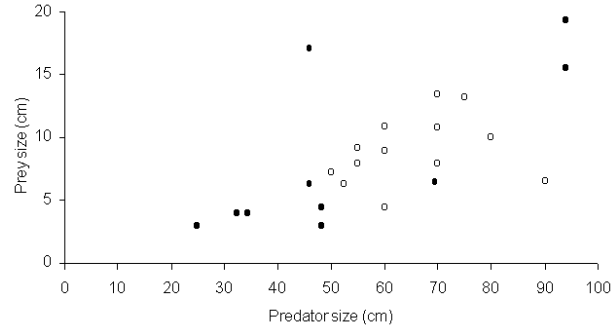

Figure 2. Relationships between predator size and prey size. Black circles are *E. marginatus versus O. vulgaris*. Open circles are *O. vulgaris versus P. elephas*; here *O.vulgaris* sizes were multiplied by 5.

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METHODOLOGICAL, BIOLOGICAL AND ENVIRONMENTAL FACTORS AFFECTING THE DEPM PARAMETERS VARIABILITY IN THE MEDITERRANEAN ANCHOVY

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Abstract

Methodological, biological and environmental factors affecting the DEPM egg and adult parameter estimates in the Sicilian Channel in 1998 and 1999 are identified, analyzed and compared with other Mediterranean regions. The Sicilian Channel anchovy population represents a discrete stock highly influenced by the hydrological/climatic regime prevailing in the area and the oligotrophic nature of its waters. These environmental conditions affect its reproductive potential as shown by the batch fecundity, spawning fraction and daily egg production estimates that represent the lowest found in the Mediterranean.

Keywords : Pelagic, Fishes, Reproduction, Sicilian Channel

The DEPM has been used to evaluate the anchovy spawning biomass of the Catalan sea in 1990 (1), Catalan Sea-Gulf of Lions in 1993 and 1994 (2), Ligurian-North Tyrrhenian seas in 1993 (2), North Aegean sea in 1993 (3 and 4), south-western Adriatic sea in 1994 (5), and Sicilian Channel in 1998 and 1999 (6). This communication aims to compare these estimates, identifying and analysing the factors affecting the DEPM parameters.

Material and methods

The DEPM methodology applied in the Sicilian Channel is detailed in (7). Bibliography provided the methodology and the DEPM parameters estimates of the other Mediterranean regions (Table 1).

Results and discussion

The daily egg production of the Sicilian Channel was the lowest observed. Only the SW Adriatic exhibit similar values while the other regions present greater estimates. Different methodologies can partially explain it. In the Aegean Sea, where exceptionally greater estimates were found, oblique Bongo tows were done instead of vertical CalVET tows, and the spawning area was not entirely covered. Besides, different temperatures approaches were used to assign ages to eggs in different regions (sub-surface T^a in the Aegean Sea, mean T^a of the first 20 m or 10 m in the Catalan Sea and Sicilian Channel respectively).Despite methodological differences, the Sicilian Channel stock is the less egg productive among the analysed areas : A_1 is the smallest, P and P_1 are the lowest and Z is the highest. Inter-annual variations in the Sicilian Channel are also clear. In 1998 a more expanded spawning area and also a higher egg density occurred, indicating a dramatic decline in spawning intensity caused by environmental and/or biological changes. Differences in adult parameters could also be attributable to methodology. Different fish sampling gears were used, and the adult sampling in the Aegean and Catalan Sea was done with commercial fishing vessels restricting the sampling to commercial fishing grounds. *W* in the Sicilian Channel was similar to the Catalan Sea, Catalan Sea-Gulf of Lions (93) and Ligurian-Thyrrenian Sea. The other estimates showed greater values indicating the regional, inter-seasonal and inter-annual variation in the size/age structure of this Mediterranean resource. *F* is strongly correlated with *W*. Catalan Sea shows greater *F* values than other regions with similar *W* due to methodological differences. *F* is calculated through the Hydrated Oocyte Method (8), but in the Catalan Sea it followed (9). More striking differences not related with the methodology exist. At similar weights, *F* is much greater in the Aegean Sea than in the Catalan Sea-Gulf of Lions (94), but similar to the Adriatic Sea where *W* was lower. *RF* comparison suggests that *F* differences could be attributable to intra-seasonal or/and inter-annual variations, but also to fecundity differences among the Mediterranean anchovy stocks. In relation to the Sicilian Channel, *RF* increased 30% in 1999. Although *W* was 1g lower in 1999, *F* increased in ± 1000 eggs/batch.

R estimates were quite consistent over time and space.

S estimates in the Sicilian Channel showed the greatest variation in comparison to the rest of the Mediterranean areas.

Anchovy females who are actively spawning are more vulnerable to trawl capture causing an oversampling of day-0 females. Since day-1 and day-2 females were utilised to estimate *S* in the Sicilian Channel, these low S cannot be attributed to this spawning behaviour. *S* (as *F*) increases with size and age (10), but this does not explain the low *S* estimates in the Sicilian Channel since other Mediterranean regions with similar population structure showed much greater *S* estimates.

S tends to 0 as the population moves farther from the peak of spawning. The gonad-somatic index evolutions in the Sicilian Channel indicate that the DEPM samplings were done within the peak spawning. One of the most precise methods of determining the end of the spawning period is analysing the degree of atresia. In 1998 the incidence of atretic females was unusually high in some of the first samples, reaching 37.5%. If this atresia was indicative of the end of the spawning period, it could be expected that it increased with time. However, no specimens showed atresia in the subsequent 10 hauls. Therefore, this atresia does not indicate the end of the peak spawning period but the end of the spawning activity of a fraction of this population. In 1999 a substantial amount of inactive females were observed, but not atresia.

If feeding resources are scarce during the spawning period, anchovies can react reabsorbing the oocytes (atresia), prolonging the intervals between spawning and even becoming inactive (11). The Sicilian Channel waters are of oligotrophic nature and the environment is subject to drastic changes in short time periods. The high degree of atretic stages in 1998, the amount of inactive females in 1999, and the low S estimates can be related to these particular conditions. These features can also affect *F* and *P*, that are lower than in the other Mediterranean regions analysed.

The inter-annual variation in the Sicilian Channel can be attributable to environmental variability, mainly wind regime, which drives the intensity of upwelling. The great decrease of the anchovy population from 1998 to 1999 could also cause lower competition and a greater feeding availability resulting in the higher reproductive potential observed in 1999 (higher values of *F* and *S* with lower *W*).

Table 1. DEPM egg and adult parameter estimates from different Mediterranean regions.

		Egg Parameters						*Adult Parameters*						
		T^a	*A*	A_1	P_1	*P*	*Z*	P_t	*F*	*S*	*W*	*R*	*RF*	*DSF*	*SF*	*B*
	Jun-Jul	18.5	13295	5329	65.55	26.27	1.63	0.14	4835	0.14	15.18	0.59	319	26	7	13224
SICILIAN	1998	22.5			(0.21)	(0.33)	(0.33)	(0.33)	(0.16)	(0.12)	(0.06)	(0.12)				(0.22)
CHANNEL	Jun	18.4	1318	769	43.62	25.44	2.06	0.02	5871	0.17	14.08	0.55	416	39	6	853
	1999	22.7			(0.21)	(0.27)	(0.23)	(0.27)	(0.11)	(0.10)	(0.07)	(0.10)				(0.25)
	May	17.6	17081	8095	120.61	57.16	0.56	0.46	8006	0.36	14.25	0.54	562	110	3	4199
CATALAN	1990	19.6			(0.15)	(0.29)	(0.44)	(0.22)	(0.02)	(0.10)	(0.04)	(0.09)				(0.28)
SEA	Jul								7283	0.31	12.79	0.56	569	99	3	
	1990								(0.12)	(0.16)	(0.10)	(0.10)				
	July	13.3	44554	33012	86.67	64.22	1.09	2.12	4958	0.31	14.31	0.64	346	69	3	30849
CATALAN SEA	1993	22.5			(0.15)	(0.17)	(0.26)	(0.17)	(0.11)	(0.13)	(0.07)	(0.05)				(0.30)
GULF OF LIONS	May-Jun		42085	31692	81.71	61.53	0.47	1.95	7039	0.21	22.92	0.59	307	38	5	52557
	1994				(0.18)	(0.21)	(0.26)	(0.21)	(0.02)	(0.20)	(0.06)	(0.19)				(0.36)
LIGURIAN AND	July	18.9	15424	8221	93.57	49.87	0.86	0.41	4894	0.32	14.17	0.63	345	70	3	5829
TYRRHENIAN	1993	22.5			(0.28)	(0.32)	(0.34)	(0.32)	(0.10)	(0.11)	(0.07)	(0.05)				(0.36)
AEGEAN SEA	Jun	16.7	17396	17396	259.49	259.49	1.04	4.51	11542	0.28	22.73	0.55	508	78	4	58988
	1993	25.0			(0.32)	(0.32)	(0.46)	(0.32)	(0.04)	(0.15)	(0.02)	(0.04)				(0.35)
SW ADRIATIC	Jul-Aug		14790	9244	50.11	31.32	0.55	0.29	11866	0.16	18.57	0.55	639	56	6	8129
	1994				(0.16)	(0.10)	(0.12)	(0.10)	(0.03)	(0.08)	(0.03)	(0.05)				(0.24)

T^a, temperature range (°C) registered in the positive stratum (spawning area).
A, total survey area (km²) registered in the whole sampled area
F, batch fecundity
P_t, daily egg production per m²
P, daily egg production per m² standardized to 1 hour
S, spawning fraction

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DAILY EGG PRODUCTION METHOD FOR ESTIMATING SICILIAN CHANNEL ANCHOVY SPAWNING BIOMASS IN 1998 AND 1999

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Abstract

Daily Egg Production Method (DEPM) was carried out to estimate the spawning biomass of the Sicilian Channel anchovy (*Engraulis encrasicolus*) in 1998 and 1999. The spawning biomass suffered a drastic decline from 13224 TM in 1998 to 853 TM in 1999 evidenced by a great reduction of the positive stratum from 5329 to 769 km2, and the decrease of egg abundance over this stratum from 65.5 to 43.62 eggs/m2. The adult population, however, showed a greater reproductive potential in 1999; batch fecundity increased from 4835 to 5871 eggs/batch and spawning fraction from 0.14 to 0.17.

Key-words: Pelagic, Fishes, Spawning, Biomass, Sicilian Channel

Introduction

Since its first application to the mediterranean anchovy, *Engraulis encrasicolus*, of the Catalan Sea in 1990 (1), the DEPM has been used in the Mediterranean to evaluate the anchovy spawning biomass of the Catalan Sea, Gulf of Lions and Ligurian-North Tyrrhenian seas (2), North Aegean sea (3 and 4) and South-Western Adriatic sea (5). This communication presents the results of the DEPM spawning biomass estimates of the Sicilian Channel anchovy in 1998 and 1999 within the framework of the EU DG-XIV financed projects MED-96-052 and MED-98-070.

Material and methods

Egg surveys (Fig.1) were carried out between June 23-July 24 1998 (BANSIC-0698) and June 19-June 25 1999 (BANSIC-0699). Surveys were designed to include the full range of anchovy spawn following a 4x4 NM track basic stations scheme. Plankton sampling took place on a 24 hour-a-day basis, using a 25 cm diameter CalVET net (150μ mesh) retrieved vertically from a depth of 100 m at 1 m/s. Temperature and salinity with depth from CTD probe were obtained in each station. Plankton samples were analysed on board to observe the eggs presence/absence and fixed and conserved in at 5% buffered formalin. Adult surveys (Fig. 2) were combined spatially and temporally with egg surveys: ANCHEVA-0698 during June 19 to June 25 1998 and ANCHEVA-0699 between June 6-June 17 1999. Judgment sampling with a semi-pelagic trawl, according to echogram registers, was accomplished. Hauls ranged from 06:00 to 24:00 GMT intensified between 19:00 and 24:00 to collect hydrated females. Fifty randomly selected individuals per haul were sampled. When hydrated females appeared, extra sampling was done to obtain the highest possible number of these per length class. All the ovaries were fitted in buffered formaldehyde (4%) in the first two hours after death.The spawning biomass estimate is based on Stauffer and Picquelle's equation (6),

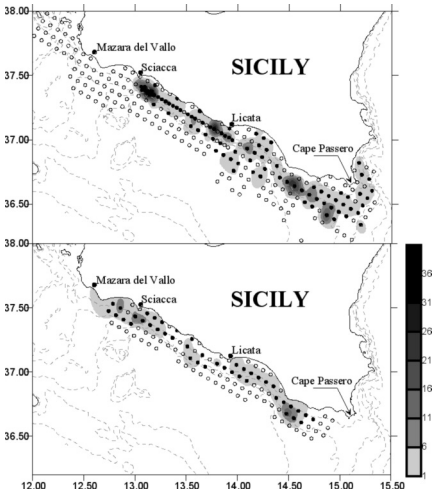

Figure 1. DEPM egg surveys showing anchovy egg distribution and abundance (eggs/0.1m2) interpoled by Kriging Method. (,) Positive stations. (+) Negative stations .

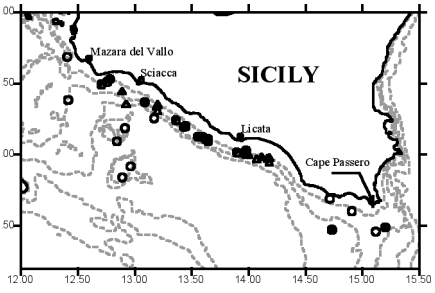

Figure 2. DEPM adult surveys with positive (bold) and negative (light) hauls for anchovy.

$$B = k \cdot A\,(P \cdot W) / (R \cdot F \cdot S)$$

where, B = spawning biomass (metric tons), k = conversion factor (grams to metric tons), P = daily egg production (eggs produced per sampling unit per day), A = total survey area (in sampling units), W = average mature females weight (grams), R = sex ratio (fraction in weight of mature females), F = batch fecundity (average number of eggs per mature female per spawn), and S = spawning fraction (fraction of mature females spawning per day). The variance of the biomass estimate was calculated through the delta method (7), as a function of variance and covariance of the estimates of parameters.The mean and variance of the egg and adult parameters were estimated following Picquelle and Stauffer's procedure (8). Its application for the Sicilian Channel anchovy has been described in (9) in great detail.

Results and discussion

Table 1 shows the collections gathered and the details from both the egg and adult surveys. The fitted linear models obtained to adjust observed weight for hydrated females and for the estimation of batch fecundity appear in Table 2. The DEPM parameters and the spawning biomass are summarised in Table 3. Spawning biomass suffered a substantial reduction from 1998 to 1999. This drastic decline is mainly attributed to a great decrease observed in egg abundance. The anchovy egg distribution area was more restricted and northward displaced in 1999. The positive stratum (A1) in 1999 only represented 14% of A1 in 1998. Moreover, although two of the three main spawning grounds found in 1998 remain (Sciacca and Scicli), they showed a great decrease in anchovy egg abundance (Fig. 1). Lower temperature found in 1999 could only explain partially this egg reduction since it involves longer time exposure to mortality by predation. But it can not account for the great variation observed and other biological and environmental factors must be involved. The estimates of P1 and Z reflect these changes, although the final stratified estimates of the daily egg production (P) are quite similar (Table I). In respect to the adult parameters, spawning frequency (based on the average number of day-1 and day-2 females) was 7.1 and 5.8 days in 1998 and 1999 respectively. The 1999 adult population showed higher reproductive potential since despite W was ±1g lower, F and S were greater.

Table 1. Collections gathered and details from egg and adult DEPM surveys.
+Stn, Positive egg stations; Tª, 10 m depth average Tª in ºC; A, in km2; +Trwl, Positive trawls for anchovy; +Hyd, Positive trawls for hydrated anchovy females.

	Egg Surveys						Adult Surveys				
	Stn	+Stn	Eggs	Tª	A0	A1	Trwl	+Trwl	+Hyd	Males	Females
1998	253	116	822	21.7	7966	5329	28	17	10	302	399
1999	107	49	163	20.8	549	769	11	11	4	197	352

Table 2. Fitted linear models.

	Regression Fij-Wij*	Regression Wij-Wij*
1998	$F_{ij} = 219.07 + 320.08\ W_{ij}^*$ (n=67; R^2=0.5238; p<0.001)	$W_{ij} = -0.0663 + 1.0461\ W_{ij}^*$ (n=292, R^2=0.9983; p<0.001).
1999	$F_{ij} = -2617.89 + 630.83\ W_{ij}^*$ (n=30; R^2=0.7973; p<0.001)	$W_{ij} = 0.1333 + 1.0260\ W_{ij}^*$ (n=280, R^2=0.9975; p<0.001).

Table 3. DEPM parameter and biomass estimates from Sicilian Channel anchovy.
A in km^2, P referred to sampling unit (0.05m^2).

	A	P1	P	Z	W	R	F	S	B
1998	13295	3.28	1.31	1.63	15.18	0.59	4835	0.14	13224
		(0.21)	(0.33)	(0.33)	(0.06)	(0.12)	(0.16)	(0.12)	(0.22)
1999	1318	2.18	1.27	2.06	14.08	0.55	5871	0.17	853
		(0.21)	(0.27)	(0.23)	(0.07)	(0.10)	(0.11)	(0.10)	(0.25)

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OBSERVATIONS ON REPRODUCTION AND FECUNDITY OF *SPHOEROIDES PACHYGASTER* (PISCES - TETRAODONTIDAE) FROM THE SICILIAN CHANNEL (MEDITERRANEAN SEA)

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Abstract
Ovaries of 210 females of *Sphoeroides pachygaster* trawled in the Sicilian Channel were analysed to get first information on reproduction and fecundity. Ovaries features were observed and gonosomatic indeces (GSI) were computed as the proportion of ovaries weight on somatic weight. The number and size of the oocytes were recorded. GSI values up 0.43 were obtained and advanced ovaries were observed in winter and late summer. A maximum egg size of 0.75 mm and an average eggs number of 1540.5×10^3 were recorded. in mature females. Present results suggest that *S. pachygaster* is a high fecundity-total-spawner with a prolonged spawning period.

Keywords : Sphoeroides pachygaster, reproduction, spawning, Sicilian Channel

Information about reproduction and fecundity represent a key feature in the dynamics of a marine population [1;2]. It becomes more relevant when the species is an intruder such as the "blunthead blaasop" *Sphoeroides pachygaster* (Muller & Troschel, 1884), about which the biological knowledge is scant [3]. Its presence was reported in the Mediterranean for the first time in 1979 and records of the species were continuous in the last decades [3], suggesting a high spreading ability. Although the diffusion of a species is related also to an implicit reproductive success, no information is available on the reproductive patterns of these populations. The aim of this note is to present first data on ovaries features, gonosomatic index and fecundity of *S. pachygaster* from the Sicilian Channel.

A total of 210 *S. pachygaster* females over a period of 5 years (1990-1995) were recovered from commercial (on a voluntary base) bottom trawlers operating in the Sicilian Channel. Defrosted fish were measured (standard length, SL; 1 mm) and weighed (somatic weight, SW; 0.1 g). Ovaries were weighed (GW; 0.1 g) and gonosomatic index (GSI) was computed as GW/SW. Fifty specimens (124 to 405 mm SL) were selected to analyze total number of oocytes (herein eggs) and eggs size and length frequency distribution (LFD). An empirical maturity scale of three stages (table) was employed, based on macroscopic features. Ovaries being asymmetrical (the left one is larger) in gravid females, but eggs being of similar size in both ovaries [crf.4], only the left one was considered. A sample of the median portion was placed in Gilson's solution for 3 months to digest ovarian tissue. Eggs were then placed in a graduated cylinder and water added to bring the volume to 100 ml. Large size eggs (>0.3 mm) subsamples were placed in plastic petri dishes and eggs counted at 20x magnification. Small size egg subsamples were placed in Counting Chambers of Jessen (25 square cells of 1 mm^2 each; 16 squares of 0,25*0,25 mm). Eggs diameters were measured on randomly taken subsamples of 100 eggs with an ocular micrometer at 40x. Total number of eggs in the ovary was estimated by expanding the mean count *per* subsample to the total volume of the egg suspension. A rough estimate of absolute fecundity as the average number of eggs in the ovaries of mature females was obtained. The geometric mean of the stage 3 GSI was employed to estimate the instantaneous rate of natural mortality (M/year) according to the linear approximation M = 0.03+1.68*GSI [5].

GSI ranged between 0.001 and 0.433. Only values less than 0.05 were observed in fish smaller than 140 mm SL, whereas in larger specimens GSI varied highly according to the sampling month. Higher GSI values (>0.2) were observed in February and August-October, but ripe and recovering females were present all over the year. The mean eggs size by stage ranged between 0.095 and 0.404 mm (Table) and the corresponding LFD (Figure) presented a multimode shape with one more prominent component. The rough estimate of absolute fecundity resulted in 1540.5×10^3 eggs (Table) and the natural mortality coefficient (M/y), based on a GSI of 0.166, was 0.309.

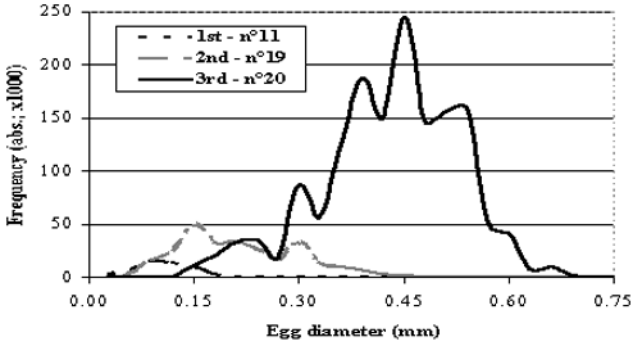

Figure - Length frequency distribution of eggs by maturity stage in *Sphoeroides pachygaster*

The newly employed maturity scale needs to be validated but it worked out its purpose, allowing a preliminary analysis of reproduction in the investigated species. Results obtained indicate a quite prolonged reproductive periodicity with variable seasonal peaks as already reported for the congener *S. nephelus* [6] and *S. maculatus* [6;7]. Data on eggs size and their LFD also are consistent with those reported for *S. maculatus* [4] (egg size ranging between 0.35 and 0.7 mm and an "approximately unimodal" LFD), while fecundity resulted higher in the present case (eggs number ranging between 288.000 and 350.000 in *S. maculatus*). The natural mortality coefficient obtained (0.309) is also high and indicates a population with a relatively high turnover rate. All these elements indicate a quite efficient reproductive pattern, which may be a key factor for the quick spreading ability of the Mediterranean populations.

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Table - Eggs size and number and GSI values of *Sphoeroides pachygaster* from the Sicilian Channel.

Maturity status (*)	N	Size range (SL; mm)	Gonosomatic index (GSI) range	g-mean	Mean egg size (mm)	St. dev. (mm)	Mean eggs number (x1000)
1 - Immature	11	124-295	0.006-0.04	0.015	0.095	0.0333	53.4
2 - Maturing or recovering	19	237-360	0.02-0.086	0.044	0.210	0.0618	274.4
3 - Mature and spawning	20	245-405	0.089-0.43	0.166	0.404	0.0680	1540.5

(*) 1 - Ovaries inconspicuous, whitish or pale pink. Eggs scarcely visible.
2- Ovaries still symmetrical, medium swollen. Vascularization evident but not diffuse. Eggs visible.
3 - Ovaries asymmetrical, fully swollen, highly vascularized. Eggs round, orange and translucent.

CHANGES IN A NORTH WESTERN MEDITERRANEAN FISH COASTAL ASSEMBLAGE ON THE BASIS OF THE CATCHES OF THE CAMOGLI TUNA TRAP

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Abstract

The tuna trap of Camogli is an installation of small dimensions which operates from April to September. The fishermen who note down the catched species with accuracy during every single fish operation, made fishing statistics available since 1951. Considering that the characteristics of the installation are substantially unchanged in the years, the data recorded may be a valid witness of the evolution of the fish population. This work presents the data corresponding to two periods of five years each (1956-1960, 1996-2000) making a comparison on the yields and on the dominant species. During the last five years the Carangidae has become more important : in particular *Seriola dumerili* which in the fifties was a catch of secondary importance has become the most important species.

Keywords : tuna trap, fish-catches, Western Mediterranean, Seriola dumerili.

Introduction

The tuna trap of Camogli (Ligurian Sea, Western Mediterranean) is an installation which belongs to a pluricentenary tradition. It's a small sized tuna trap (about 8300 m^2), still made of coconut fibre in prevalence, positioned near the Portofino headland.

The fishermen generally make three hauls per day (dawn, morning, afternoon); sometimes more on indication of a guardian who observes with a view-finder while fishes enter in the death chamber.

For their cooperative organization, fishers always noted catched species in details in every single fish operation. Fishing statistics have been available since 1951. The catches of the 1951-74 period were described (1). Since the characteristics of the installation are essentially unchanged in the years, data recorded may be a valid witness of the evolution of the fish population.

Camogli's tuna trap also provided records of the presence of new species in the Mediterraean like the shark *Sphyrna mokarran* (2) and the marlin *Makaira indica* (3).

Sharks have been the object of a paper which focused on a considerable decrease from the fifties to seventies (4), a trend which was observed also in Mediterranean demersal resources (5).

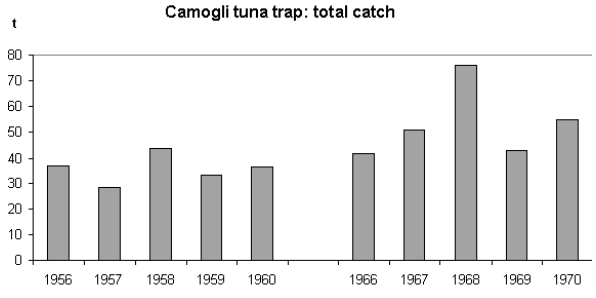
Methods

This work presents two sets of five years data (1956-1960, 1996-2000), making a comparison on the yields and on the most abundant species. The data belonging to the first period comes from literature (1); the last period was elaborated thanks to the documentation belonging to the "Cooperativa Pescatori Camogli".

Shark catches have been analysed withouth considering some species which now are released alive because they haven't any commercial value (i.e. Cethorinus maximus).

Results

Total catches appear to be increased (fig.1), but there are no significant



difference according to the Mann-Whitney test (U=2).

Figure 1 – Camogli tuna trap : total catches (t) in two periods, 1956-1960 and 1996-2000.

Considering the ten main species over the last years (fig. 2) *Auxis rochei, Sarda sarda* and *Scomberesox saurus* decrease. On the contrary, increased catches were recorded for *Mola mola, Sarpa salpa* and especially for Carangidae with *Trachurus* sp.p. and *Seriola dumerili*, which now is the main species, while in the fifties was captured sporadically. *Scomber japonicus* apparently has taken the place of *Scomber scombrus*.

Mola mola, despite the incresing occurence, has been recently banned as a commercial product by the " Italian Ministry of Health", as a potential dangerous Tetraodontidae. So the landings are no more comparable.

Among the three shark families of potential commercial value only Alopiidae has given some catches, confirming the above mentioned negative trend (Tab. 1).

The increase of Carangidae and other southern species such as *Sphyraena viridensis* might be linked to the global warming of last years. The spreeding of this family in the Mediterranean is confirmed by the recent adding of two non native species (*Seriola carpenteri* and *Seriola fasciata*) to the *S. dumerili* fishery in the Sicilian Straits (6; Andaloro p.c.).

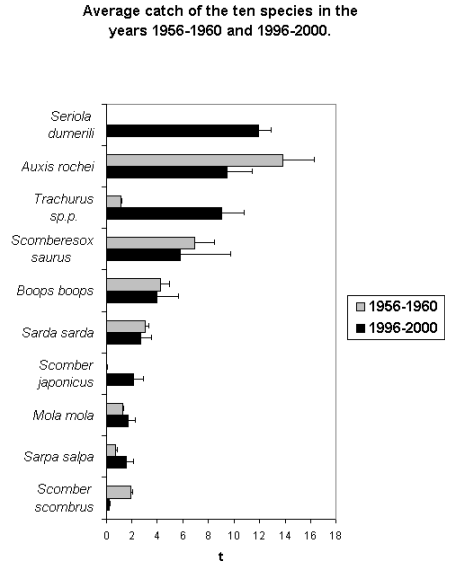


Figure 2 – Camogli tuna trap : average catches (t) of ten main species in two periods 1956-1960 and 1996-2000.

Family	1956-60	1996-2000
Alopiidae	11	7
Carcharhinidae	1	0
Triakidae	13	0
Total	25	7

Tab. 1 – Camogli tuna trap : shark catches in the two periods.

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TREND OF TRAWL CATCHES IN THE LIGURIAN SEA

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Abstract

Two short time series of biomass indexes deriving from national (GRUND) and international (MEDITS) trawl surveys were used to describe the variation in the commercial catches during 1985 to 1998 in the Ligurian Sea (NW Mediterranean).

Keywords : demersal resources, trawl surveys, biomass index, Ligurian Sea

Introduction

Since 1985 onward, within the framework of Italian Law L.41/82 and national coordination on demersal resource assessment (1, 2, 3), the team of the Laboratory of Marine Biology and Animal Ecology at present belonging to the Dip.Te.Ris. (University of Genoa), carried out trawl surveys. The team is also involved, since 1994, in the MEDITS project – Mediterranean International Trawl Surveys (4). The aim of these researches is the knowledge of the exploitation state of the demersal resources caugth by trawlers and in our specific case in the Ligurian Sea (NW Mediterranean Sea). In this note we present a brief description of the abundance dynamics regarding the overall commercial catches (kg/h) during seasonal trawl surveys performed in the Ligurian Sea from 1985 to 1998 within the frame of GRUND and MEDITS projects. Furthermore, biomass indexes has been processed to study the situation on shelf and slope both in term of catch per hour and in term of percentage variation in respect of the mean value of the overall period (only for the GRUND survey).

Material and method

The commercial catches regards all Teleosteans, Selachians, Cephalopods, Crustaceans and other (mainly Gastropods and Bivalve) that are important from economical and scientific point of view. The dataset consist of standardized catch index obtained during the otter trawl surveys from 1994 to 1998 (MEDITS) and from 1985 to 1998 (GRUND), carried out in spring and in late summer/early autumn (2, 5). Day-light hauls were effected on the bottoms ranged between 10 to 800 m depth off the ligurian coast. Catches per hour of trawling were used to estimate average index of biomass for strata (0-50, 50-100, 100-200, 200-500 and 500-800m depth). An average weigthed in respect of trawling hours for strata was used to obtain a yearly value both for shelf (0-200 m depth) and slope (200-800 m depth). Finally, a percentage variation in respect of the overall mean for fishing ground (shelf and slope) was processed.

Results

In Table 1 GRUND catches per hour for year and strata are shown. Highest values are recognized in the first stratum (0-50m depth) with a maximum in 1990 of 93,9 kg/h. In the deeper stratum (500-800m depth) a minimum value of 5,3 kg/h was obtained. Mean yearly values ranged between 13,52 kg/h in 1986 and 32,34 kg/h in 1992.

Table 1 – GRUND commercial species catches in kg per hour of trawling during the summer (*) or autumn per year and per stratum. (**) In these years the second and third strata were pooled togheter.

Year	0-50	50-100	100-200	200-500	500-800	Mean
1985*	27,0	16,3	9,1	16,2	19,9	17,7
1986*	17,2	14,4	12,2	12,9	12,3	13,5
1987*	17,1	10,7	7,6	24,9	15,8	16,8
1990**	93,9	22,0		9,5	11,2	31,0
1991**	78,6	7,7		12,0	5,3	23,9
1992**	84,3	21,4		17,3	7,6	32,3
1993**	46,5	13,1		13,9	7,2	19,0
1994	37,7	15,7	12,1	26,5	15,9	21,4
1995	17,5	61,7	38,2	41,5	20,1	31,9
1996	80,5	22,2	53,1	21,6	8,0	25,5
1997	30,1	13,3	15,0	20,6	13,0	17,5
1998	71,7	18,7	25,1	14,0	13,0	22,0

In Table 2 MEDITS catches per hour for year and strata are shown. The first stratum shows highest values in 1996, 1997 and 1998 (2.50, 2.39 and 2.45 kg/h), while in 1994 and 1995 maximum values were obtained in the third stratum respectively 2.30 and 8.13 kg/h; the latter is the highest value recognized in the overall period. Minimum values were obtained in 500-800 m depth, expect in the 1994 in the first stratum (0.82 kg/h) and 1997 in the fourth one (0.56 kg/h) that it's also the lowest value in the period (94-98). Mean yearly values ranged between 1.15 kg/h (1997) and 3.23 kg/h (1995).

Table 2 – MEDITS commercial species catches in kg per hour of trawling during the spring per year and per stratum

Year	0-50	50-100	100-200	200-500	500-800	Mean
1994	0,82	1,34	2,30	1,08	0,88	1,28
1995	2,01	3,81	8,13	1,36	0,83	3,23
1996	2,50	1,98	0,99	0,97	0,73	1,43
1997	2,39	1,27	0,64	0,56	0,90	1,15
1998	2,45	1,87	1,94	1,43	0,66	1,67

In figure 1 GRUND commercial catches on shelf and slope and overall mean of the period are shown. Generally the shelf value are higher than the slope ones, except in 1987, 1994, 1995 and 1997. For the shelf the highest values were recognized in 1990, 1991 and 1992 trawl surveys, instead for the slope the maximum was in 1995. In 1987 and in 1991 the minimum values were obtained respectively for the shelf and slope.

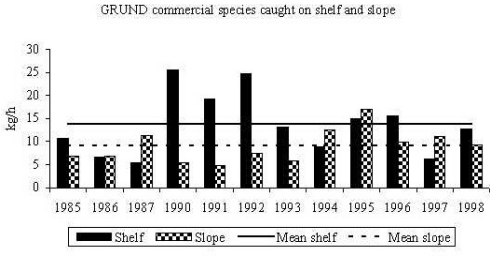

Figure 1. GRUND commercial catches on shelf and slope and the overall mean (respectively 13,67 kg/h and 9,04 kg/h) of the period.

In figure 2 MEDITS of all commercial catches on shelf and slope and the overall mean of the period are shown. Shelf values were higher than the slope ones for the overall period. For the shelf the highest values was recognized in 1995 (about 5 kg/h), instead for the slope the maximum was in 1995 (about 1 kg/h).

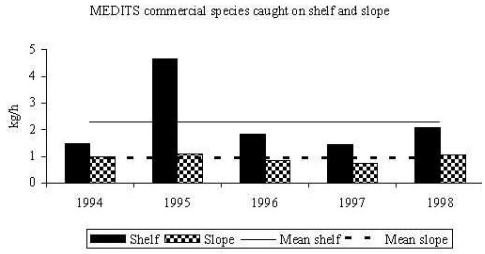

Figure 2. MEDITS commercial species caught on shelf and slope and the own overall mean (respectively 2.3 kg/h and 0.94 kg/h) of the period.

Figure 3 show the GRUND percentage variation of yearly catch per hour in respect of the overall mean for the two fishing grounds. Shelf values oscillated around the own mean, instead slope values show two phases. In the first, between 1985 to 1993 (except 1987), the yearly vlaues were under the mean, while from 1994 onward were higher.

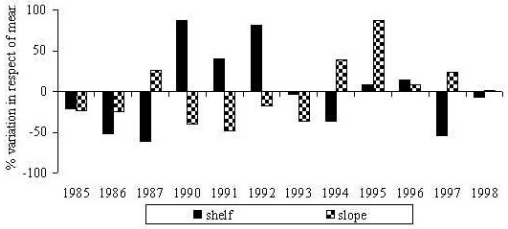

Figure 3. GRUND percentage variation of yearly catch per hour in respect of the overall mean for the two fishing grounds.

Discussion

Standardized commercial catches, given by stratified national and international trawl surveys, show that, generally, catches per hour on the shelf bottom are higher than slope ones. MEDITS catch per unit effort is lower respect to the GRUND one. This fact can be explained considering that the recruitment process of some of the main demersal species (i.e. red mullet) occur in autumn (the season in which GRUND trawl survey is performed) (6). GRUND percentage variation of yearly catch per hour in respect of the overall mean for shelf and slope show different pattern for the two fishing grounds. Infact shelf values fluctuate around the own mean, instead slope ones show two phases : in the first, between 1985 to 1993 (except the 1987), the yearly values were lower than the mean, while from 1994 onward were higher. Finally, no clear trends in trawl catches are detectable both for GRUND and MEDITS. So it is important to continue and improve the monitoring of biomass indexes by trawl surveys taking into account other possible forcing variables like environmental factors and fishing effort.

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EFFECTS OF FISHING RESTRICTIONS ON THE ABUNDANCE, SIZE STRUCTURE AND MORTALITY RATE OF A WESTERN MEDITERRANEAN POPULATION OF *SCORPAENA SCROFA* (LINNAEUS, 1758)

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Abstract
This study evaluates the changes occurred in a population of *Scorpaena scrofa* after eight years of protection (fishing ban) in the Columbretes Islands Marine Reserve (western Mediterranean). Relative abundance, size structure and mortality rates of the protected stock are compared with those of exploited stocks in the region. Higher abundance and a greater number of large-size individuals characterise the protected stock. A first estimate of the natural mortality rate, together with estimates of the exploitation rates in the fished stocks, is also given.

Keywords : fishing ban, marine reserve, Scorpaena scrofa, western Mediterranean.

Introduction

In the western Mediterranean *Scorpaena scrofa* is an important commercial species captured mainly in trammel-net artisanal fisheries. It is a slow growing1 benthic predator that inhabits mainly hard substrates between 20 and 200 m depth. The rather limited mobility of *S. scrofa* and its slow growth make this species particularly vulnerable to overfishing. For the same reasons, fishing restrictions are expected to be particularly effective in rebuilding populations of *S. scrofa* although to date no studies exist that evaluate this response. This study assesses for the first time the responses of *S. scrofa* to fishing restrictions in terms of population abundance, size structure and mortality. These changes are the most widely documented effects taking place in marine populations positively affected by protection2.

Material and Methods

Study areas. The study was conducted in the Columbretes Islands Marine Reserve (MR) and in two areas open to fishing (OF) : the Subarra area (OF-I) (40º 03' 30''N – 00º 40' 50'' E) and the area off the NE coast of Mallorca island (OF-II) (39º 52' 00''N – 03º 29' 00''E). The MR was established in 1990, extends over an area of 14 km^2 and is located 30 miles off the eastern coast of the Iberian peninsula (39º 52' 50''N – 00º 40' 20''E). All fishing is forbidden in the MR with the exception of purse seine and pole-and-line fishing in restricted areas.

Sampling design. Trammel net fishing was carried out in the MR (surveys) and in the open fishing areas (commercial) between 50 and 80 m of depth during the summers of 1998, 1999, and 2000. Trammel nets were 600 m long and had a drop of 1.7 m. The mesh size of the inner and outer panels were 80 mm and 300 mm respectively. Given the complex morphology of *S. scrofa* (spines and appendices), trammel net selectivity for this species may be approximated by a logistic model where all animals over a certain size are entangled3. Twelve sets were done in the RM and a larger number were sampled in the open fishing areas (OFI and OF II) each year. Abundance indices were estimated from catch rates (numbers caught per set) standardised to one night soak time.

Statistical analysis. To assess temporal and spatial differences in relative abundance, catch rate data were analysed by orthogonal analysis of variance with year and area as fixed factors. Multiple comparisons after ANOVA were done by SNK tests4. Data were log-transformed to comply with the assumptions of the analysis 4. To obtain equal samples sizes in the three areas, random subsets of 12 replicates per year were drawn from the larger pool of samples available from the OF areas.

For the analysis of length data, samples of the three years were pooled to increase sample size. Spatial differences in mean size were assessed by one factor ANOVA.

Mortality rates. Total mortality (Z) was estimated for the protected and exploited populations from the size frequency distributions using the Beverton and Holt's Z equation for length data 3. The growth parameters were taken from Bradai and Bouain 1.

Results and discussion

The abundance of *S. scrofa* did not vary significantly over time in any of the study areas ($F_{0.05\ (1)\ 2,99} = 0.361$, $p = 0.70$). However, abundance was significantly higher in the marine reserve than in the open fishing areas at all times ($F_{0.05\ (1)\ 2,99} = 10.08$, $p < 0.0001$), while it was similar in the two exploited areas (Fig. 1).

S. scrofa catches were comprised mainly of specimens between 26-40 cm TL in the exploited areas and between 32-46 cm TL in the MR (Fig.2). The mean size of *S. scrofa* varied significantly among areas ($F_{0.05\ (1),\ 2,\ 294} = 46.70$; $p < 0.0001$) with a high proportion of large (hence old) specimens in the MR. The modal and mean sizes in the MR (39.5 ± 4.7 cm TL) were larger than in any of the OF areas which showed similar modal and mean sizes (OF-I : 33.7 ±4.2 cm TL; OF-II : 33.0 ± 4.3 cm TL) (Fig. 2).

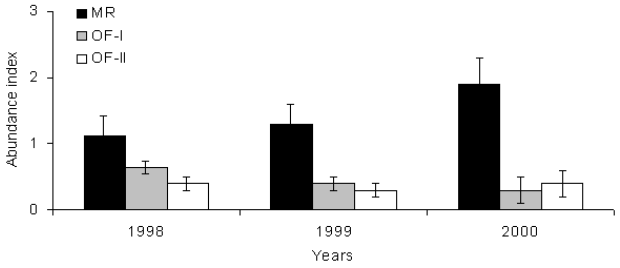

Figure 1. Abundance index (catch in number per standard set) (± standard error) of *S. scrofa*.
MR : Columbretes Islands Marine Reserve; OF-I : Subarra open fishing area; OF-II : NE Mallorca Island open fishing area.

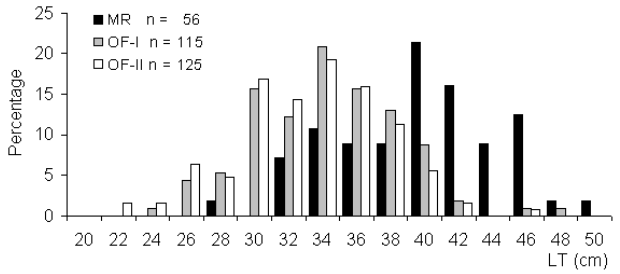

Figure 2. Size frequency distributions of *S. scrofa* in the three study areas.
MR : Columbretes Islands Marine Reserve; OF-I : Subarra open fishing area; OF-II : NE Mallorca Island open fishing area. LT : total length.

The total mortality rate estimated in the protected population provides a first approximation to the natural mortality rate (M) of the exploited phase of *S. scrofa*. The value of M ranges between 0.09 and 0.14 per year depending on the choice of first size group under full exploitation. Given the similarity of size frequency distributions obtained in the two OF areas, Z was calculated for both areas combined. The fishing mortality (F) in the OF areas, estimated by the difference between Z and M, ranged between 0.18 and 0.33 per year.

The results of this study suggest a swift response of *S. scrofa* to the cessation of fishing and a progressive recovery of the population in the marine reserve after 8 years of protection. On the basis of the estimated mortality rates, annual survival of the exploited phase of *S. scrofa* in the Columbretes Islands Marine Reserve is 15-24% higher than in the exploited areas.

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ON THE PRESENCE OF *ENSIS SILIQUA MINOR* (BIVALVIA : SOLENOIDEA) ALONG THE SOUTHERN COASTS OF SICILY (MEDITERRANEAN).

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Abstract

During an experimental survey of the Southern coasts of Sicily soft bottoms, carried out by hauling a "dry" dredge regularly monitored by scuba divers, the presence of Razor shell specimens was observed. The almost totality of the sample was represented by Ensis siliqua minor specimens caught in 51 stations.

Keywords : Bivalves, Sicilian Channel, Mediterranean

Introduction

The small scale fisheries of the Sicily are suffering a general decline in the traditional exploited stocks, such as bony fish and crustaceans.

In order to figure out alternative resources, a program was launched in 1996 by the Regione Siciliana with the aim of evaluating the abundance of natural bivalves stocks inhabiting the soft bottoms along the coastal strip of the Southern coasts of Sicily (1).

During this research, the presence of Razor shell specimens (*Ensis siliqua minor* L., 1758) was observed, with other benthic species. Moreover the morphometry of the collected *E. siliqua minor* specimens is reported.

The distribution area of the Razor shell along the Southern coasts of Sicily was derived by integrating the specific underwater observations. These information could be, in fact, useful for any future assessment by using more specific gear, such the hydraulic dredge.

Materials and methods

The study area, extended from 0 to 10 m of depth from Capo Granitola to Capo Scalambri (fig.1). Overall 51 stations were carried on by hauling a "dry" dredge (11 mm mesh side in the bag) regularly monitored by scuba divers, from September to November 1996 .

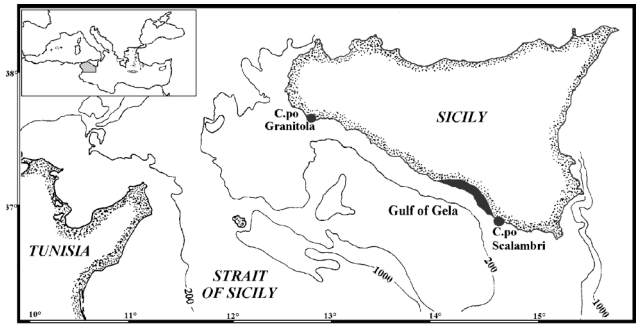

Figure 1 : Study area. The dark zone indicates the main occurrence area for *Ensis siliqua minor*.

Sediment samples, collected by divers, were used for granulometric analysis (2); the mean size values (Mz) were expressed as $\Phi = - \log_2 \varnothing$ mm. The specimens were measured (width, height). The bionomic significance according to Pérès & Picard (3), was attributed to all the associated benthic species.

Results

Overall 83 specimens of *Ensis siliqua minor* were found in 51 stations, mainly located in the eastern sector (Gulf of Gela) of the sampled area, from 1.6 to 7 m of depth.

The underwater observations and the analysis of the sediment samples showed *E. siliqua minor* occurred on fine and very fine well classed sand ($1.69 < M_z < 3.35\ \Phi$).

Main associated species were the bivalves *Tellina tenuis, Tellina fabula, Donax trunculus, Donax venustus, Mactra stultorum*, the echinoid *Echinocardium cordatum*, the polichaetes *Owenia fusiformis, Onuphis eremita, Sigalion mathildae* and decapod crustaceans *Diogenes pugilator* and *Liocarcinus vernalis*, all characteristic species of the Biocoenosis of Fine Well Sorted Sand (SFBC) (3).

The morphometry values (width, height) were included between 5.2 and 9.9 cm, 0.6 and 1.5 cm, respectively.

Discussion and conclusion

Considering the obtained results regarding the associated benthic species, the granulometric and sedimentological features, as well as underwater observations, it is possible to define the environment in which *E. siliqua minor* was detected as SFBC biocoenosis. Infact razor shells are burrowing (till 20 cm in depth) bivalves which occur on fine and very fine coastal sandy bottoms mainly between 2-4 m of depth. Moreover this species is exclusive characteristic of SFBC biocoenosis (3).

Razor shell (mainly *Ensis siliqua minor*) represent a very sought after bivalve in Italy (4; 5) and local beds are exploited even at low density (6).

In the specific case, it is not possible to evaluate the real abundance of the stock, given the poor efficiency of the dredge employed. Most of the specimens, in fact, were able to escape from the bottom panel of meshes by quick movement of the "foot", indicating that the consistence of the population is higher than that revealed by the retained catch.

With regard to Italian seas, routine monitoring programs have pointed out the wide year-by-year and area-by-area variability in the abundance of both target and non target bivalve species, and the periodic occurrence of catastrophic mortality with the almost total disappearance of local beds and successive recovery (7; 5). A similar phenomenon was recently detected in a Tyrrhenian Razor shell population (8).

Given that some period of higher abundance cannot be excluded *a priori*, the commercial value of E*nsis siliqua minor* might justify the exploitation of beds even at low density (the minimum profitable density was estimated at 10 g/ m^2 (6).

Present results do suggest a more consistent presence of Razor shells in the investigated area, also confirmed by underwater observations as well as by edaphic and bionomic features of the bottom, although sampling with a specific dredge (for example, longer teeth and finer mesh) will be necessary to check the usefulness for the Southern Sicilian small scale fisheries.

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THE SWORDFISH FISHING BY HARPOON IN THE STRAIT OF MESSINA

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Abstract

This study reports results on two years investigation (1999-2000) focused on a traditional Sicilian fishing : swordfish catching by harpoon. Census of fisheries, amounts caught of swordfish and the by-catch species were described. Only for one sample-boat were reported also data on weight, lower jaw fork length, and sex of samples catched. Results show a peak of catches in June and July and a higher percentage of female specimens. For the relatively poor impact of this fishing activity on resource and other characteristic, authors underline the need of a revaluation of harpoon fishing also as tourist-fishing activity.

Keywords : Strait of Messina, pelagic.

Introduction

The sword-fish fishing (*Xiphias gladius* L., 1758) by harpoon has been practised in the Strait of Messina since many years ago (1). During the summer in the Calabrian and Sicilian coasts some particular fishing boats, called "motopasserelle" or "feluche" daily sail from early in the morning until the sunset for the sword-fish catching.

Material and method

The investigation was carried on between 1999 and 2000, from April to August in the Strait of Messina and in the neighbouring areas (Aeolian islands, Ionic Calabria). The census of the boats has been made by considering the mean characteristics of length (m), horse power (hp), Gross Registered Tonnage (GRT) and year of building. The daily landings have been collected from the ground about all the fishing boats as well. For which concerns the sample-boat, the length (LFJL cm) and weight (Kg) measures have been divided according to their sex, that was determined through macroscopic observations. The mean daily landings, expressed in weight, have been worked out by taking in consideration the useful days. Besides, the effect of this kind of fishing on other species has been observed, during the two years of activity.

Results and discussion

This two years investigation led to the conclusion that the swordfish catching by harpoon is practised in Sicily by 8 boats distributed in the fishery of Torre Faro (ME) and Ganzirri (ME), and by 5 boats in Calabria. Our investigation only refers to the Sicilian fishing boats with the following mean characteristics : length 16 (m), horse power 249 (Hp), GRT 12 (t), year of building 1969.

For the sample-boat, during the fishing season of 1999, 112 specimens were sampled, of wich 45 males and 67 females; 101 specimen were sampled in 2000, of wich 38 males and 63 females, that is to say a total of 213 specimen. The length of the specimen were included between 110 and 215 cm of LFJL, both for the males and females. The sex-ratio has shown the predominance of the females specimen, that represents the 61.03% of the total (tab.1). In particular this predominance concerns the classes of size up to 135 cm, as other authors stated (2,3). From the analysis of the catches worked out on all the boats, it has emerged that during 1999, the main catches were the ones of June and July, with values respectively of 6745 and 5879 Kg. The total catches of the whole season was of 16606 Kg. During the fishing season of 2000, the most catches were the ones of June and July, with a rise in the weight in comparison with the previous seasonal with values respectively of 8603 and 6646 Kg. The mean daily was worked out monthly and it registered the highest mean values in June and July, with values respectively of 34.9 and 32.6 kg for the season 1999 and of 41.3 and 36.3 Kg for the 2000 (tab.2). The analysis of the by-catch showed representative catches of pelagic species as Spear-fish (*Tetrapturus belone*), Bluefin tuna (*Thunnus thynnus thynnus*) and Dolphin-dish (*Coryphaena hippurus*). The spear-fish, the most representative, was mainly caught in August and has increased from 1999 to 2000; the other two species showed a decrease (tab. 3) .

Tab.1 – Number of species for sex at different length frequency

LFJL	105-135 cm	>135 cm	Total
Females	66	64	130
Males	65	18	83
% females	50,4	78.0	61.03

Tab.2 – Monthly, total and mean catches of swordfish fishing by harpoon during the years 1999-2000.

Months	N. boats		Days		(kg/d)		Total (kg)	
	1999	2000	1999	2000	1999	2000	1999	2000
April	0	1	0	6	0	30	0	180
May	7	7	82	119	38.1	25.8	3131	3075
June	8	8	193	208	34.9	41.3	6745	8603
July	8	8	180	183	32.6	36.3	5879	6646
August	8	8	112	109	7.59	12.7	851	1385
Total			**567**	**625**	**29.3**	**31.8**	**16606**	**19889**

Tab.3 – By-catch of swordfish fishing by harpoon.

Species	Total landing (Kg)	
Year	**1999**	**2000**
T. belone	1519	1911
T. thynnus	686	518
C. hippurus	74	45

Our investigation showed that this kind of fishing is highly selective, in fact it affects a group of adult specimen. It is practised only during the summer for this is the only period in which the favourable atmospheric conditions let the use of these particular fishing boats; it is based only on the sighters'and harpooners'skills, who take adavantage of the habits of the swordfish, that often returns in pairs on the surface or jumps out the water. The selection of the specimen to catch is visually made according to the fishermen's experience and its effect on the resource can be considered less considerable in comparison to the other kinds of fishing; suffice it to think about the number of boats using drifting gill-net and long-line that, in the same period land huge quantities of fishes and, besides, work the whole year in the sicialn fishery (4-5). It would be interesting to maintain this traditional kind of fishing, that, by respecting the environment and the resource, could also be turned into an activity of touristic fishing and become an alternative source of profit in an island where many traditions have been abandoned for a long time.

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DONNEES PRELIMINAIRES SUR LA REPRODUCTION DE *SIGANUS REVULATUS* (FORSKAL, 1777, PISCES, SIGANIDAE), DANS LES EAUX COTIERES DE SYRIE

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Résumé

Les résultats reportés ci-dessous concernent la proportion numérique des sexes, la taille de première maturité et le cycle sexuel de *Siganus revulatus*, espèce lessepsienne d'origine Indo-Pacifique migrante dans la Méditerranée orientale (1, 2)

Mots-cles : Siganus revulatus, Siganidae, Biologie., Bassin Leventin.

Siganus revulatus est pêché à l'aide de filets et de lignes à main dans les eaux côtières de Syrie. 1469 poissons de longueur standard (LS) variant de 10 à 21 cm, ont été collectés durant la période septembre 1999-août 2000 pour cette étude.

Proportion numérique des sexes

Elle est calculée sans tenir compte de 202 poissons dont le sexe n'a pu être déterminé à l'œil nu, de taille comprise entre 10 et 16 cm. Sur 1267 poissons, 1051 sont des femelles et 216 des mâles, soit respectivement 82.9% et 17.1%; la dominance des femelles sur les mâles est statistiquement significative. L'évolution des proportions numériques des sexes en fonction du temps (table 1) montre que les mâles rares en automne et en hiver sont plus abondants en fin de printemps et début d'été, c'est-à-dire pendant la saison de reproduction. Cependant quelque soit la période de l'année, le nombre des femelles est toujours significativement plus élevé que celui des mâles. L'évolution des proportions numériques des sexes en fonction de la longueur standard indique que la fréquence des mâles diminue au profit de celle des femelles avec l'augmentation de la taille; au delà de 19 cm, nous n'avons récolté que quelques rares mâles. Néanmoins, le sexe-ratio diffère significativement au risque de 5% pour toutes les classes de taille et les femelles sont ainsi toujours numériquement plus importantes que les mâles.

Taille de première maturité sexuelle.

L'évolution par classe de taille du pourcentage d'individus mûrs et immatures, durant la période de reproduction (mai-juin) montre que les plus petits mâles et femelles immatures mesurent 13 cm de longueur standard; les plus grands mâles et femelles immatures sont de 16 cm. La taille à laquelle 50% des femelles sont adultes est égale à 13.5 cm (contre 14 cm pour les mâles) et celle à laquelle 100% des poissons le sont est de 16.5 cm (contre 17.5 cm pour les mâles).

Cycle sexuel

Le rapport gonado-somatique (RGS) des femelles, calculé pour les individus dont la classe de taille est d'au moins 13 cm (LS) s'élève rapidement à partir d'avril pour atteindre son maximum en mai (phase de maturation). Il reste élevé durant le mois de juin, puis diminue brutalement à partir de début juillet (période de ponte). La période de repos sexuel s'étend d'août à fin février. Le RGS des mâles suit une évolution cyclique analogue à celle des femelles, cependant l'amplitude moyenne du RGS est plus élevée chez les femelles (2.5-11.45) que chez les mâles (1.8-8.79) (fig.1). Le coefficient de condition (K) présente un maximum pendant la période de prématuration (mars-avril) puis diminue pendant la période de reproduction.

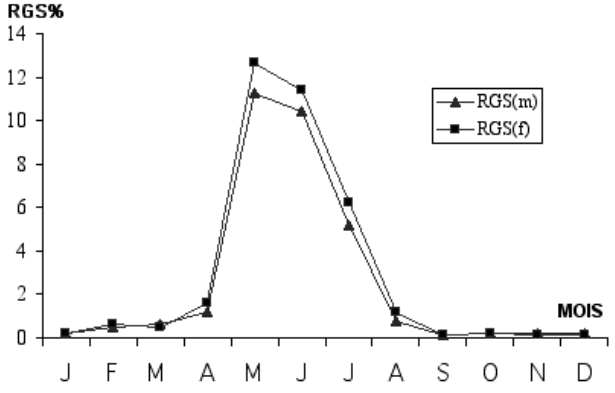

Fig. 1 : Evolution mensuelle de RGS des males et famelles de *S . revulatus*

La condition des mâles semble moins affectée par la reproduction puisque le coefficient de condition (K) continue a s'élever durant la période de reproduction

Table 1. Variation des proportions numériques des sexes de *S. revulatus* en fonction du temps.

Mois	Nombre des mâles	Nombre des femelles	Total (mâles + femelles)	% des mâles	% des femelles
Janvier	0	112	112	0	100
Fevrier	0	63	63	0	100
Mars	18	71	89	20.2	79.8
Avril	23	85	108	21.3	78.7
Mai	58	132	190	30.5	69.5
Juin	63	112	175	36	64.0
Juillet	14	85	99	14.1	85.9
Aout	9	82	91	9.9	89.1
Septembre	12	90	102	11.8	88.2
Octobre	14	80	94	14.9	85.1
Novembre	0	65	65	0	100
Decembre	5	74	79	6.3	93.7
Totale	216	1051	1267	17.1 %	82.9 %

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SEPIOLIDAE (MOLLUSCA, CEPHALOPODA) FROM THE CATALAN SEA NORTHWESTERN MEDITERRANEAN

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Abstract
This paper reports information on the distribution and abundance of nine sepiolid species collected in the NW Mediterranean. The length frequency distribution of the most abundant species is also reported.

Keywords : Cephalopods, Bathymetry, Balear Sea

Introduction

The family Sepiolidae is represented in the Mediterranean Sea by 15 species. Recent studies have increased the information about the family Sepiolidae (1). However, the species belonging to this family represent one of the lesser-known cephalopod groups. The object of the present study is to provide information on the abundance and distribution of sepiolids collected between 33 to 773 m in the NW Mediterranean.

Material and methods

The study was conducted in Vilanova port of the Catalan coast (NW Mediterranean), between January 1996 to June 1996. Samples were collected on a quartly basis in a total of 34 experimental haul in a depth stratified sampling grid between 33 to 773 m depths. A commercial fishing trawl gear was used. All specimens were frozen and after thawing at room temperature, the samples were analysed. Dorsal mantle length (DML) of all the specimens was measured in mm using a calliper, after which they were sexed, and identified to species level following Bello (2).

Results and discussion

The number of specimens caught during the study surveys and the depth distributions are recorded in table 1.

Table 1. Cephalopod species captured from June 1995 to June 1996 off the Catalan coast (NW Mediterranean).
Numbers of individuals; Minimum depth of capture (Min.); Maximum depth of capture (Max.) and Mean depth of capture are indicated

Species	Number	Min.	Max.	Mean
Sepiola rondeletti (Leach 1817)	7	39	78	55.5
*Sepiola ligulata (*Naef, 1912)	12	34	149	122.4
*Sepiola robusta (*Naef, 1912)	25	34	196	69.2
Sepietta aweniana (d'Orbigny *in* Ferussac & d'Orbigny, 1841)	108	39	459	178.1
*Sepietta neglecta (*Naef, 1912)	23	62	196	81.5
*Sepietta obscura (*Naef, 1916)	3	39		
Rondeletiola minor (Naef, 1912)	58	62	372	130.8
Rossia macrosoma (Delle Chiaje, 1830)	4	281	407	375.3
Neorossia caroli (Joubin, 1902)	5	377	558	407.0
Heteroteuthis dispar (Rüpell, 1844)	1	761		
Stoloteuthis leucoptera (Verrill, 1878)	1	377		

Sepietta oweniana is the most common species in our study. A total of 108 specimens were taken from depths varying between 39 and 459 m. Of these 59 were males measuring between 12.6 and 32.5 mm DML and 49 were females ranging in size from 12.2 to 35.7 mm DML (Fig.1). The smallest sexually mature male measured 18.2 mm DML, the smallest mature female 17.3 mm DML. The maximum density was 8.06 specimens/hour of trawling at 257 m. The minimum density was recorded in the deepest and shallowest parts of it depth distribution range (Fig. 2).

Rondeletiola minor. Of total of 58 specimens collected, 30 were males (14.2-21.5 mm ML) 28 were females (10.3-25.6 mm DML) (Fig.1). The smallest sexually mature male measured 15.3 mm DML, the smallest mature female 16.9 mm DML. The animals were found at depths ranging from 62 to 372 m. The minimum density was recorded in the deepest and part of it depth distribution range The maximum density was 2.44 specimens/hour of trawling at 137 m. (Fig. 2).

Sepiola robusta. In all, 24 specimens of this specie were collected, 13 were males (10.2-25.7 mm ML) 11 were females (11.2-20.8 mm DML) (Fig.1). The smallest sexually mature male measured 18.7 mm DML, the smallest mature female 15.3 mm DML. The animals were found at depths ranging from 34 to 196m. The maximum density was 1.06 specimens/hour of trawling at 36 m. (Fig. 2). After this depth became less abundant.

Sepietta neglecta. A total of 23 specimens were collected at depths between 62 and 196 m. Eleven males ranging from 14.8 to 26.7 mm DML and 12 females ranging from 9 to 34.2 mm DML (Fig.1). The smallest sexually mature male measured 16.7 mm DML, the smallest mature female 21.1 mm DML. The maximum density was 0.78 specimens/hour of trawling at 67 m. (Fig. 2).

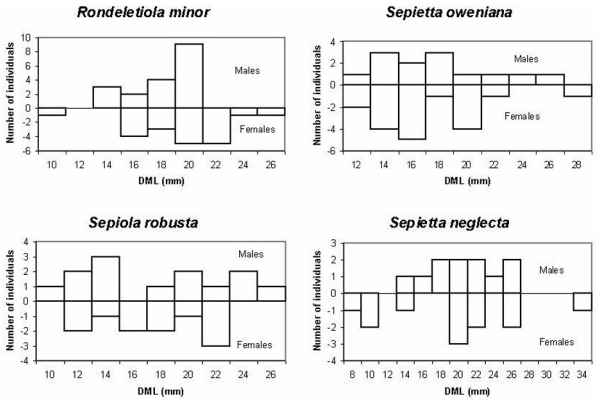

Figure 1. Size frequency distribution for males and females for the four most important sepiolid species.

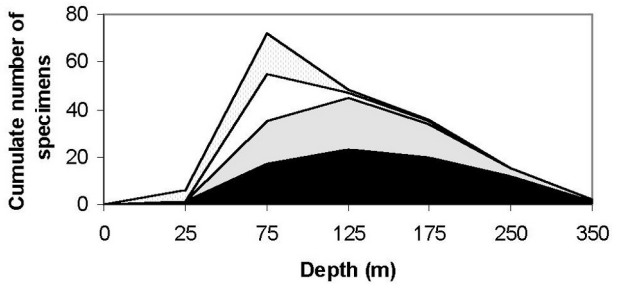

Figure 2. Cumulative number of specimens by the most abundant species and depth.

Although all the sepiolid subfamilies and genera known in the Mediterranean are represented in our records, some species were rarely caught; 4 species were absent altogether. This pattern may due, at least partly, to our sampling methods. No samples were carried out in shallow waters (<33m).

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ANALYSIS OF THE IMPACT OF THE FISHERY ON THE ADULT POPULATION OF EUROPEAN HAKE IN THE NORTHWESTERN MEDITERRANEAN

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Abstract

The impact of the fishery on the adult population of *Merluccius merluccius* was studied in two areas of the north-western Mediterranean. From the analysis of the commercial landings and of the corresponding size structures, appreciable differences in the exploitation pattern of the different fishing gears were evidenced.

Keywords : fisheries, demersal, population dynamics, fishes, Tyrrhenian Sea.

Introduction

The European hake, *M. merluccius*, (L., 1758), is one of the most important species exploited by the Mediterranean demersal fisheries. In order to improve the knowledge on the exploitation of this species, a study on the impact of different gears on the adult population was carried out following the activity of the fishing fleets in two north-western Mediterranean areas, the Catalan Sea and the northern Tyrrhenian Sea. This work has been carried out in the framework of investigations funded by the European Union, in particular the FAIR project 97-3522 ("Llucet").

Material and methods

In the years 1998-'99, on a monthly basis, information on landings, fishing effort and demographic structure of the European hake was collected by port and gear. In the Catalan Sea the fleet of Vilanova i la Geltrú was studied (traditional trawling, gillnet, longline), while in the northern Tyrrhenian Sea those of Porto Santo Stefano (traditional trawling, wide opening trawling and gillnet) and Marina di Campo (gillnet) were followed. Data were collected by different approaches : directly at the auction, from official archives, by samplings on board, by monitoring and inquires at the landing points, and by the distribution of log books. Length frequencies were obtained measuring (Total Length, TL, to the lowest 0.5 cm) representative samples of the monthly landings of each gear. In order to a better comparison of the results, a one year data period (January '99-December '99 for Vilanova, November '98-October '99 for the northern Tyrrhenian Sea) was subsequently chosen for all the foreseen analysis. The study was focused on the specimens bigger than 25 cm TL, considered to represent the adult population of *M. merluccius*, taking in account the biological characteristics of this species (1).

Results and discussion

Table 1 resumes the characteristics of the fleets targeting hake in the studied period. *M. merluccius* was one of the targets of the multispecific catch of trawling, while it was the most important objective of gillnet and longline, especially from autumn to spring.

During the one year period considered, a total of 150 tons of hake was estimated to be landed by the fleet of Vilanova, 435 by the fleets of Porto Santo Stefano and Marina di Campo (Tab. 1)

The adults of *M. merluccius* represented a percentage between 37 and 46% of the total landings of this species, with 55.3 and 199.1 tons in the two areas. Trawling resulted the gear accounting for the majority of hake landings, with the 95% and 83% of the total biomass landed, in the Catalan and Northern Tyrrhenian Sea, respectively (Tab. 1). The contribution of the artisanal gears, negligible for the total hake landings, was noticeable when the adults were considered : gillnet and longline of Vilanova represented the 15% of the biomass landed of this demographic fraction, gillnets of Porto Santo Stefano and Marina di Campo accounted for 34% in Northern Tyrrhenian Sea (Tab. 1 and Fig. 1). The predominance of trawling in providing the landings of hake was also due to the greater fishing effort performed by the fleet using this gear. For example, in the ports of northern Tyrrhenian Sea 31 trawlers worked in the studied year on average 5 days each week, in comparison with the 15 vessels with gillnet (Tab. 1) working on a seasonal basis and with large periods of inactivity due to the adverse weather conditions.

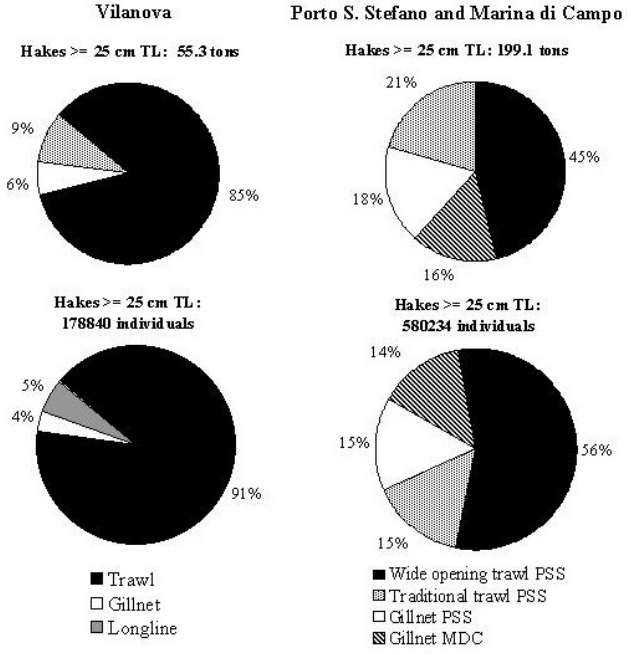

Fig. 1 - Composition of the annual landings of adults of *M. merluccius*, by gear and port

In spite of this, the landings per unit effort of adult hakes (LPUE, kg per fishing day per boat) of artisanal gears were higher respect those of trawling (Fig. 2). Moreover, in both areas it was observed a seasonal pattern in the LPUEs; trawling reached a maximum in the late spring-summer, while the artisanal gears showed, in general, the highest values in winter and autumn, with the exception of the peak in April showed by the gillnet of Porto Santo Stefano.

Table 1. Characteristics of the fishing fleets and annual landings of *M. merluccius*.

	N° of Boats	G.R.T. Total	G.R.T. Mean (± SD)	Kw Total	Kw Mean (± SD)	Hake Landings (tons) Total (%)	Hake Landings (tons) Adults (%)
a) Catalan Sea – Vilanova							
Trawl	26	918	35(±24)	4253	164(±152)	142.5 (95)	47.8 (86)
Longline	6	59	9(±6)	402	67(±31)	4.5 (3)	4.5 (9)
Gillnet	9	36	4(±2)	339	50(±38)	3.0 (2)	3.0 (6)
b) Northern Tyrrhenian Sea – Porto Santo Stefano and Marina di Campo							
Trad. trawling PSS	15	618	41(±30)	4272	305 (±138)	116.5 (27)	41.0 (21)
Wide op. trawling PSS	16	775	48(±12)	5461	390 (±116)	241.8 (56)	91.6 (45)
Gillnet PSS	5	62	12(±5)	627	125(±26)	35.3 (8)	35.2 (18)
Gillnet MDC	15	163	11(±5)	1855	124(±34)	41.1 (9)	31.3 (16)

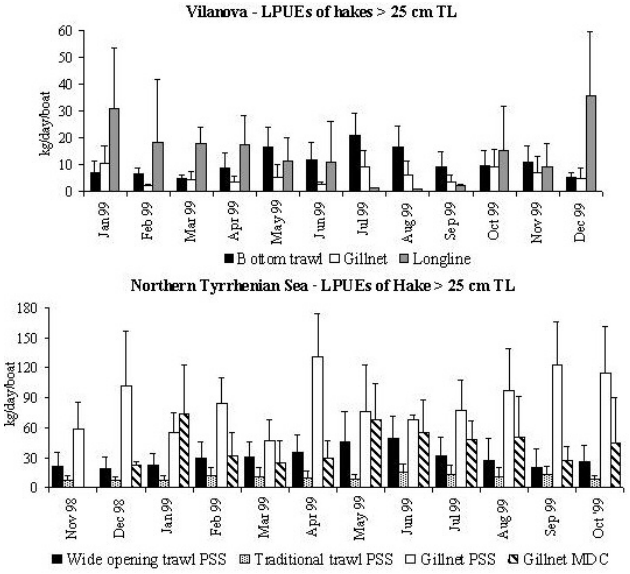

Fig. 2 - Monthly landings per unit effort (kg/day/boat) of adult *M. merluccius*, by gear and port.

Considering the landings in number of individuals, the contribution due to trawling resulted even higher compared to that in biomass (Fig. 1). This was due to the fact that the adults landed by trawling were smaller respect to those landed by the artisanal gears (Fig. 3).

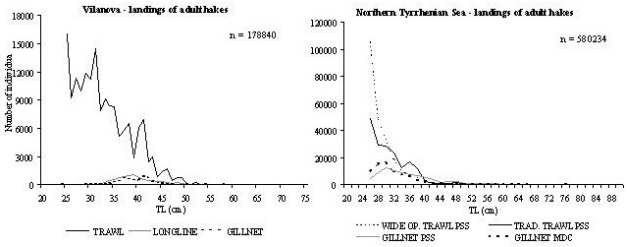

Fig. 3 - Size structure of the annual landings of adult of *M. merluccius*, by gear and port.

Comparing the demographic structure of the landings of each gear with the Kolmogorov-Smirnov test, in Vilanova significant ($p<0.001$) differences emerged in all the comparisons with trawling, while for gillnet and longline no statistical differences were evidenced; in this port the adult hake landings of trawling were mostly composed of specimens till 35 cm TL, while the majority of those caught by artisanal gears ranged from 35 to 45 cm TL. In the northern Tyrrhenian Sea, significant ($p<0.001$) differences emerged from all the comparisons; landings of adult hakes by traditional trawling differed from those of wide opening trawling for the greater importance of specimens > 30 cm TL in the landings of the first gear; gillnet of Marina di Campo was mostly represented by specimens till 40 cm TL, while in the gillnet of Porto Santo Stefano the specimens of bigger sizes resulted more important (Fig. 3).

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Introduction

The common sole, *Solea vulgaris*, Quensel 1806, is undoubtedly the most important flatfish in the Mediterranean Sea, both for its abundance and economic value. According to FAO statistics (1) the annual landings of *S. vulgaris* in this area increased from about 4500 tons in 1972 to about 10000 tons in 1992. The fishing activity is mostly carried out with towed gears (bottom and beam trawling), even if passive gears (set nets) are commonly employed to fish this species. Although common sole has been currently object of studies, basic information on the exploitation of this resource is still lacking in the Mediterranean area. The aim of this paper is to provide information on technical aspects and on catch composition of the common sole fishery performed by means of gill net by the artisanal fleet of Livorno (Eastern Ligurian Sea).

Material and methods

Data on the structure of the artisanal fleet of Livorno were collected from the official archives at the harbour office ("Capitaneria di Porto"). At the same time, interviews with fishermen were performed in order to identify the boats using gill net, to know the technical characteristics and the fishing activity of this gear.

From January to December 2000, a monthly sampling on the gill net commercial landing was performed. At the landing site, for 4-8 days each month, the biomass landed of *S. vulgaris* and of the accessory species was registered. Moreover, the size of a representative sample of common sole was measured (Total Length, TL, to the nearest 0.5 cm below). Trips of researchers on board of commercial vessels were carried out to obtain information on the discard in this type of activity.

Results and discussion

In the studied period, the artisanal fleet of Livorno accounted for 63 vessels (mean gross tonnage of 4.1 tons ± 2.7 s.d., mean total length of 7.7 m ± 2.6 s.d. and mean engine power of 54.4 Hpa ± 41.4 s.d.); only four boats employed gill net regularly, while the other fishing units utilised this type of gear only occasionally and jointly with trammel net. These four boats employed a gill net of about 3500 m length during each trip; the length of the net varied from 1000 to 5000 m, according to the weather conditions. The gear was built by a single mono-filament panel 3 m high with a 82 mm stretched mesh size. The technical features of a single sheet of net (135 m) are shown in Table 1.

The fishing ground was localised in the surroundings of Livorno, from the harbour to the mouth of the Arno river, on sandy-muddy bottoms. The nets, placed between 4 and 40 m depth, were lowered into the sea at dusk and pulled in at dawn.

The mean monthly landing of *S. vulgaris*, standardised to 1000 m of net per fishing day, was characterised by high variability (Fig. 1), due to the influence of the meteo-marine conditions on the yields of this type of fishery. However, from March to October, noticeable yields were observed, with values ranging from a minimum of 1.5 kg/1000m /day in June to a maximum of 2.6 kg/1000m /day in September.

The size composition of the landing of *S. vulgaris* did not show differences among the seasons (Fig. 2). The distributions were uni-modal with modal class ranging from 26 to 28.5 cm TL. The majority of the specimens, comprised between 23 and 35 cm TL, was larger than the minimum legal size of commercialisation (20 cm TL, EU regulation 1626/94) and of the size at first maturity (25 cm TL) (2).

As regards the catch composition, *S. vulgaris* was the most important species reaching 34.4% of the total biomass caught (from 28% in summer to 38% in winter, Fig. 3). Among the commercial species, it is worth of noting *Raja asterias* (21.1% of the total catch), *Squilla*

GILL NET FISHERY TARGETING *SOLEA VULGARIS* QUENSEL, 1806 IN THE EASTERN LIGURIAN SEA

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Abstract

Information on the gill net fishery targeting *Solea vulgaris* was collected in Livorno, Eastern Ligurian Sea, from January to December 2000. During the study, sixty-eight species were caught; *S. vulgaris*, *Raja asterias, Squilla mantis* and *Trigla lucerna* contributed to the total biomass caught for about 65%. Discard accounted for an important fraction of the catches; the reject of *S. vulgaris* was due to damaged specimens and it varied from 0.3% to 5.2% of the total catch in spring and autumn, respectively. The size composition of *S. vulgaris* catches was characterised by large specimens (>20 cm TL).

Keywords : Ligurian Sea, coastal management, demersal, fisheries

mantis (4.8%) and *Trigla lucerna* (4.5%). Therefore, the above mentioned four species accounted for over 64% of the total biomass caught, confirming the high selectivity of this fishery. Other 64 species were collected (42 fishes, 10 crustaceans, 10 molluscs and 2 echinoderms), but the majority of them resulted occasional in the catches.

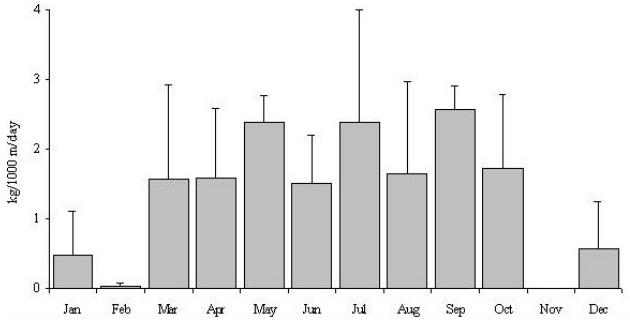

Fig. 1 – Landings per Unit of Effort (kg/1000 m /day + s.d.) of *S. vulgaris* during the studied period.

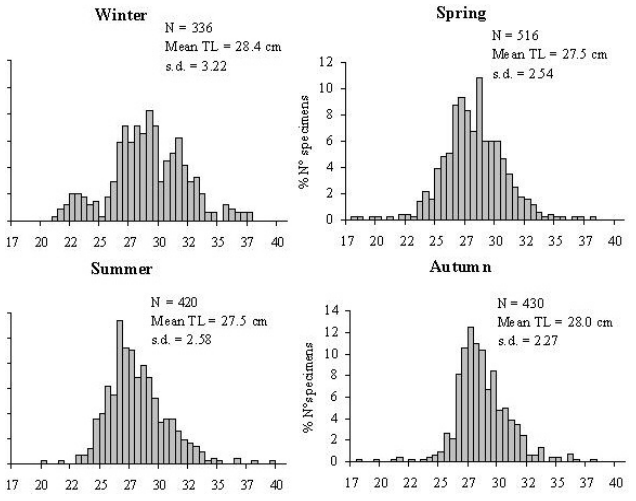

Fig. 2 – Demographic structure of the landing of *S. vulgaris* during the studied period.

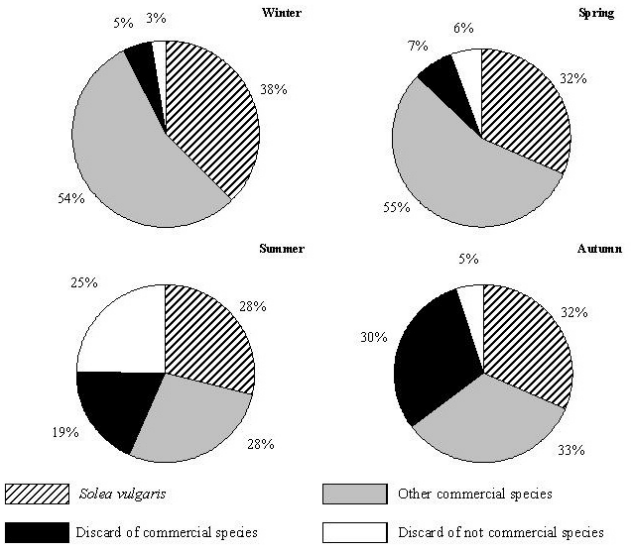

Fig. 3 – Composition of the gill net catches during the observations on board.

The total discarded biomass constituted an important fraction of the total catch, ranging from 8% in winter to 44% in summer. Not commercial species (crustaceans, molluscs and echinoderms) and damaged specimens of commercial species represented a high percentage of the discard of this fishery. A high reject in biomass of not commercial species (25%) was observed in summer, mostly due to the crustacean *Dardanus arrosor* (21.1% of the total catch). The discard of commercial species showed a clear increase during the year, with important values in summer (19%) and in autumn (30%). The discarded biomass of *S. vulgaris*, exclusively represented by damaged specimens, ranged from 0.3% of the total catch in spring to 5.2% in autumn.

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Tab. 1 – Technical characteristics of the gill net used in Livorno.

PANEL							FLOATS				HEADLINE			LEADLINE	
Height (m)	Length (m)	N. mesh width	Material	Stretched mesh size (mm)	Diameter of the filament (mm)	Hanging ratio	Total number	Diameter (mm) max	Diameter (mm) internal	Length (mm)	Length (m)	Diameter (mm)	Material	(gr x m)	Length (m)
3	135	2000	monofilament nylon	82	0.18	0.33	33	30	12	60	45	25	cotton	120	45

THE LOBSTER FISHERY WITH GILLNETS IN THE EASTERN ADRIATIC

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Abstract
Lobster fishery in the Eastern Adriatic should be performed with pots and lobster gillnets, but other gillnets and trammel nets are also used. Influence of gillnets, with inadequate mesh size, on lobster has been evaluated according to length frequency of caught lobsters, percentage of immature specimens, sex ratio and length-weight relationship. According to obtained results, impact of gillnets with inadequate mesh size on lobster is very harmful, so lobster fishing with such gillnets should be forbidden, in order to prevent overfishing and extinction of this species in the Eastern Adriatic.

Keywords : fisheries, Adriatic Sea

Introduction

Common spiny lobster, *Palinurus elephas* (Fabricius, 1787), is known from the western and central Mediterranean up to coasts of Turkey, while in the Atlantic it occurs from the British Isles to the Azores (1). In the Eastern Adriatic it is distributed throughout the entire coast at depths from 20 to 120 meters, but it is rare in the Northern Adriatic. Main areas of its distribution and in the same time its most important fishing areas are southern sides of distant islands (2).

According to croatian fishing legislation lobster fishing season is from 1st May to 31st August and it should be performed by lobster pots with minimum mesh size of 110 mm or by lobster gillnets with minimum mesh size of 240 mm. Because of deficient fishing legislation, in lobster fishing areas, trammel nets and, especially, gillnets with 120 mm mesh size, originally used for fishing of cartilaginous fish (3), are also used for lobster fishing. Futhermore, lobster gillnets (240 mm mesh size) are mainly abandoned and replaced by 120 mm mesh size gillnets. Although there is no proper fishery statistics regarding lobster landings, different sources (fishermen, fishery market...) indicated decline in lobster landings during the last decade, with inadequate gillnets as presumed main reason for that situation. Accordingly, research has been carried out in order to evaluate impact of these gillnets on lobster population.

Material and methods

Research has been carried out in different lobster fishing areas of southern and central eastern Adriatic during 1998. and 1999. Gillnet with mesh size of 120 mm, height of 10,5 meshes and 0,33 hanging ratio has been used. Total length (TL) from tip of the rostrum to the end of telson in mm, carapace length (CL) in mm, weight (W) in grams and sex has been measured for each lobster specimen. According to previous researches (4; 5) and fishery legislation, 28 cm of total length is length at first maturity and minimum landing size for common spiny lobster in the Eastern Adriatic. Length-weight relationship is analysed according to following equation: $W = a\,TL^b$.

Results and discussion

Total number of 594 specimens was caught and analysed. Fig.1 shows length frequency distribution of common spiny lobster, both males and females, according to total length. Length range of caught specimens was between 12 and 42 cm of total length, while weight range was between 48 and 2228 g. 477 specimens were under 28 cm of total length, which represents 80,30 % of immature specimens.

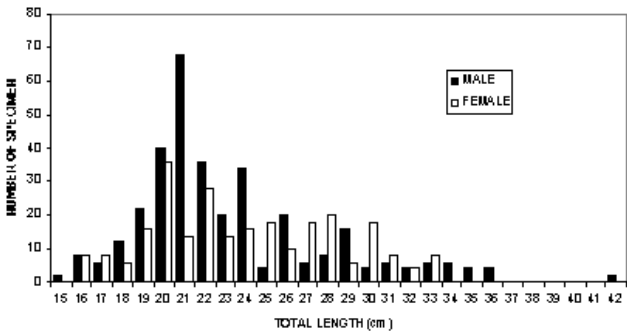

Figure 1: Length frequency distribution of common spiny lobster.

Length-weight relationship of common spiny lobster is presented with following equation :
$W = 0{,}033924\ TL^{2{,}905}$ ($r = 0{,}958$),
while for males is : $W = 0{,}039437\ TL^{2{,}860}$ ($r = 0{,}969$),
and for females is : $W = 0{,}041658\ TL^{2{,}832}$ ($r = 0{,}955$).
Sex ratio for common spiny lobster is 1,3 :1 in favour of females.

Only seven berried females were caught (0,011 %), mainly during the end of August, which proves that berried females occur mainly from September onwards in the Adriatic (6), what is the same period as in the Mediterranean (7). Therefore, closed season falls during spawning period, which is prerequisite for better protection and management of lobster.

Recent investigations shows that length at first maturity for common spiny lobster in Mediterranean and Atlantic is 82-86 mm CL (7) what is in relation with obtained CL of lobsters with 28 cm TL in the Eastern Adriatic. This means that minimum landing size of 28 cm TL for lobster is in accordance with length at first maturity. Comparison of investigated gillnets with lobster gillnets shows significant differences. Mesh size of lobster gillnets is twice of mesh size used in investigated gillnets. Furthermore, hanging ratio of investigated gillnets (E= 0,33) in relation to hanging ratio of lobster gillnets (E= 0,67) is significantly unfavourable for species with body characteristics such as in lobster. Accordingly, result of these gear characteristics is high percentage of immature specimens (80,30%) in catches. These results show that impact of gillnets on lobsters is very severe. Therefore, in order to prevent overfishing of lobster, which signs were already present, and to allow normal reproduction of species, fishing with these gillnets should be forbidden at the lobster fishing areas.

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COVARIATION IN MEAN ABUNDANCE OF LARVAL MYCTOPHIDS AND ZOOPLANKTON BIOVOLUMES IN THE NE AEGEAN SEA

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Abstract
Species composition and abundance of mesopelagic larvae during June 1993, 1994, 1995 and 1996 are presented in waters of the northeastern Aegean Sea (Eastern Mediterranean). Significant interannual differences were found that appeared to be associated with differences in environmental conditions. In June 1996 waters were colder, less saline and richer in zooplankton. Larvae of laternfishes were significantly more abundant in 1996.

Keywords : Ichthyoplankton, Aegean Sea

Introduction

It has been suggested that small-sized pelagics, such as anchovies, respond quickly to variations in the adult feeding environment by adjusting their egg production parameters –batch fecundity and interspawning interval (1). This can be reflected by the abundance of their spawn in the plankton.

In the present communication we present evidence that planktivorous laternfishes, which are also small-sized fishes, present increased ichthyoplankton abundance when waters are richer in zooplankton.

Materials and methods

Larval fishes were collected during four surveys carried out in 7-11 June 1993, 19-23 June 1994, 15-22 June 1995 and in 6-14 June 1996 in the NE Aegean Sea (Eastern Mediterranean). Stations were located at approximately 5 (1993 and 1995) or 10 (1994 and 1996) nautical-mile intervals on transects running parallel to lines of longitude and spaced 10 nautical miles apart (Fig. 1). In 1996, five additional offshore stations were sampled. At each station, a vertical profile of salinity and temperature was made using a Seabird 19 CTD. Ichthyoplankton sampling gear and methodology, as well as laboratory analysis of samples, are described in (2).

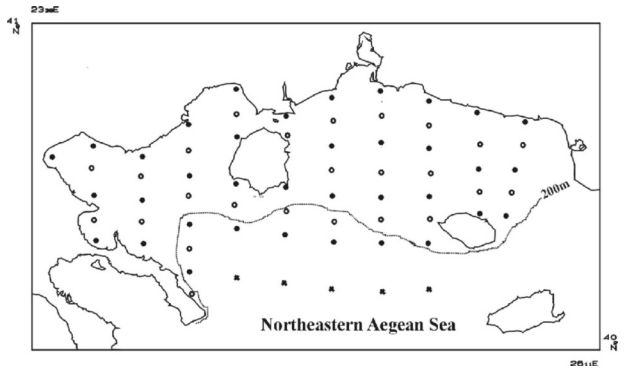

Fig.1. Map of the study area showing the location of sampling stations.
Black cycles = stations sampled during all years. Open cycles = stations sampled only in 1993 and 1995. Crosses = offshore stations sampled in 1996.

To provide a more powerful test for among years differences in the abundance of larvae, we bootstrapped 95% confidence intervals on resulting means (3). A preliminary analysis showed that interannual differences in sampling intensity and the five additional offshore stations of 1996 (see above) did not affect results.

Results and discussion

The upper water column was generally cooler and less saline in 1993 and 1996 than in 1994 and 1995 (Fig.2). Mean zooplankton displacement volume (ZDV), measured from the catch of the 0.250-mm mesh net, was higher in the "cool" years (1993 and 1996), especially in 1996 when it was almost twice as much than in the "warm" years (1994 and 1995) (Fig.2).

A total of seven species of Myctophidae were identified in the ichthyoplankton collections (Table 1). Most of them (*B. glaciale, C. maderensis, M. punctatum, H. benoiti, L. crocodilus*) were more abundant in 1996 (Table 1, Fig. 3). *M. punctatum* and *H. benoiti* had also relatively high abundance in 1993 (Fig. 3).

This pattern of interannual variation in the abundance of myctophid larvae was similar to larvae of the anchovy, which were more abundant in June 1993 and June 1996 (4). Interannual differences in the environmental conditions observed during June in the NE Aegean Sea were attributable to cold and wet winters in 1993 and 1996 (4).

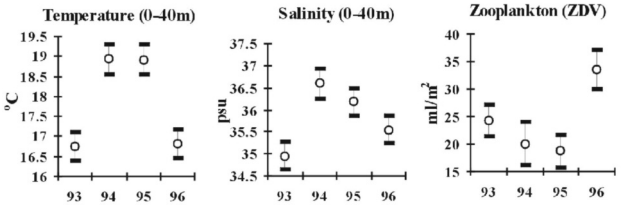

Fig. 2. Mean values and 95% confidence intervals for selected environmental parameters

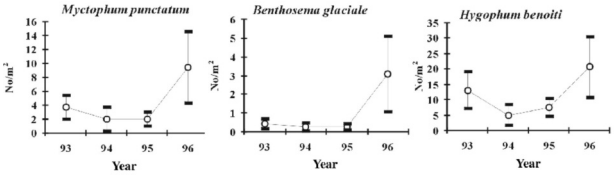

Fig. 3. Mean abundance and 95% bootstrapped confidence intervals for myctophid larval species exemplifying interannual differences.

Table 1. NE Aegean Sea. Mean abundance (larvae/m^2) of myctophid larvae in June 1993, 1994, 1995 and 1996.
Asterisks denote non-overlapping 95% bootstrapped confidence intervals between 1996 and 1994-1995.

Species	1993	1994	1995	1996
Benthosema glaciale	0.42	0.19	0.24	**2.51***
Ceratoscopelus maderensis	4.00	16.77	17.42	**33.00***
Diaphus holti		0.03	0.03	
Hygophum benoiti	12.11	4.67	7.09	**19.58***
Lampanyctus crocodilus	0.17	0.75	0.36	1.65
Lobianchia dofleini	0.34	0.20	0.62	0.84
Myctophum punctatum	3.50	1.62	1.86	**8.50***

In a way similar to short-term within-year changes, interannual variability in the abundance of larval fishes in the plankton, particularly during the transitional period of spring-early summer, may reflect variability in physical processes and be particularly useful in highlighting reproductive adaptations of species to the pelagic environment (5).

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INTRODUCING SELECTIVE DEVICES IN THE GREEK TRAWL FISHERIES

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Abstract

The project Netrasel aimed to test a grid system to separate fish from Norway lobster in the Greek bottom trawl fishery. The results show that the grid was proved to be functional and selection of target species and sizes was occurred. The introduction of grids in the commercial trawl fishery should help in the reduction of discard problem in multispecies fisheries.

Keywords : Aegean Sea, Eastern Mediterranean, trawl surveys, Teleostei, Decapoda.

Introduction

Selection grids are now widely used in many commercial fisheries, for both fish and crustacean sorting. They are seen to deliver tangible benefits to conservation and sustainable fisheries development (1,2). The aim of this work was to adapt the grid technology developed in the North Sea fisheries to deal with the specific discard problems associated with the Greek fisheries. Catch comparisons were undertake in order to test and to prove the performance of the western European trawl with the use of a selective grid and two codends in the conditions of Aegean Sea. The purpose was to evaluate the selectivity of the three grids used in the sea trials.

Materials and methods

The grids were manufactured from a semi-flexible polymer and positioned at the front of the extension. The extension of the net had a separator panel and this divides into two codends, the lower and the upper being manufactured from 30mm netting. The grids have the following characteristics : 800mm wide, 850mm length, bar spacing 25/30/35mm and gap 150/200mm. With the grid 35mm/200mm, a netting deflector in the shape of funnel was placed in order to "guide" the catch to the base of the grid, making easier for the crustaceans (Norway lobster and shrimp) to access the gap of the grid.

Two sea trials with a commercial trawler were effectuated in the North Aegean Sea to test the selective grid devices. The vessel used operates a single otter trawl. The first sea trials (A) took place from 8-13 May 2000. Two primary grids (25mm/200mm and 30mm/150mm) were used for fish/Norway lobster selection. The second sea trials (B) took place from 18-23 September 2000, and we use a different grid (35mm/200mm). At the end of each haul, the nets and the cod-ends were taken on board. After the cod-ends were emptied, the catches were separated into species level.

Results

A total of 12 hauls were carried out during the first sea trials (A), at depths ranging from 338-460m. During the second trials (B), 10 hauls were carried out. Depths of the hauls range from 106-400m with mean depth 231m, considerable shallower than the sampling in May. Because of the shallower depth, we found differences in species composition and abundances in relation to the previous sampling.

With the first grid (25mm/200mm), five hauls were completed. A total of 1165 specimens of Norway lobster were caught with this grid, and the percent of retention in the lower cod end were from 70,5-75,9% (mean 73,7%). With the second grid 30mm/150mm, six valid hauls were completed and were fished 1066 specimens of Norway lobster. The percent of retention in the lower cod end were from 58,6-79,5% (mean 73,3%). During the second sea trials, nine hauls have been measured using the grid 35mm/200mm. Only 238 individuals of Norway lobster were fished and the percent of retention in the lower cod end ranged from 66,7-91,7% (mean 83,2%). Generally, the vast majority of Norway lobster was found in the lower codends of all three grids (73,3-83,2% of the total catch). In the upper codend were found fewer specimens and measured more than 50mm of carapace length as seen in Figure 1.

The size selection of Norway lobster seems to be different between the upper and lower cod-end as a result of the selection made by the grids. A significant difference was found in the mean carapace length of Norway lobster between the upper and lower cod-end (1-way ANOVA test, $p<0,05$). Moreover, the higher mean length was found in the upper codend (42,5mm) while in the lower was smaller (35,2mm).

The results obtained for the shrimp *Parapeneus longirostris* show that the average retention in the lower codend was varied from 51,4% (25mm/200mm), to 48,1% (30mm/150mm) and to 70,1% (35mm/200mm). Furthermore, the mean carapace length of shrimp

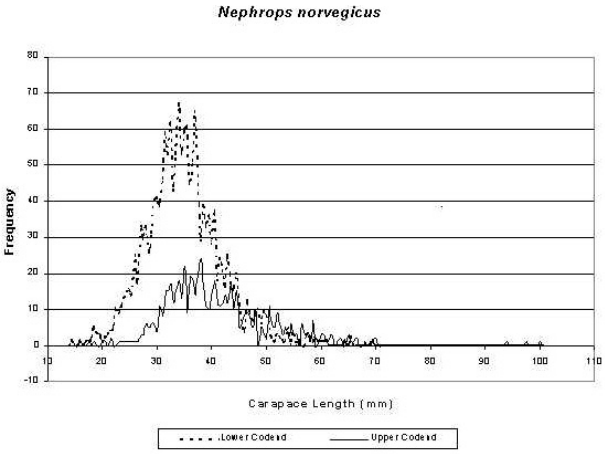

Figure 1.

was found to be statistically different for the upper and lower cod-end in all cases ($p<0,05$).

Hake *Merluccius merluccius* was separated quite acceptable with the use of the grids. The average percent of retention in the upper codend was from 62,1% (25mm/200mm) to 72,2% (30mm/150mm). At the second sea trials, the great majority of fish with TL<200mm (N=1052) was found mainly in the lower codend (mean retention in the upper codend was 31%), while the bigger sizes (TL>200mm, N=361) are located mainly in the upper codend (81% percent retention). The selection pattern of hake over the length classes was found to be statistically different for the upper and lower codend ($p<0,05$).

Discussion

In theory and based on the experience gained in the North Sea (1), with the use of selective grids is possible the separation of fish from Norway lobster. From our results it seems that fish try to avoid the grid and lead to the upper codend, while Norway lobster pass through the gap and through the bars of the grid and direct to the lower codend. The percent of Norway lobster that remains in the lower codend arrives to 92% (haul 5B) - ranged from 59-100% with a mean of 77% at all hauls - a quite remarkable figure for conditions of real fishery. The size classes of Norway lobster are selected with the grid and only few and big individuals are not selected and go toward the upper codend, together with the fish. The other target as *P. longirostris* and *M. merluccius* show a more complex pattern of selectivity; small hake are directed with priority towards the lower codend (69%), while bigger fish are mainly found in the upper codend (81%). Finally, the shrimp was separated with the grid (30%-70% in the upper and lower codend respectively) but not size selection was achieved.

Actually the conclusion of the two sea trials in N. Aegean Sea is that the separation of Norway lobster and fish is quite feasible with the use of selective devises as the one used in the sea trials of the project.

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VARIABILITY IN FISH LANDINGS, UNCERTAINTY AND ECOSYSTEM MANAGEMENT : AN EVOLUTIONARY PERSPECTIVE

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Abstract

In this report I briefly discuss some aspects of fish landing variability, which, together with other facts, contribute to the failure of conventional fisheries models and management practices. Consequently, I argue that in evolutionary terms the effects of climate on landing variability differ from those of fishing and that placing fisheries management into an ecosystem framework is the only alternative compatible with an evolutionary perspective.

Keywords : Fisheries, Fishes, Coastal management

Variability in fish landings and uncertainty

Fisheries landings (Fig. 1) are generally highly variable at different time scales and there have been various attempts to describe their variability pattern (e.g. 1,2), the results of which indicate that landings exhibit trends and cycles, with their variability increasing with the length of time over which it is calculated. Such patterns in variability have important ecological and managerial implications (for review see : 3). Firstly, they suggest that there is not any equilibrium yield, the latter being the basis of most conventional models presently used for fisheries management. Secondly, variability, by introducing uncertainty into various estimations, which is not usually taken into account in yield projections, results in increased risk of stock depletions. Thirdly, because variability increases with a decrease in body size, one may assume that fishing, by decreasing body sizes, should increase variability.

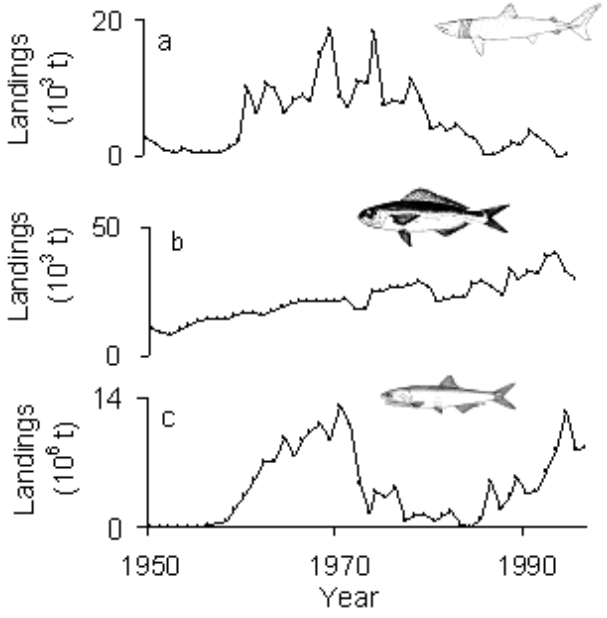

Fig. 1. Landings of (a) *Cetorhinus maximus* in NE Atlantic, (b) *Boops boops* in Mediterranean and (c) *Engraulis ringens* in SE Pacific, 1950-1996 (data from FAO), which although differ by 3 orders of magnitude all exhibit trends, cycles and increasing variability with time (Stergiou unpubl. data).

Thus, conventional fisheries models are inadequate for dealing with the present situation because landings at long time scales do not satisfy the assumption of equilibrium conditions and, secondly, because of fishing-induced increase in uncertainty. In general, fish stocks have adapted to the dynamics of their host ecosystems through long evolutionary processes. Such an adaptation must also concern the pattern of their variability as well as those of their predators and preys. Thus any factor affecting variability may have important evolutionary repercussions for the species or ecosystems in concern. This issue is discussed below.

Factors affecting variability and ecosystem management

Two of the most important factors affecting variability are climate and, in recent decades, excessive fishing mortality expended on fish stocks. Although it is rather difficult to separate the effects of the two factors, they must differ in terms of evolutionary repercussions. In general, no environmental factor is considered *a priori* as unfavourable, and organisms (or ecosystems) have not to resist but simply to react (*sensu* 4). As far as organisms manage to adapt to the new conditions (i.e., the new state is within the evolutionary norm of reaction of the organisms), the imposed "stress" is not only harmless but also constructive [eu-stress; *sensu* Lichtenthaler, cited in (4)] because it results in improved resistance and adaptive evolution. However, if the adaptability of the organism is overtaxed then the imposed stress can be destructive [distress; sensu Lichtenthaler, cited in (4)], leading to permanent damages or even to extinction (i.e., catastrophic events).

Intensive fishing activities, practised with highly efficient, non-selective fishing gears and mass-detection electronic equipment, have imposed, especially during the last decades, new conditions (*e.g.*, heavy size-related mortality rates) at a fast pace and over large geographical areas, thereby potentially affecting all populations of a species at the same time (3,5). On the short-time scale, species may react to fishing pressure by reproducing earlier (*e.g.*, 3,5), which is against previously evolved adaptation patterns and contributes to increased variability. Over the long-term, fishing may increase the overall population variability and decrease the re-colonization chances of extinct populations through dispersal from extant populations (i.e., the rescue effect). This results in a lower viability of the metapopulation than if the new conditions were not imposed to all populations (*e.g.*, 6). Since genetic changes caused by fishing are not easily reversed by altering fishing patterns (*e.g.*, 5), fishing-induced changes in variability, being also size-related, will also not be easily reversed.

Thus, over the long-term scale, fishing, when compared to climate, most likely approximates distress, having the potential to bring about drastic changes in total abundances as well as extinctions. Indeed, fishing has drastically reduced fish abundances (*e.g.*, 3,7) whereas fishing-induced species' extinctions, or near extinctions, are more frequent than previously thought (8). Hence, management models and strategies should be redesigned. Placing fisheries management into an ecosystem framework seems to be the only alternative (*e.g.*, 3,7,9), compatible with an evolutionary perspective. Within such a framework, the use of ecosystem modeling tools such as ECOPATH (9) and the adoption of a variety of "ecosystem" objectives, indicators and corresponding reference points that trigger management actions becomes a necessity (7). The establishment of large-scale (i.e., more than 40% of the fishable management area) marine protected areas, in which fishing will be totally prohibited, satisfies simultaneously the various objectives for ecosystem management (3) and provides a natural laboratory for studying variability.

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TRAMMEL NET CATCH SPECIES COMPOSITION IN CYCLADES WATERS (AEGEAN SEA, GREECE)

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Abstract

In the present study, we compared the species composition of the trammel net catches (inner mesh sizes : 40, 48 and 56 mm, stretched) in Cyclades (off Naxos Island), using data from 41 experimental fishing trials conducted during 1999-2000. *Mullus surmuletus* and *Pagellus erythrinus* dominated the catches in terms of numbers and weights. Multivariate analysis revealed the formation of mesh-size/season groups reflecting to a large extent the seasonal effect.

Keywords : Aegean Sea, Cyclades Islands, Coastal management, Fisheries, Fish

Introduction

Small-scale fisheries contribute significantly in terms of weight and value to the total Greek fishery (1). Yet, little quantitative information is available on various aspects of the Greek trammel net fisheries (2-4). In this report, we compared the catch species composition and overlap for different mesh sizes of trammel nets in the Cyclades (off Naxos Island).

Materials and methods

Forty-one fishing trials were carried out in the Cyclades (off Naxos Island, Aegean Sea), using trammel nets of 3 different mesh sizes (40, 48 and 56 mm, stretched length; 750 m per mesh size). Sampling took place seasonally from October 1999 to September 2000. For the study of gear overlap, matrices comprising the weights of all species per 1000 m net from each mesh size and season were constructed. From this matrix, triangular matrix of similarities between all pairs of meshes was computed, using the Bray-Curtis similarity index applied on logged data, and subjected to both clustering (group-average linking) and non-metric multidimensional scaling (MDS), using PRIMER(5).

Results and discussion

Overall, all mesh sizes combined caught a total of 4677 specimens, belonging to 61 fish, 4 cephalopod and 3 crustacean species. The 40 mm trammel net catch was dominated, both in terms of numbers and weight, by *Mullus surmuletus* and *Pagellus erythrinus*, the 48 mm trammel catch by *Diplodus annularis* and *Mullus surmuletus*, numerically, and *Mullus surmuletus* and *Scorpaena porcus*, in terms of weight, and the 56 mm trammel catch by *Pagellus erythrinus* and *Scorpaena porcus*, both in terms of numbers and weight (Fig. 1).

Both cluster and MDS indicated that, at the 60% similarity level, the 12 mesh-size/season combinations fall into groups reflecting the seasonal effect (Fig. 2). Group I was dominated by *Mullus surmuletus* (24.1%), *Sepia officinalis* (7.7%) and *Octopus vulgaris* (7.7%), whereas Group II was dominated by *Pagellus erythrinus* (13.7%), *Scorpaena porcus* (13.2%) and *Mullus surmuletus* (11.3%).

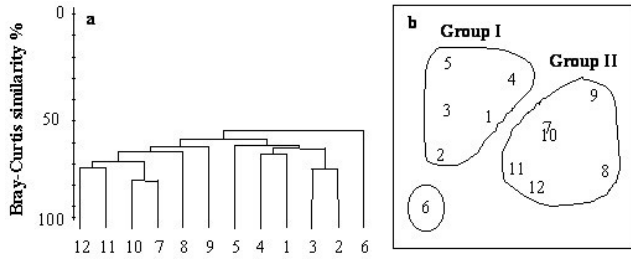

Figure 2. (a) Dendrogram for group-average clustering and (b) multidimensional scaling (MDS) of catch weights of all species per mesh size and season combinations.
1=Aut. 40 mm; 2=Aut. 48 mm; 3=Aut. 56 mm; 4=Win. 40 mm; 5=Win. 48 mm; 6=Win. 56 mm; 7=Spr. 40 mm; 8=Spr. 48 mm; 9=Spr. 56 mm; 10=Sum. 40 mm; 11=Sum. 48 mm; and 12=Sum. 56 mm.

The catch species composition in the study area differs from those in Kastellorizo waters – 44 mm trammel net catch : numerically dominated by *Spicara maena, Sparisoma cretense, Siganus luridus* and *Boops boops*; (3)–, and Kyparissiakos Gulf – 56 mm trammel net catch : numerically dominated by *Lithognathus mormyrus, Psetta maxima, Engraulis encrasicolus* and *Scorpaena scrofa*; by weight : *Lithognathus mormyrus, Psetta maxima, Sarpa salpa* and S*phyraena sphyraena*; (4). In contrast, they are similar to those in South Evvoikos Gulf (combined trammel net catch of 38, 48 and 60 mm meshes : dominated in terms of numbers and weights by *Diplodus annularis, Pagellus erythrinus, Mullus barbatus* and *Mullus surmuletus*; 2).

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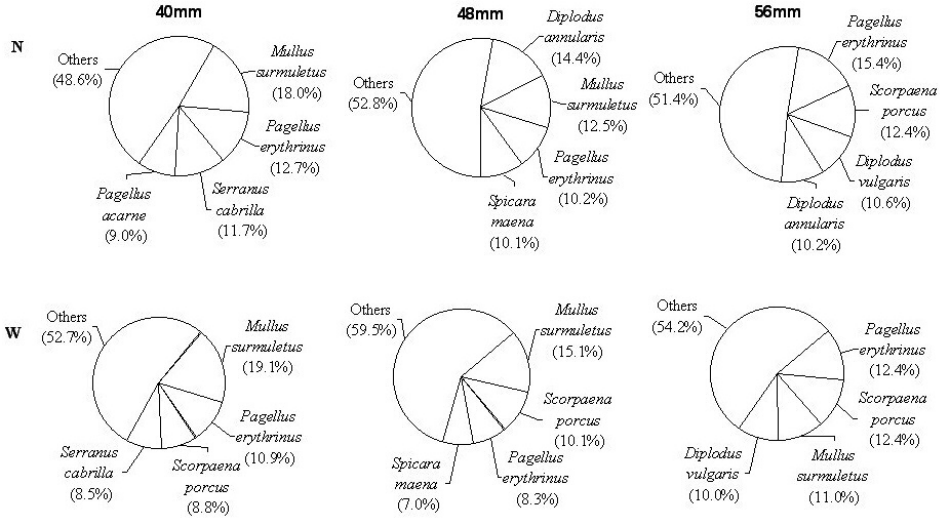

Figure 1. Catch species composition by number (N, upper) and weights (W, lower) of trammel nets by mesh size (40, 48 and 56 mm, stretched length).

REPRODUCTIVE CYCLE AND FECUNDITY OF BLUE-MOUTH (*HELICOLENUS DACTYLOPTERUS*, DELAROCHE, 1809) IN THE EASTERN MEDITERRANEAN (IONIAN SEA, GREECE)

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Abstract

In this work, preliminary results on the reproductive cycle and on the fecundity of *Helicolenus dactyloperus* are presented. The breeding period of the species was found to occur from December to March in the Eastern Mediterranean. Total fecundity ranged from 330639-9559 and batch fecundity ranged from 22630-91 oocytes. Ovaries contained a pronounced bimodal distribution of oocyte diameters, ranging from 0.22 to 0.64 mm and from 0.7 to 1.24 mm, indicating that the blue-mouth exhibits group-synchronous oocyte development.

Keywords : Ionian Sea, reproduction, spawning, teleostei.

Introduction

The blue-mouth, *Helicolenus dactylopterus* (Delaroche, 1809), is a benthic species which inhabits the seabed at between 200 and 1000 m depth (1). It is widely distributed in the eastern Atlantic, from the Norwegian coasts to the south-west coast of Africa (2). In the Mediterranean, blue-mouth is found along the continental shelf edge and slope, where it is caught as by catch species of the bottom trawl, long line and gill net fishery (3).

Material and methods

Samples of blue-mouth were collected on a monthly basis with a hired commercial bottom-trawler in the East Ionian Sea (West Coast of Greece) during July 1999 to June 2000. The depths of the sampling stations ranged from 300-750 m. A total of 1229 specimens were collected (462 males and 767 females). The maturity stage was determined using the gross sexual classification scale of Nikolsky (4). Spawning period was determined from the analysis of the monthly evolution of both the percentages of mature individuals and the mean gonadosomatic index (GSI) throughout the sampling period. All individuals classified as stages I to II were considered to be sexually immature, stage III as pre-spawning and those classified as stages IV to VI were considered to be sexually mature. The volumetric method (5) was used for the study of the fecundity. Overall, 22 gravid gonads were examined. Oocytes were sized and counted. Hydrated and non hydrated oocytes were counted and measured. Steel screens with openings 1, 0.5 and 0,25 mm were used to separate the oocytes in size ranges.

Results

The occurrence of gravid and spawning (stages IV-V) female blue-mouth is predominant during winter months (January-March), indicating the spawning time (Fig. 1). On the other hand, pre-spawning females were found from November to July. The GSI of the females was high during winter months (Fig. 2). In December there is an increase that peaks in February (1.27). It thereafter decreases slightly in March, and in June approaches again the low values (0.19) similar to the rest of the year.

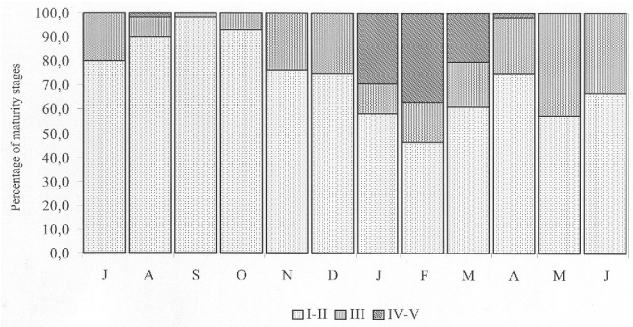

Figure 1. Monthly percentages of immature (I-II), pre-spawning (III) and spawning (IV-V) of female blue-mouth.

Ovaries contained a pronounced bimodal distribution of oocyte diameters ranging from 0.22 to 0.64 mm and from 0.70 to 1.24 mm (Fig. 4). The mean diameter of hydrated oocytes was found to be 0.834 mm. Total fecundity felt into the range 330639-9559 oocytes while batch fecundity ranged from 22630-91 oocytes.

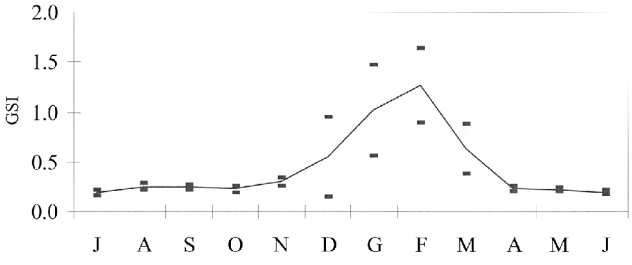

Figure 2. Annual cycle of the gonadosomatic index (mean +/- SD) of female blue-mouth.

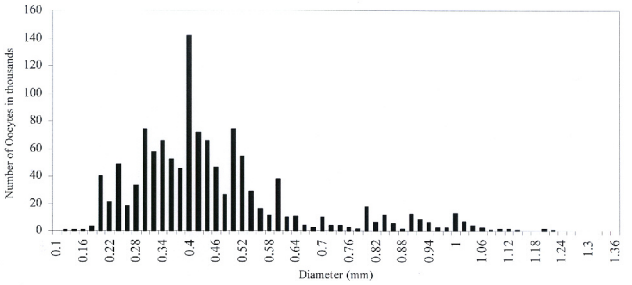

Figure 3. Diameter distribution of the oocytes.

Conclusion

The seasonal patterns of the percentage of mature blue-mouth (stage IV and V) and the mean GSI, indicate the existence of a short reproductive period, which extends from December to March. From the preliminary results of the fecundity it can be said that this species exhibits group-synchronous oocyte development.

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ROSE SHRIMP FISHERY'S ASSOCIATED FAUNA IN NOT EXPLOITED GROUNDS ON THE ALBORAN SEA SLOPE (WESTERN MEDITERRANEAN SEA)

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Abstract

We present a quantitative analysis of the composition (commercialised catch and corresponding discard) of trawl catches, in a non exploited fishing ground on the Alboran Sea (Western Mediterranean) between 500-800 m depth. The target species was the Rose shrimp *Aristeus antennatus* Risso, 1816. A sampling programme on board commercial vessels was carried out from September 1997 to May 1998.

Keywords : Decapoda, Alboran Sea, fisheries, demersal, continental slope.

The rose shrimp *Aristeus antennatus* Risso, 1816 is a deep water penaeid of importance to commercial fishing. Its geographical range includes the Mediterranean and the Atlantic coast from Lisbon (Portugal) to the Cape Verde Islands. In the Alboran sea commercial trawling catches are made on the continental slope and around the Alboran island at depths of 500 to 800 m. Rose shrimp is the target species on deep waters, and the typically multi-species Mediterranean fishery becomes an almost mono-species fishery in deep waters (1). The fishing activity was carried out during 5 to 6 day-surveys in the study area. The followed effect of the fishing activity on this not exploited ground over several days was "to clean" them, that is to say, to increase the rose shrimp yields by removing competitors. The purpose of this study was to analyse the *Aristeus* fishery in the Alboran sea from boarding in commercial vessels, considering two fractions in the total catch : commercialised and discarded. The composition of these fractions by number and weight are analysed, together with the discard types observed in this fishery.

Material and methods

The sampling programme was carried out by observers on board during normal fishing activity, from September 1997 to May 1998, in the North Alboran Sea, western Mediterranean. The project's main goal was to study of the faunistic list and yields in bottoms where the trawl fleet does not work regularly. Two commercial trawlers were used equipped with a trawl of 50 mm cod-end mesh size. Only one stratum has been explored, from 500 to 800 m, according with *A. antennatus* distribution. For each haul, date, position, duration, depth and course were noted. The weight of the commercialised and discarded catch was estimated by species using dynamometers (± 5 g). The catch of the total, commercial and discarded fractions by haul was standardised to hourly yields (kg/h and n/h). Size frequency distributions were monthly obtained for commercial species and the most frequent discarded ones. Mean weight and number per fishing hour and standard deviation were calculated for the discarded and commercial species.

Results

A total of 179 hauls were carried out between 500-800 m depth. However, discard fraction only has been studied in 94 hauls. 115 species were identified. The most frequently represented groups were fish, with 55 species, crustaceans with 26, and molluscs with 21. The relative proportion corresponding to the commercial and discard fractions was 65% and 35% respectively. Table I shows the mean weight for the discard and commercial fraction. *Galeus melastomus* was the species with a highest mean weight, followed by *Trachyrrhynchus trachyrrhynchus, Phycis blennoides* and *A. antennatus*. Among the discarded species pointed up the presence of *G. melastomus* and *Nezumia aequalis*, followed by *Etmopterus spinax* and *Hoplostethus mediterraneus*. *Geryon longipes* stands up (or reached the highest values) within the discarded crustaceans group. *A. antennatus* was the most abundant species in number of the commercial fraction.

A few discard types were observed in this fishery. 85 species, with no commercial value, are always discarded. A varying criteria is applied for those species with a low commercial value (*G. longipes, T. trachyrhinchus, H. mediterraneus*), depending on the catch quality. Its price increases when they have been fished recently.

Discussion

Chondrichthyans are a very sensitive group to fish exploitation because of its biology : slow growth, late maturity and low fecundity (2). In this fishing ground, Chondrichthyans yields are clearly higher than those in exploited grounds in the area, where Almeria fleet often works.

Skipper experience supports that *A. antennatus* yields increase with a higher fishing effort while Chondrichthyans decrease eventually. They state that repeating the same haul many times (with one or many ships) could prove this along the same day. This experience was discussed by Massutí (3) for the same area in the 1960s decade. The huge differences when comparing with mean abundances from close exploited fishing grounds (4) seem to confirm this hypothesis. The net effect on the bottom, moving around the mud, leads to *A. antennatus* come up and enter into the nets. This hypotheses and others have been discussed by Sardà (1) and this one does not appear to be the main cause. The removal of demersal fish competitors from the fishing grounds at a higher rate than shrimp could have a real influence on *A. antennatus* yields.

Table 1. Mean weight per fishing hour and standard desviation for discarded and commercial species. Results from 94 hauls in two commercial trawlers in the Alboran Sea.

SPECIES	DISCARD		COMMERCIAL	
FISHES	**g/h**	**sd**	**g/h**	**sd**
Alepocephalus rostratus	2248.7	6046.8		
Centrolophus niger			14.7	130.8
Centrophorus uyato	5.7	50.3	557.5	1428.5
Chauliodus sloani	12.5	33.7		
Chimaera monstrosa	399.4	1363.6		
C. coelorhynchus	564.4	2584.7		
Conger conger	474.2	967.1	208.2	593.5
Dalatias licha	30.6	124.9	540.7	1588.1
Epigonus denticulatus	3.4	12.5		
Epigonus telescopus	48.7	97.9	22.3	198.5
Etmopterus spinax	3241.3	4414.5		
Gadiculus argenteus	61.2	527.3		
Galeus melastomus	9859.3	16401.3	21583.0	31453.4
Helicolenus dactylopterus	25.0	86.8	1102.6	2084.0
Hoplostethus mediterraneus	3074.5	4332.4	1240.1	2295.3
Hymenocephalus italicus	3.8	12.8		
Lampanyctus crocodilus	1515.8	3203.1		
Lepidopus caudatus	415.1	1715.6		
Lepidotrigla cavillone	6.5	57.8		
Lophius budegassa			773.0	1829.1
Merluccius merluccius	1.2	10.2	2112.0	2386.7
Micromesistius poutassou	709.3	970.5	2492.4	3267.1
Mora moro	2.4	13.3		
Myctophidae	6.9	58.9		
Nezumia aequalis	4589.5	4213.2		
Notacanthus bonapartei	6.7	27.5		
Oxinotus centrina	15.6	88.6		
Pagellus acarne	0.4	3.4	83.2	238.9
Pagellus bogaraveo			271.2	1108.5
Phycis blennoides	154.7	394.3	3927.3	3555.3
Raja circularis	126.6	1125.1		
Raja clavata	93.7	832.6	62.7	316.0
Stomias boa	65.6	128.0	0.0	0.0
Torpedo nobiliana	278.7	2256.4	50.9	322.4
T. trachyrhinchus	667.5	3203.1	6288.2	16773.7
Trachyscorpia cristulata	1.7	14.7	1.7	15.6
Trigloporus lastoviza	26.2	232.6		
Other fishes	7.2	52.8		
CRUSTACEANS				
Aristaeomorfa foliacea			3.8	33.8
Aristeus antennatus	11.9	35.0	3830.5	2917.4
Bathynectes maravigna	3.9	16.3	73.3	651.1
Dardanus arrosor	1.4	9.5		
Geryon longipes	433.0	1380.5	1338.4	1754.6
Nephrops norvegicus	0.4	3.4	37.1	172.4
Pagurus alatus	76.1	146.2		
Pasiphaea multidentata	3.6	7.1	12.6	49.4
Plesionika acanthonothus	5.7	7.5		
Plesionika edwarsii	0.1	0.6	22.9	187.8
Plesionika heterocarpus	0.3	2.5	7.3	38.7
Plesionika martia	28.6	78.3	493.7	675.3
Polycheles typhlops	63.8	105.4		
Rochinia carpenteri	8.6	13.2		
Sergia robusta	2.5	3.9		
Solenocera membranacea	2.8	11.1		
Other crustaceans	4.4	28.2		
CEPHALOPODS				
Ancistroteutis lichtensteini	29.1	64.2		
Bathypolypus sponsalis	14.2	32.0		
Histiotheuthis spp	125.3	433.9		
Todarodes sagittatus	60.6	166.2	695.0	1343.5
Other cephalopods	5.2	31.1		
OTHER INVERTEBR.	157.5	939.6		

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RÉSULTATS PRÉLIMINAIRES POUR UNE CARACTÉRISATION BIOCHIMIQUE DE L'ARTEMIA DANS LA SALINE DE SFAX (TUNISIE).

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Résumé

Depuis la découverte de la valeur nutritive des nauplii d'*Artemia* pour les alevins de poissons, l'utilisation de ce crustacé à des fins aquacoles n'a cessé de s'amplifier. Plusieurs souches d'*Artemia* ont été testées en vue d'évaluer leur potentiel d'application en aquaculture. Nous nous sommes intéressé à l'*Artemia tunisiana* (souche de Sfax) pour une caractérisation biochimique de cette souche.

Mots-clés : lagune - salinité - zooplancton - aquaculture.

Les acides gras sont les principaux constituants des lipides dans les organismes aquatiques (1, 2; 3). Ces composés biochimiques assurent un double rôle : un rôle structural associé aux phospholipides membrannaires des cellules et un rôle énergétique assurée par leur apport nutritionnel. La valeur nutritive des acides gras notamment le groupe des acides gras polyinsaturés (de la série n-3 et n-6) fait que ces composés sont toujours présents dans le régime alimentaire des organismes zooplanctoniques (4).

La qualité nutritionnelle de l'*Artemia* est déterminée par la richesse en acides gras essentiels : acide linolénique (18:3) (n-3), acide écosapentaénoïque (20:5) (n-3) et acide docosahéxanoïque (22:6) (n-3) (5).

Le dosage des acides gras par la méthode de Folch (6), en utilisant la technique de chromatographie en phase gazeuse (CPG), au niveau des unités fonctionnelles d'*Artemia* (nauplii et adultes mâles et femelles) vivant dans les bassins sursalés de la saline de Sfax a montré une variation qualitative et quantitative en contenu lipidique entre les nauplii et les adultes (tableau 1 et figure 1).

Au niveau des nauplii, on remarque une biomasse importante en acides gras en C18:1 (acide oléïque) et en C16:0 (acide palmitique). Cette richesse en acides gras indispensables à la croissance des alevins de poissons met en relief la valeur nutritive de l'*Artemia*. Au niveau des mâles adultes, nous assistons à des quantités équivalentes à celles observées au niveau des nauplii, à l'exception de la présence de l'acide linoléïque (C18:3) synthétisé au niveau des mâles. En ce qui concerne les femelles adultes, elles présentent des teneurs plus importantes en acides gras (C16:0, C18:1 et C18:3) que les nauplii et les adultes mâles avec une richesse particulière en acide gras linolénique (C18:3). Ceci pourrait être expliqué par le fait que les femelles triées lors de l'analyse sont ovigères et donc il s'agit essentiellement d'une stratégie de reproduction adopté par l'*Artemia*. La comparaison entre les teneurs en acides gras saturés et insaturés (figure 2) montre que ce sont les femelles qui ont le maximum d'acides gras saturés et insaturés avec des concentrations supérieures à 70μg / individu.

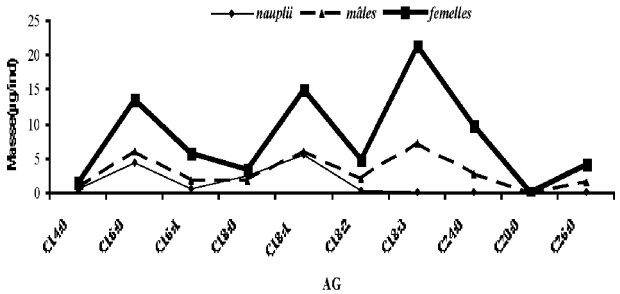

Figure 1 : variation qualitative et quantitative en acides gras au niveau des unités fonctionnelles d'*Artemia*

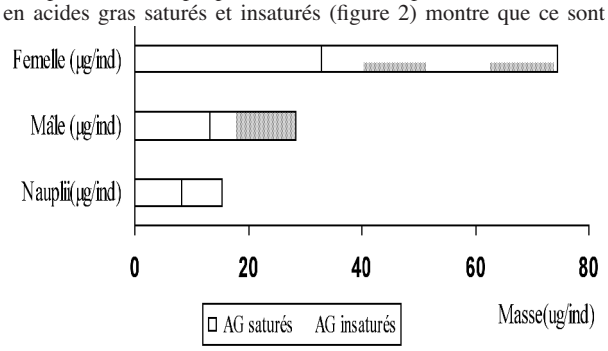

Figure 2: variations des teneurs en acides gras saturés et insaturés au niveau des nauplii, adultes mâles et femelles d'*Artemia*.

	Nauplii		Mâles		Femelles	
	pourcentage(%)	masse(µg/ind)	pourcentage(%)	masse(µg/ind)	pourcentage(%)	masse(µg/ind)
Acide méristique C14:0	4.008	0.683	2.059	0.661	1.988	1.630
Acide palmitique C16:0	26.988	4.599	19.221	6.172	16.81	13.782
Acide palmétoleïque C16:1	4.423	0.754	6.178	1.984	7.076	5.802
Acide stéarique C18:0	15.185	2.588	6.091	1.956	4.236	3.473
Acide oleïque C18:1	32.624	5.559	18.736	6.017	18.359	15.052
Acide linoleïque C18:2	2.462	0.419	6.343	2.037	6.092	4.995
Acide linolénique C18:3	1.687	0.287	22.524	7.233	26.188	21.471
Acide ligno-sérique C24:0	0.782	0.133	8.736	2.805	11.979	9.821
Acide arachidonique C20:0	0.558	0.095	0	0	0.152	0.125
Acide eicosahexaénoïque C26:0	1.503	0.256	4.923	1.581	5.088	4.172

Tableau 1: variation des teneurs en acides gras (exprimés en µg/ individu) au niveau des nauplii, des adultes mâles et femelles de l'*Artemia*.

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MORPHOMETRIC COMPARISON OF TWO *SCOMBER JAPONICUS* POPULATIONS IN EASTERN AND WESTERN MEDITERRANEAN

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Abstract

Two populations of *S. japonicus* from Eastern and Western Mediterranean were compared using multivariate morphometric analysis. The principal component analysis showed that the cephalic measurements are bigger in the Eastern Mediterranean population. These morphological differences may be related to genetic or environmental factors.

Keywords : Scomber japonicus, biometrics, Mediterranean

Introduction

Fisheries management is based upon stocks or population units (1), which may differ due to genetic and/or environmental factors (2). Fish morphology can be used to determine these differences (3,4) that can be directly related to genotype, although there is a likely variability related to environmental factors (5). The species *Scomber japonicus* denominated commonly as chub mackerel is a widely distributed pelagic species in the Mediterranean (6), but little is known about its population structure. The aim of this document is to study the populations of *S. japonicus* from two different sites of the Mediterranean and to examine their likely differences by comparing their morphomertric features.

Material and methods

The study was carried out in two geographically separated areas (Kavala, Greece, E. Med. and Barcelona, Spain, W. Med.) during the period April – June 2000. Samples with the maximum range of lengths were taken from each port and classified in length class intervals of 5 mm. 35 individuals are selected in each area. 15 morphological measurements were selected (Fig. 1). Body size and allometric effects that occur during fish growth were avoided by normalising all measurements to standard fork length (7). The standard fork length in this study is 25.0 cm. The principal component analysis (PCA) used in this study was carried out from the correlation matrix R from the standardised morphometric variables.

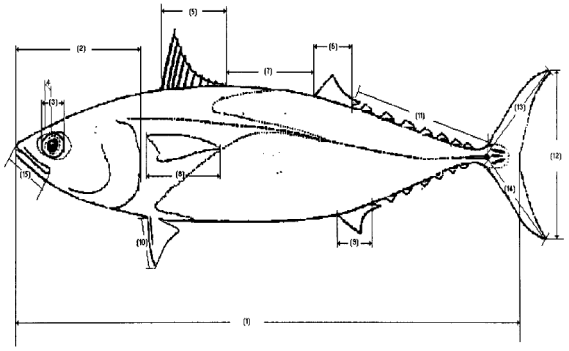

Fig.1. Scheme of 15 selected measurements. 1, Fork length. 2, Head length. 3, Orbital diameter. 4, Interorbital length. 5, First dorsal fin length. 6, Second dorsal fin length. /, Interspace. 8, Pectoral fin length. 9, Anal fin length. 10, Pectoral first fin ray length. 11, Tail length. 12, Caudal fin height. 13, Upper first ray length of caudal fin. 14, Lower first ray length of caudal fin. 15, Jaw length.

Results and Discussion

The PCA revealed a distribution gradient for the two groups analysed. Individuals from Barcelona are placed at the negative values, and those of Kavala at the positive values of the gradient. The first principal component explained 42.21% of the total morphometric variability (Fig. 2). The coefficient of morphometric variables of the first component, which were positive and negative, indicates shape differences along the first axis (Table 1). Kavala specimens are characterised by a greater relative size of the cephalic measurements (Fig. 1, Table 1). The second principal component (13.69%) showed much less variability than the first one (Fig. 2). This variability is related with intragroupal variation between specimens of the same area.

Multivariate morphometric analyses, used in this study, are good quantitative tool to identify intraspecific variation of *S. japonicus*. The principal factors of variability between the two groups are related with cephalic dimensions (head, eyes and jaw), that are bigger in the Eastern Mediterranean groups. Biometric studies carried out in *S. japonicus* along the W. S. Atlantic coast indicate differences in the development of cephalic measurements related with water temperature and stage of development (8). Studies based in otolith shape, found differences between two genetic separated populations of *S. scombrus* in the N. Atlantic (9). In our study, the size and allometric effect was removed. In consequence, the morphological differences may be related to genetic or environmental factors. Validation of our results is needed by comparing morphometric and genetic analyses.

Table 1. Factors loading the intraspecific variability in the PC analysis. The highest correlated variables with the axis 1 (PC1) and axis 2 (PC2) are indicated in black frame

Variables	PC1	PC2	VariablesN	PC1	PC2	Variables	PC1	PC2
2 Head l.	0.936	0.012	7 Interspace	-0.019	-0.193	12 Caudal h.	0.532	0.098
3 Orbital d.	0.902	-0.035	8 Pectoral l.	0.741	-0.087	13 Upp. caudal	0.707	0.222
4 Interorb. l.	0.729	-0.060	9 Anal l.	-0.124	0.831	14 Low. caudal	0.724	0.181
5 1st dorsal l.	-0.744	0.368	10 Pelvic l.	-0.026	0.864	15 Jaw l.	0.905	-0.120
6 2nd dorsal l.	0.454	0.292	11 Tail l.	-0.488	-0.323			

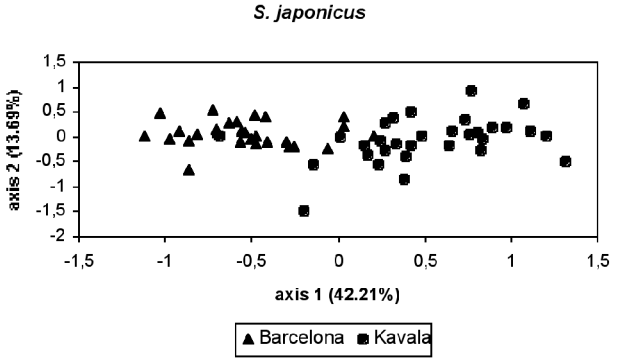

Fig. 2. Principal component analysis (PCA). Scatterplot of factor scores from the intraspecific principal components analysis of two geographic groups of *Scomber japonicus*.

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STRUCTURE OF JUVENILE FISH ASSEMBLAGE IN LOPUD BAY, STRUCTURE OF JUVENILE FISH ASSEMBLAGE IN LOPUD BAY, ISLAND OF LOPUD, SOUTH-EAST ADRIATIC SEA

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Abstract

From May 1998 till June 1999, 1740 juvenile fish specimens, belonging to 14 families and 45 species were caught in Lopud bay. Fish from families Mugilidae (44.02%) and Sparidae (16.03%) dominated the catch. Species *Oedalechilus labeo* (25.45%), *Atherina hepsetus* (15.22%), *Chelon labrosus* (8.44%), *Liza aurata* (8.33%) and *Pagellus acarne* (6.43%) represent 63.90% of total catch. Other species contributed from 0.05% to 6.4 3%. The overall value of richness (D) was 2.92, ranging from 1.97 in September to 4.74 in July. The overall diversity value (H) was 1.52, ranging from 0.71 in September, to 2.21 in July. Eveness (J) values were 0.27 in September and 0.72 in May, with an overall value of 0.53. Total number of caught species was highest in July (28) and lowest in September (14).

Keywords : biodiversity, coastal waters, fishes, Adriatic Sea

Introduction

There are very few publications on ecology and biology of juvenile fish in the eastern part of Adriatic sea. Previous fish studies conducted in this region are primarily related to taxonomy and general fisheries problems (1), while biology of different species [1, 2] and studies of juvenile fish in middle Adriatic sea [3, 4, 5] received little attention. The present study provides the preliminary data on juvenile fish composition in the Lopud bay, island Lopud near Dubrovnik.

Materials and methods

Sampling of qulitative-quantitative composition of juvenile fish in Lopud Bay (south Adriatic; 17°55'E, 42°39'N) was conducted bimonthly in the period from May 1998 till June 1999. Samples were collected with modified beach seine net, 50 m long and 5 m high at the central part with central bag. Mesh size was 8 mm at outer wings and 4 mm at central part of the net. Working depth was from 4 to 0 m. Collected material was fixed in 4% formaldehyde. Species were identified according to publications by Jardas [1] and Soljan [6]. Total length to the nearest 0.1 cm (Lt in mm) and total weight to the nearest 0.01 g (W in g) was measured for each specimen. The community structure was specified by species richness (D), diversity (H) and evenness (J), using the equations proposed by Margalef [7], Shannon [8] and Pielou [9].

Results

During present study total of 1740 juvenile fish specimens, belonging to 14 families and 45 species were caught. The most abundant were Mugulidae (44.02%) and Sparidae (16.03 %). From other commercially interesting species, most abundant were *Atherina hepsetus* (15.22%), *Pagellus acarne* (6.43%), *Mullus barbatus* (6.32%), and *Diplodus vulgaris* (4.48%). The most dominant, from commerically less interesting species, were *Coris julis* (5.45%), *Symphodus cinereus* (2.24%) and *Symphodus roissali* (1.78%). The overall value of richness (D) was 2.92, ranging from 1.97 in September to 4.74 in July. The overall value of diversity (H) was 1.52, with 0.71 in September, to 2.21 in July. Eveness (J) values were 0.27 in September and 0.72 in May, with an overall value of 0.53. Total number of caught species was highest in July (28) and lowest in September (14).

Discussion

Shallow bays have important role in fish early life cycle as places were growth and development occurs prior to departure for deeper waters. These areas provide adequate food quantities, shelter and protection from predators. First fish enterance to shallow bays in south east Adriatic sea occurs in fry stage and only few adult specimens were found in the study area. Higher species number was noted in July and September when temperature conditions are suitable, as opposed to warm summer and cold winter. Similar observation was already noted by Dulcic *et al*. (3, 10]. According to Jardas (1) spring and summer are reproductive seasons for largest number of fish species in east Adriatic sea. A great ranges of richness (D=1.97 to 4.74), diversity (H=0.71 to 2.21) and eveness (J=0.27 to 0.72) values are similar to values obtained in studies in other bays and estuaries [3, 10]. This relatively wide range of values reflects a differential utilisation of Lopud Bay habitats by various fish species. A wide range of richness values is considered as an indicator of the nursery function of a specific area [10]. So, we can suppose that the overall high richness values of fish assemblages in Lopud Bay underline the importance of the area as a nursery ground for several species.

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PRELIMINARY DATA ON THE REPRODUCTION OF MEDITERRANEAN ANCHOVY IN GREEK WATERS

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Abstract
In the Thracean Sea, gonadal maturity of the Mediterranean anchovy peaks in early summer. Size of specimens ranged between 110 and 155 mm TL, males dominating among smaller fish, while females were encountered more frequently in large size groups. Anchovy batch fecundity was estimated by counting oocytes of the largest modal size present in the ovary and was found to range between 2704 and 9.239 oocytes.

Keywords : Teleostei, reproduction, Aegean Sea

Mediterranean anchovy along with sardine constitute the bulk of pelagic catches. The Aegean Sea anchovy catches rank first, and contribute to the combined Mediterranean catches by 36%. Although up to 1987 anchovy catches presented an ascending trend, recent fishery data indicated that the production of anchovy is now following a declining trend. In fact, this decreasing trend is obvious in the whole Mediterranean, and coupled with a parallel increase of the fishing effort, suggests possibly a problem of over-fishing.

The present study provides preliminary data on the sexual maturity, the sex-ratio and the fecundity of the Mediterranean anchovy in the Thracean Sea, contributing to the better knowledge of the species reproduction in this area, which is considered among the most important anchovy fishing grounds in Greek waters.

In June and July 1999, samples of adult anchovies were collected from commercial vessels (purse-seines), as well as by using a hired vessel, fishing outside the commercial fishing grounds, but inside the study area. Immediately after their collection, and in order to prevent deterioration of the ovaries, the abdominal cavity of adult specimens was opened and they were preserved in 10% formalin solution. During sample analysis, the total weight (W; nearest 0,1g), gutted weight (EW; nearest 0,1g), total length (LT; cm, nearest 1mm), gonad weight (GW; nearest 0,1g) and maturity stage according to the Holden & Raitt scale (1) were recorded. Batch fecundity was evaluated by counting oocytes belonging to the largest modal size group, present in the ovaries of 11 females.

Our data revealed that during the sampling period, spawning activities of anchovies were in progress since the 71.5% of the males and the 65.3% of the females were in the IIIrd and IVth maturity stage of the Holden & Raitt scale (1). The gonads of the 20% of the males and the 21.7% of females were at a spent condition. The considerably limited presence of virgin specimens (stage I) should be underlined, reflecting the absence of young anchovies (<110 mm TL) from our samples, mainly due to gear selectivity.

Regarding sex-ratio, males dominated till 134 mm TL, while in the length interval 134-138 mm the sex-ratio did not differ significantly from the theoretical 1:1 value. In larger specimens, however, females outnumber males, dominating completely beyond 146 mm. Males were more numerous than females in all samplings, except : during the end of the spawning season, when females dominated (Fig. 1). One-way analysis of variance indicated significant differences between the mean lengths of males and females (F=68.35, P<0.001).

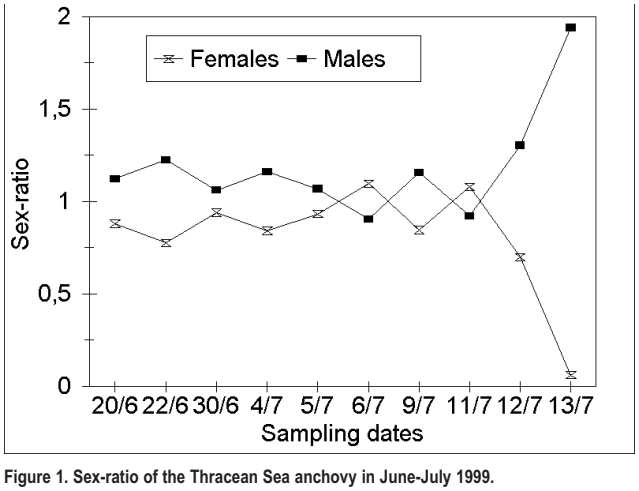

Figure 1. Sex-ratio of the Thracean Sea anchovy in June-July 1999.

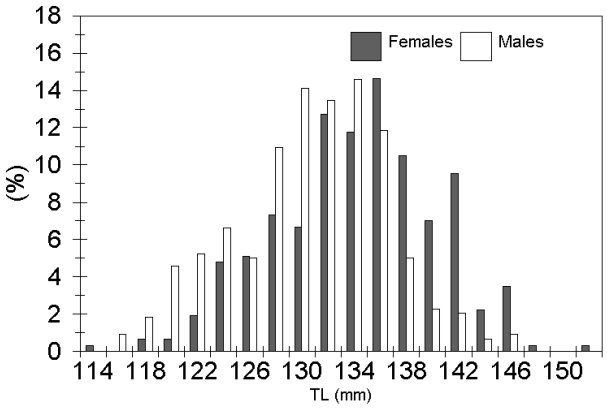

Figure 2. Length frequency distribution of the anchovy collected in the Thracean Sea in June and July 1999.

The study of the length frequency distribution of the anchovies collected in the Thracean Sea revealed that the bulk of the males was comprised between 126 and 136 mm TL, while the majority of the females was between 130 and 144 mm TL. The fact that females reached bigger sizes than males was also mentioned for the anchovy of the Adriatic (2).

Since no hydrated oocytes were found in the samples, fecundity was estimated by counting the largest and most advanced oocytes (Fig. 3). Batch fecundity of the Thracean Sea anchovy appeared to range between 2704 and 9.239 oocytes, values that do not seem to differ significantly from those mentioned for the anchovy of west Mediterranean (3).

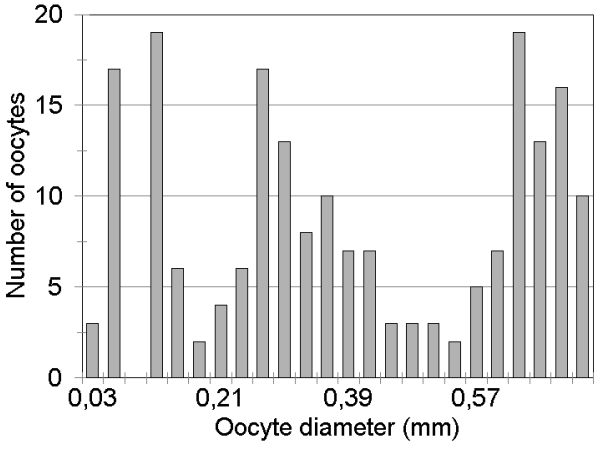

Figure 3. Distribution of the oocyte diameters (maximum dimension) found in the ovary of a 136 mm female anchovy collected in the Thracean Sea in June 1999.

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THE BIOLOGY-ECOLOGY OF A DEMERSAL FISH IN A HIGHLY EUTROPHIC LAGOON OF NORTHEASTERN MEDITERRANEAN

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Abstract
Data on the biology and ecology of the red mullet in a major gulf of western Greece, submitted to high organic enrichment, are provided. The red mullet stock in the study area comprised relatively small specimens, which appeared to perform an ontogenetic movement to the neighbouring Ionian Sea, at the onset of their sexual maturity. Reduced feeding intensity and growth of the specimens in the study area are also discussed.

Keywords : Teleostei, growth, diet, eutrophication

The Amvrakikos Gulf, is a nearly enclosed water body, with a maximum depth of 65 m, in which two rivers discharge relatively large quantities of fertilizers and pesticides used in the intensively cultivated surrounding plains. Moreover, aquaculture farms located in the northern part of the gulf, as well as domestic sewage from three coastal cities, contribute to further organic enrichment. The study of various chemical, as well as biological parameters have revealed that the area should be considered as one of the most eutrophic in the Mediterranean Sea (1). Distribution of water properties in the gulf suggests that surface salinity remains very low throughout the year, resulting to strong stratification of the upper layer, low oxygen values near the bottom and to the formation of laminated sediments at deeper areas and at bottoms of the inner part. The above are possibly connected, at least to a certain extent, with the decline of demersal fish catches in the Amvrakikos in recent years.

The red mullet (*Mullus barbatus*), along with the common sole (*Solea solea*) and the marine shrimp (*Penaeus kerathurus*) constitute the three commercially most important species of the Amvrakikos. The present study provides data on the biology/ecology of the red mullet, in order to shed some light on the status of the stock in the gulf, and clarify certain trends that appear to the respective fishery.

Samples were collected from 13 stations, using a 17 mm trammel net, during five seasonal cruises conducted in the Amvrakikos. The fork length (FL in mm), body weight (W in grams), sex and gonadal maturity were recorded for each specimen, while the otoliths (sagittae) and stomach were extracted and preserved for studying respectively the age and feeding habits of the species in the Amvrakikos.

In all, 1518 red mullet were caught, the 73.8% of which had a size belonging to the 120-140 mm length interval (Fig. 1a). The dominant age groups of the stock were one and two years, while larger (three-year old) specimens were rarely encountered (Fig. 1b). Mean length-at age appeared to be smaller than in other Greek areas (2), suggesting possibly a reduced growth rate for the species in the gulf. Growth in weight was allometric, implying the existence of thinner specimens for their length. The study of the gonadal maturity of the fish revealed that in May, when red mullet spawn in Mediterranean waters (2), very few specimens with mature gonads were collected in the gulf. The latter could be associated to the fact that the red mullet stock in the Amvrakikos comprised relatively small, sexually immature specimens. In the striped mullet (*M. surmuletus*) the existence of an ontogenetic movement to deeper waters appeared to be triggered by first maturity (3). If this is also the case for red mullet, it appears possible to hypothesize that laminated sediments in deeper areas of the gulf prevent the dwelling of living organisms there, causing possibly the migration to the Ionian sea, where the species appears to reproduce, according at least to the results of an ichthyoplankton survey study (1). Moreover, the feeding intensity of red mullet in the Amvrakikos appeared to be reduced, particularly in the inner part of the gulf and during the winter-spring period. The latter coincides with the period of increased river flow, which seemed to be critical for the benthos of the area (1). The observed reduced feeding intensity might result to reduced growth of the specimens, and was also mentioned for the cod in the gulf of St. Lawrence (4), and was correlated with existing hypoxic conditions. In the framework of the present study, it was impossible to isolate hypoxia effects, as well as those of interacting factors in this highly eutrophic area.

Our data show that the Amvrakikos red mullet stock consists of relatively young, sexually immature fish, and although trawl fishing is prohibited in the gulf, this stock is fully vulnerable to coastal fisheries. Moreover, further study is needed, in order to evaluate the observed trends regarding reduced feeding intensity and consequent growth performance, as responses to the prevailing conditions in the gulf. In fact, a thorough investigation on the Amvrakikos current fishery potential should be conducted.

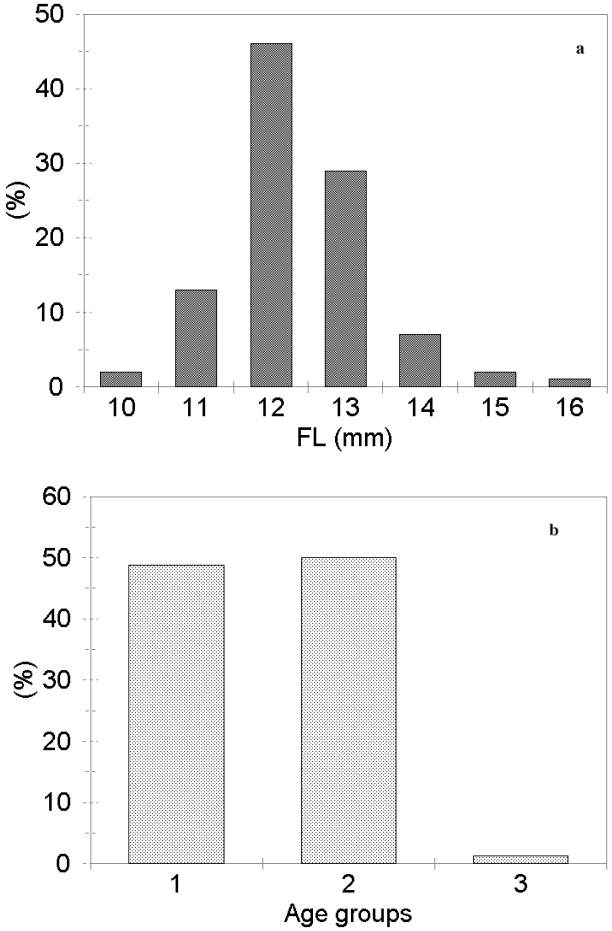

Figure 1. Length (a) and age (b) frequency distribution of the red mullet in the Amvrakikos Gulf.

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REPRODUCTIVE BIOLOGY OF *DIPLODUS SARGUS* (FAMILY : SPARIDAE), IN THE MEDITERRANEAN ENVIRONMENT

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Abstract

The maturity stages of *Diplodus sargus* were detected through the morphological examination of the gonads by the naked eyes into seven stages (thread; immature; mature; nearly ripe; ripe; spawning and spent stages). The length at which *D. sargus* attains its first sexual maturity in the present study was 16.5 cm. However, all *D. sargus* fish of total length longer than 19.5 cm are mature. The monthly distribution of the maturity stages revealed that *D. sargus* has a long breeding season : from January to April with a peak in March.

Keywords: Fish, Eastern Mediterranean Sea

Introduction

Bream species offer good prospects for new fish culture in the Mediterranean Sea. Most of the approximately 100 species belonging to family Sparidae had been found in the tropical and temperate marine waters, while some had been adapted to very cold water. It has been reported (1) that fish species of the family Sparidae represent about 17% of the total tonnage landed from Egyptian Mediterranean waters. These demersal fish are captured mainly by bottom trawling or poles with baited lines. The present study aims to the investigation of the important aspects of the reproductive biology and physiology of the white sea bream *D. sargus* in the Mediterranean Sea.

Materials and methods

Specimens of living *D. sargus* ranging in length from 11.0 to 29.6 cm were collected monthly from the Mediterranean coast near Kayet Bay castle at Anfoushy region, Alexandria from September 1996 to August 1997. The fish was dissected to determine sex and maturity stage, the gonadal weight (Wg) was recorded and after removal of the organs from the abdominal cavity, "gutted weight" (Wa) was recorded. Gonadal weight and gutted weight were used to calculate the gonadosomatic index: Wg/Wa x 100 to estimate fecundity, the ripe ovaries of 30 fish specimens were calculated during the breeding season.

The paired ovaries were weighed to the nearest milligram, and then 0.1 gm of ovary was preserved in 4% neutral formalin. The number of eggs in the weighed sample was counted and the total number of eggs in the ovaries were estimated by the following equation :

$$\text{Total no. of ova} = \frac{\text{weight of ovary}}{\text{weight of sample}} \leftarrow \text{no. of eggs in thr sample}$$

To estimate the egg diameter, known portion of the ovary preserved in 4% neutral formalin were spread in a small Petri dish and the diameter of all eggs were measured using eye piece micrometer. The measurements were then converted into microns.

Results and discussion

To demonstrate the reproductive biology of *D. sargus*, many important parameters were studied. These parameters are : maturity stages, length at first sexual maturity, monthly distribution of maturity stages, gonadosomatic index (GSI), egg diameter during the spawning season and fecundity. The maturity stages were determined first by morphological characters of the gonads by the naked eyes. In the present study, seven maturity stages, including the thread, were recorded using the scheme of Zaki *et al*. (2) : stage I (thread); stage II (immature stage); stage III (maturation stage); stage IV (nearly ripe stage); stage V (Ripe stage); stage VI (Spawning stage); and stage VII (Spent stage).

The length at first sexual maturity is very important item for fisheries management and induced spawning. The length at which the species attain its first sexual maturity is different from one species to another. In the present work, *D. sargus* less than 16.5 cm were immature. However, the percentage of mature individuals increased with the increase of the fish length, where all fish of total length longer than 19.5 cm are mature. The same idea about the relation between the length and the sexual maturity was observed in many fish species, as reported for *Dicentrarchus labrax* and for *Rhabdosargus haffara* (3). The monthly distribution of the maturity stages is one of the methods used for the determination of the beginning and duration of the spawning season.

In the present study, the monthly distribution of the different sexual maturity stages for *D. sargus* revealed that this species has a long breeding season extending from January to the end of April with a peak in March. From June to November, specimens of the studied *D. sargus* were localized in the first three stages, which are thread, immature or mature. In December, stage IV (nearly ripe stage) started to appear, while the ripe stage appeared in January. In February, the majority of the fish are ripe. The spawning stage started to appear in March reached its peak at the end of March and during April. By the end of April, the majority of the fish were observed in the spent stage. In May, all the fish were in the spent stage.

Gonadosomatic index represents the percentage of gonad weight to the body weight. It is assumed that the period during which GSI value is highest corresponds to the breeding season. Gonadosomatic index is usually established for males and females alike, although the development of gametes is not reflected by this index in an identical way in both sexes.

The monthly distribution of gonadosomatic index values indicated that GSI values were very high from January to March i. e. during the breeding season. The maximum value was attained in February for both sexes. It was 5.89 ± 1.15 for females and 5.29 ± 1.24 for males. During March, the gonadosomatic index values decreased due to the discharge of ova and sperms during the spawning process. A sharp decrease in the Gonadosomatic index values for males and females was observed in April due to the discharge of most ova and sperms. This decrease continued until it reached its lowest value in August.

However, the gonadosomatic index value of the females throughout the year is greater than that of the males. This is due to the fact that the eggs as the end product of ovogenesis in the females are much heavier than the spermatozoa or the end product of spermatogenesis of males. This observation was noticed by many authors for *Mugil cephalus* (4) and for *Diplodus cirvinus hotentotus* (6). The analysis of ova diameter is of great importance in the determination of the spawning frequency and the duration of the spawning season.

The ovary of *D. sargus* showed three batches of eggs. The first batch includes the eggs with diameters less than 0.35 mm. It represents the minute and immature eggs. The minute ones have a round shape while the larger may have polygonal or rectangular shape. This batch represents the oocyte stock.

The second batch includes the larger eggs, which are yellow in colour and their diameters ranged from 0.35mm to less than 0.6mm. The third batch includes the largest ova, which are transparent and yolky with ova diameters ranging from 0.6 mm to 0.8 mm.

The present study demonstrated the monthly distribution of egg diameters from the beginning of December to the end of April. During December, the majority of eggs are within the first and the second batches. During January a new class of large egg size started to appear with a very low percentage value (1%) and a maximum egg diameter about 0.68 mm. Another new class of large egg size appeared at the end of January with a diameter of 0.765 mm.

During February, the frequency distribution curve of the ova was shifted towards the higher values of egg diameters. During March, the fish started to discharge some of the ripe ova. Due to the discharge process, the frequency distribution curve was shifted towards the smaller egg diameter. During April, the discharge process continues until the frequency of the large ova becomes very small. Also, the GSI value decreased sharply during this month.

One of the most important items in the study of reproductive biology is the estimation of fecundity. In the fecundity estimation, it is necessary to take into account whether the fish has a short or long spawning period. However, the present study showed that the *D. sargus* has a long spawning season. The fecundity was estimated from the fully ripe ovaries. All groups of yolky eggs were counted, and could be conveniently assorted in those ovaries.

The present study showed that there is a good agreement between the observed and the calculated values of both absolute and relative fecundity. This observation indicates the fitness of the equations expressed the relations between the absolute fecundity and the length as well as the weight of the fish.

The mean observed absolute fecundity ranges from 33665 to 168449 eggs for mean total lengths ranging from 18.4 to 31.5cm while the corresponding observed relative fecundity ranged from 1830 to 5348 egg per cm.

The results of the present study followed the same trend like those of Abou Shabana (5) for *Diplodus cirvenus hotentottus* and Abdallah(6) for *Diplodus vulgaris*.

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GONADOTROPIN AND STEROID HORMONES IN THE PLASMA AND PITUITARY GLAND OF *OBLADA MELANURA* AT VARIOUS STAGES OF MATURATION

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Abstract

Ovulation and spermiation in *Oblada melanura* are accompanied with an increase of the GTH concentration in the blood plasma. Average plasma GTH content decreases rapidly in both sexes for the spent fish; there was little or no increase during the early stages of sexual maturity (Stage I,II and III of maturity). The concentration of GTH in the pituitary gland was highly correlated with that of GTH in the plasma. The average plasma testosterone hormone level in both sexes was highly correlated with the gonadosomatic index (GSI). The value of plasma's testosterone for the female was lower than in male. Plasma progesterone in female *O. melanura* reached its maximum value in the spawning season and was highly correlated with the increase in GSI. Spawning females had higher plasma progesterone content than the spermiating males during the spawning season. The plasma progesterone concentration was higher in females throughout the whole year.

Keywords : Oblada melanura, gonadotropin , testosterone, progesterone

Introduction

Sex steroids are variably attached to plasma's transport of proteins. Naturally, the most common female hormones are 17B estradiol and progesterone.The gonadotropic potency of the pituitary gland increases during gonadal recrudescence, reaching a peak at the time of reproductive maturity. It is not clear whether an increase in plasma gonadotropin (GTH) induces spermiation in fish (1). In salmonids, sex steroid dynamics (Testosterone,estradiol, progesteron) and their cocentration in plasma in relation to gonadal maturation were studied (2). In striped mullet, *Mugil cephalus* both testosterone and estradiol-17B were highly correlated to oocyte growth (3).

Material and methods

Sampling was carried out three times during a month, The fish *O. melanura* were collected from Kayet Bay and offshore stations, there were collected 600 specimens ranging between 9.5 to 25 cm. in length. After acclimatization, blood was collected. Pituitaries were homogenized in 0.5ml of Tris-HCl buffer pH. 8.6 and stored frozen. The gonads were removed and weighted to record the degree of the maturity. The analysis was based on the Radioimmunoassay (RIA) procedure, ICN chorionic gonadotropin hormone Iodine 125 Kits no."07-156102" were used to measure the level of GTH in plasma and pituitary gland; Pantex testosterone and progesterone 125 Iodine Kits number 335 and 337 were also used. Statistical analysis was carried out in order to compute and analyze the variance and significance of the results.

Results

The fish has a long spawning period, extending from early May to late July.

***Gonadotropin hormone (GTH) in plasma of female and male* O. melanura :**

Ovulation and spermiation in *O. melanura* are accompanied by an increase in plasma GTH concentration. This is depicted by the high statistical significance throughout the year ($P<0.01$). Average plasma GTH content rapidly decreases in both sexes of the spent fish as the high significance indicates throughout the year ($P<0.1$). There was little or no increase during the early stages of sexual maturity (Stage I,II and III of maturity).

***Gonadotropin hormone (GTH) in pituitary gland of female and male* O. melanura :**

Ripe and spawning fish have a maximum concentration of pituitary GTH .The average value of the content significantly decreases in the spent fish. There was little or no significantly increase during the period from late September to April.

Testosterone hormone in plasma of female and male* O. melanura *:

The average level of the plasma testosterone in both sexes was highly correlated with GSI and reached the maximum value during spawning. The average value of testosterone concentration rapidly decreases significantly in both sexes of the spent fish($P<0.1$). The plasma testosterone value in the female was lower than in male

Progesterone hormone in plasma of female and male* O. melanura *:

Plasma progesterone in *O. melanura* reached its maximum value during spawning season and was highly correlated with the increase in GSI. Progesterone content rapidly decreases. The average value of both sexes for spent fish ($P<0.1$)). The plasma progesterone concentration was higher in females throughout the whole year.

Discussion

In all teleosts studied so far, oocyte maturation and ovulation are accompanied by a significant increase of the pituitary and plasma gonadotropin levels (4).

The increase in plasma and pituitary GTH in both sexes of *O. melanura* is highly correlated with the increase gonadosomatic index. These results are in agreement with previous studies on male and female *Mugil capito* (5). The GTH increase might have a physiological significance in relation to the preparation of spawning : A similar increase occurred in male along with the presence of ovulated and active female as in the *Oncorhynchus keta* (6) . The increase in plasma testosterone for both sexes of *O. melanura* is highly correlated with the increase in GSI. These results are in agreement with those of the brown bullhead catfish (7).

The maximum value of the plasma progesterone in female fish has been observed during May, with a slight decrease during the spawning season. The present results are in agreement with those for Salmonids (8) .

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AGE ESTIMATION AND CATCH COMPOSITION OF BLUEFIN TUNA IN THE EASTERN MEDITERRANEAN

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Abstract

Bluefin tuna, *Thunnus thynnus*, caught by the Greek fleet in the Eastern Mediterranean was sampled from November 1998 to July 1999. Age was estimated using anal fin spines. Mean lengths at age were calculated. The specimens ranged from 99 to 264 cm in length and their ages were between two and eleven years.

Keywords : Eastern Mediterranean, Growth, Pelagic, Teleostei, Thunnus thynnus.

Introduction

Bluefin tuna, *Thunnus thynnus*, is a pelagic species with a high commercial value, characterized by intensive migration and wide geographical distribution. There have been few studies estimating age and growth of the Mediterranean bluefin tuna. The objectives of this work were to estimate the age of bluefin tuna using anal fin spines and to evaluate the size and age structure of the stocks exploited by the Greek fleet.

Materials and Methods

Anal fins and fork length (FL) measurements were collected from 285 bluefin tuna caught in the Aegean and Ionian Sea, from November 1998 to July 1999. Since many sampled fish were eviscerated and without heads, from each individual the pectoral fork length (PF) was measured too. The relationship between fork length and pectoral fork length was evaluated and pectoral fork lengths were converted to fork lengths.

Three sections near the spine base (0,7 to 1 mm thick) were taken from the first four anal spines using a slow speed saw. Growth bands were counted to estimate the age of fish [1].

Results

The fork length of 285 specimens ranged from 99 to 264 cm with a mean value of 150,5 cm. The most frequent length classes were between 130 and 160 cm (figure 1). A significant linear relationship was found between fork length and pectoral fork length (FL=1,369PF; P<0,05).

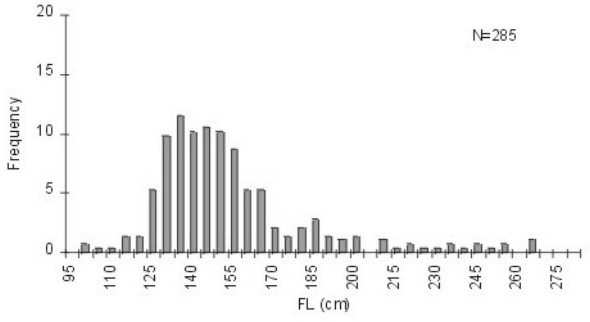

Figure 1. Length frequency distribution of bluefin tuna caught by hand line in the Eastern Mediterranean in 1998-99.

Based on the counts of the translucent zones we estimated ages between 2+ years and 11+ years. Vascularization of the bony tissue was observed in the centre of the spines. The mean lengths per age group are illustrated in figure 2.

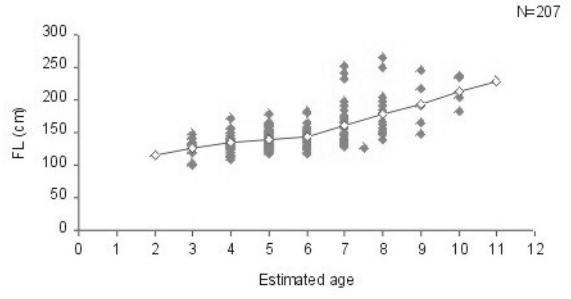

Figure 2. Mean fork lengths at estimated ages for bluefin tuna caught by hand line in the Eastern Mediterranean Sea in 1998-99.

Age group 5 was found to be the most recurrent, with a percentage of 30.92%, following by the age groups 4, 6 and 7 with percentages of 13%, 21.26% and 15.46%, respectively. Juveniles were completely absent.

Discussion

A wide variety of aging techniques have been applied to bluefin tuna, including examination of hard parts such as scales, otoliths, vertebrae and spines [1]. Dorsal spines have been frequently used in age and growth studies of bluefin tuna [2,3,4], whereas anal spines have been used mainly for other large pelagic species.

The use of anal fin spines to estimate age had the advantage of easy sampling and the growth bands stood out clearly. The disadvantage of this method was the vascularization of bony tissue in the centre of the spine, which could lead to an underestimation of the age because of the loss of early bands. This problem, which increased with the size of the specimens, could be avoided by calculating the positions of the first bands in the spines of juveniles and considering them at the age estimations.

Age estimations of the present study appear to be realistic enough and seem consistent with what is known about the growth of the species [1, 2].

These results, even though preliminary, revealed that hand line catches in the Mediterranean Sea were made up mainly by adult bluefin tuna. In fact, the youngest specimen in our sample was 99 cm in FL and the tentative to collect smaller specimens gave no results, because those catches were very rare.

To improve age and growth knowledge on Mediterranean bluefin tuna, further investigation is required, using different techniques and a wider number of length classes, including juvenile specimens.

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SOFT BOTTOM BENTHIC INDICATORS

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Abstract
Based on real values and/or ranges of values, the benthic parameters of the number of species (S), the abundance (N), the Shannon-Wiener community diversity (H), the "key species" and the trends of these parameters, were tested as possible indicators to assess the state of the ecosystem. Ranges of the benthic indicators in Greek waters and the conditions under which each parameter should be evaluated are given. A classification scheme of marine ecosystem health is proposed.

Keywords : benthic, indicators, Greek waters

Indicator "Number of Species"

As tested in Greek waters the number of species in a benthic assemblage decreases with depth and varies with the sediment type increasing in mixed sediments comparing to muds. Also one of the central patterns in biodiversity, noted universally, is that the number of species increases with the area sampled. Figure 1, based on aggregated data collected from 9 stations, over 3 years, in Geras Gulf (2) shows such a trend.

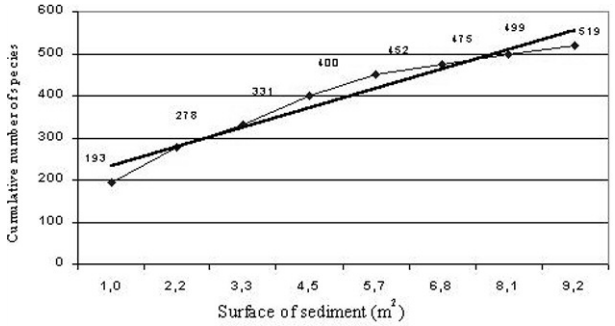

Figure 1 : Increase in number of species with sampling effort

Based on data collected over a variety of soft bottom habitats in Greek waters it appears that number of species, in undisturbed area ranges between 22 and 165 species per 0.1m^2, depending on depth and type of substratum. The number of species (S) can be a reliable measure of environmental stress provided that it is used when comparing benthic communities :

a) occurring within **a well defined sampling unit** (standard 0.1m^2)

b) from samples collected with the **same gear** (standard grab 0.1m^2, mesh sieve 0.5mm)

c) at the **same depth range and sediment type** (ranges to be defined per Sea).

d) The species identification is being done at the same taxonomic level (4 major groups or all groups).

Indicator "Abundance (N)"

The abundance of benthic organisms in a given area is too variable and cannot be used as a reliable measure of environmental stress. On the other hand, trends in abundance of "key species", if well defined, would be a good indicator.

Indicator "Key species"

Based on a synthesis of reviews on the subject and on the data of Saronikos Gulf (1,3,4) the following table shows the zones of pollution with the respective key species.

Table 1. Key species, indicative of the degree of environmental disturbance

I. Zone of maximal pollution	Azoic
II. Highly polluted zone	Opportunists: *Capitella capitata, Malacoceros fuliginosus, Corbula gibba*
III. Moderate polluted zone	Opportunists: *Chaetozone sp, Polydora flava, Schistomeringos rudolphii, Pseudopolydora antennata, Cirriformia tentaculata*
IV. Transitional zone	Tolerant species: *Paralacydonia paradoxa, Protodorvillea kefersteini, Lumbrineris latreilli, Nematonereis unicornis, Thyasira flexuosa*
V. Normal zone	Sensitive species ex. Syllis sp.

The key species characterising a pollution gradient may be different when different geographical areas are examined.

Indicator "Community diversity (H)"

The Shannon-Wiener Index (5) of community diversity in Greek waters has been calculated to range between 1,12 to 6,81, if calculated on pooled data. However, if calculated on a standard sampling unit (0.1m^2) the maximal value is 5,76 bits/unit. Figure 2 shows the variation of H in 116 sites all over Greece. Certainly community diversity is lowered by severe pollution stress compared with control areas or years. Values lower than 1,50 bits per unit have been calculated at the badly polluted areas of Saronikos Gulf (zone I), between 1,5 and 3 for highly polluted areas of Thermaikos and Saronikos (zone II), 3-4 for moderately polluted (zone III) areas, 4-4,6 for transitional zones (zone IV) and over 4,6 for normal zones. The maximum values of H coincide with the pristine areas of Sporades marine park, Kyklades plateau, Rhodes isl., Ionian Sea and Petalioi Gulf Aegean) : 6,81 bits per unit.

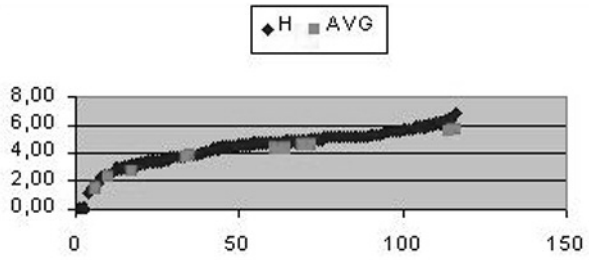

Figure 2 : Distribution of community diversity (H) over 116 Greek sites. AVG : H/0.1m^2

The range of the Shannon Diversity index should be used as a tool of pollution evaluation, taking into account not only the substrate and depth of the given area but also the regional standards of the case area. Also when evaluating H, one should take into account separately its two components together with the faunistic data, in order to detect extreme abundance of opportunists indicating disturbance. In Greek Waters based on the community diversity index alone, 5 classes of community health can be arbitrarily defined :

Class I : H<1,5 : Azoic to very highly polluted
Class II : 1,5 <H<3 : highly polluted
Class III : 3<H<4 : moderately polluted
Class IV : 4<H<4,6 : for transitional zones
Class V : H>4,6 : normal

All the above described benthic indicators were used to efficiently describe the state of the marine ecosystem in Saronikos Gulf, receiving the domestic and industrial effluent of Athens. Based on data collected between 1974 and 1999, though sparse in time, all of the above classes of community diversity were recognised at least over time.

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BIOLOGIE DE REPRODUCTION DES PRINCIPALES ESPECES DEMERSALES DE LA MEDITERRANEE MAROCAINE

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Résumé

Les stocks de pageot espagnol, de bogue, de rouget de vase et de merlu européen, constituent les espèces cibles de la flottille chalutière marocaine. Cette étude a permis de déterminer le sex-ratio et son évolution en fonction de la taille ainsi que la taille de première maturité sexuelle (tous sexes confondus) de ces stocks et ce, par observation macroscopique des gonades. Une comparaison des résultats de cette étude est faite avec ceux obtenus par d'autres auteurs.

Mots-clé : Méditerranée, Maroc, espèces démersales, reproduction.

Les stocks exploités par la flottille chalutière marocaine en Méditerranée sont constitués essentiellement par les sparidés (pageot espagnol- *Pagellus acarne*, Risso 1826 et bogue – *Boops bopps* L. 1758), les mullidés (rouget de vase- *Mullus barbatus* L. 1758), le merlu européen (*Merluccius Merluccius* L. 1758). Ce travail qui rentre dans le cadre d'un programme d'étude entamé en Méditerranée par l'INRH depuis 1995, a pour objectif d'étudier la biologie de reproduction des principales espèces de la pêcherie démersale de la région. Dans un but de comparaison, les résultats obtenus par cette étude ont été confrontés à ceux obtenus dans d'autres secteurs.

Matériel et méthodes

Les données sont collectées lors des campagnes de chalutage réalisées en Méditerranée marocaine durant la période 1995-1998. L'étude de la reproduction est réalisée chez les sparidés sur 101 individus de taille à la fourche comprise entre 10 et 22 cm pour le pageot espagnol, 110 individus de bogue ayant une taille à la fourche variant entre 11 et 23 cm, 104 spécimens de rouget de taille à la fourche situées entre 12 et 22 cm. Pour le merlu blanc, l'étude a porté sur 423 individus dont la taille totale varie entre 11 et 66 cm. Pour chaque poisson, ont été relevés la taille, le sexe et le stade de maturité, ces derniers ont été déterminés en utilisant l'échelle de Fontana (1). Dans cette étude, le sex-ratio global et son évolution en fonction de la taille ainsi que la taille de première maturité sexuelle (tous sexes confondus) ont été déterminés par espèce et ce, par observation macroscopique des gonades. La taille de première maturité est prise comme celle à laquelle 50 % des individus sont sexuellement mûrs pendant la saison de reproduction. Cette taille est régie par la relation logistique: P = 1/(1+e(-a+bL) où P est la proportion des individus matures et L la longueur du poisson en cm; a et b sont des constantes.

Résultats et discussion

Tableau 1 . Pourcentage des différents sexes des espèces étudiées

Espèces/sexe	Mâles	Femelles	Hermaphrodites
pageot	28	35	36
bogue	73	22	5
rouget	53	47	-
merlu	48	52	-

Les échantillons des espèces retenues dans cette étude sont répartis en fonction du sexe dans le tableau 1.

L'évolution de la maturité (sans distinction de sexe) des stocks en question est représentée par les figures 1-4. Pour le pageot espagnol, les 50 % d'individus matures sont atteints à partir de la taille à la fourche de 14,18 cm; à 19 cm tous les individus ont accompli au moins une ponte. Les individus ayant des tailles inférieures à 10 cm sont immatures. chez la bogue, la maturité sexuelle est atteinte à la taille à la fourche de 15,35 cm; au delà de 17,45 cm, tous les individus sont mâtures. Pour une taille inférieure à 8 cm, tous les individus sont immatures. La taille de première maturité de cette espèce, semble varier d'une zone géographique à l'autre. Le pageot espagnol atteint généralement sa première maturité sexuelle précocement dans les eaux libanaises à une taille fourche moyenne de 13.4 cm (2). La bogue atteint sa première maturité sexuelle à la fin de la première année à une taille moyenne à la fourche de 12 cm (2). Chez le rouget de vase, la maturité sexuelle est atteinte à la taille de 12,60 cm. Au delà de 17 cm, tous les poissons sont matures. Les tailles de maturité estimées par d'autres auteurs sont comparables aux nôtres. En effet, pour la côte espagnole, cette taille se situe à 11 cm (3) tandis que dans la région tunisienne, cette taille est estimée à 12,5 cm (4). Pour le merlu blanc, cette taille est estimée à 33,6 cm; les individus de moins de 25 cm sont immatures. La taille de première maturité chez cette espèce est déterminé dans d'autres secteurs; au niveau de la côte méditerranéenne espagnole, la première ponte chez le merlu est observée à des tailles variant entre 22 et 24 cm chez les mâles et entre 26 et 28 chez les femelles (5). Le merlu du Golfe de la Tunisie réalise 50% de maturité à la taille de 29 cm pour les femelles et 28 cm pour les mâles (6). Dans le golfe du Lion et la Mer Catalane, la taille de première maturité du merlu est atteinte environ à la taille de 37 cm pour les femelles et 28,4 cm pour les mâles (7). Concernant la répartition des sexes suivant la taille de ces espèces, cette étude a montréqu'au cours de la croissance de la bogue, 3 types d'individus sont observés: des individus femelles à moins de 14 cm; des individus hermaphrodites à des tailles intermédiaires situées à 16 cm environ et des individus mâles observés au-delà de 18 cm. Concernant le pageot espagnol, les mâles sont plus nombreux entre 14 et 17 cm; les individus hermaphrodites dominent de 16 à 18 cm. Au-delà de 19 cm, les femelles sont plus nombreuses. Pour le rouget de vase, les mâles sont plus nombreux que les femelles pour des tailles inférieures à 16 cm environ. Au contraire, les femelles dominent au delà et paraissent être les seules à dépasser 18 cm. Pour le merlu blanc, les femelles sont plus nombreuses que les mâles au niveau de l'intervalle de taille 17-26 cm. Ces derniers en revanche prédominent largement dans l'intervalle 26-40 cm; les mâles disparaissent au-delà en faveur des femelles qui paraissent être les seules à dépasser la taille de 42 cm.

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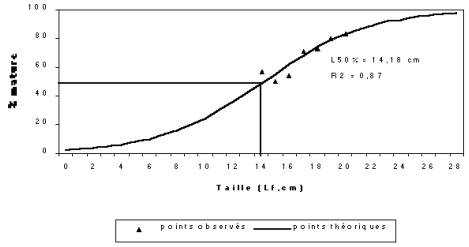

Fig. 1. Taille de première maturité du pageot

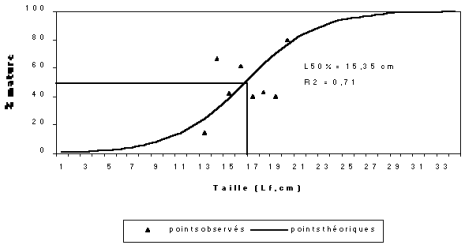

Fig. 2. Taille de première maturité de la bogue

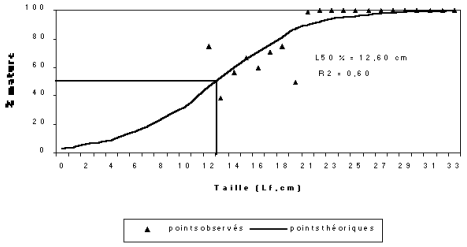

Fig. 3. Taille de première maturité du rouget

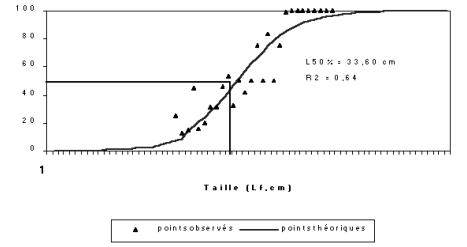

Fig. 4. Taille de première maturité du merlu blanc

ETUDE DE LA BIOLOGIE DE CROISSANCE DES PRINCIPAUX STOCKS DEMERSAUX DE LA MEDITERRANEE MAROCAINE

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Résumé

Cette étude constitue une première tentative de l'analyse de la croissance linéaire absolue et à la croissance de 4 espèces démersales de la zone méditerranéenne marocaine. Les résultats obtenus pour ces espèces dans le cadre de cette étude sont comparés à ceux enregistrés dans d'autres régions de la Méditerranée.

Mots-clés : Méditerranée , Maroc, espèces démersales, Croissance.

Les principales espèces démersales exploitées par la flottille chalutière en Méditerranée marocaine sont constituées par la bogue (*Boops boops*, L. 1758), le pageot espagnol (*Pagellus acarne*, Risso 1826), le rouget de vase (*Mullus barbatus*, L.1758) et le merlu européen (*Merluccius merluccius*, L. 1758). Cette étude qui traite des aspects relatifs à la croissance de ces stocks est réalisée dans le cadre du programme initié par l'INRH en 1985 pour l'étude de la biologie des principales espèces de la pêcherie chalutière de la Méditerranée marocaine.

Matériel et méthodes

L'étude de la croissance en taille et en poids (tous sexes confondus) des espèces retenues est réalisée sur la base des échantillons collectés lors des campagnes de prospection effectuées à bord du N/R *Charif Idrissi* de 1995-1998. Pour chaque individu ont été prélevés la taille à la fourche et les écailles pour les sparidés et les mullidés (1), la taille totale et les otolithes pour le merlu européen. La détermination de l'âge sans distinction de sexe, est faite par l'utilisation des écailles et des otolithes. Les paramètres de croissance linéaire de l'équation de Von Bertalanffy (2) ont été estimés par le logiciel FISHPARM (3). $Lt = L\infty.(1-e^{-k(t-t0)})$ avec $L\infty$ = taille asymptotique, K= taux de croissance et (t0) = l'âge théorique pour une longueur nulle. Les paramètres de la relation taille-poids: $P= a.L^b$ avec P= poids total , L= taille; ont été déterminés à l'aide de la méthodes des moindres carrés après transformation logarithmique des poids et des tailles.

Résultats et discussions

Les paramètres de la croissance linéaire absolue et de la relation taille-poids estimés pour les espèces étudiées sont donnés dans le tableau 1. Les équations correspondant à la croissance linéaire absolue de ces espèces sont exprimées graphiquement sur les figures 1-4. L'application des équations relatives à la croissance linéaire absolue de ces espèces en différentes zones, montre que la croissance de pageot espagnol paraît comparable sur les côtes algériennes (4),espagnoles (5) et méditerranéennes marocaines. Pour la bogue, nos résultats sont sensiblement comparables à ceux obtenus dans les côtes espagnoles (6). La croissance linéaire de cette espèce dans ces régions est beaucoup plus rapide que celles enregistrées sur les côtes algériennes (4) et tunisiennes (7). Concernant le rouget de vase, on constate que la croissance linéaire est plus rapide sur les côtes espagnoles (8) alors qu'elle est plus lente dans les eaux méditerranéennes marocaines et tunisiennes (9) où les croissances enregistrées paraissent afficher les mêmes allures. Quant au merlu blanc, nos résultats sont sensiblement comparables à ceux obtenus sur les côtes espagnoles (10) et tunisiennes (11). En revanche la croissance de cette espèce est beaucoup plus rapide dans l e golfe du Lion et la Mer catalane (12). En croissance pondérale relative, on constate pour le pageot espagnol qu'à une taille donnée, les poids paraissent très comparables sur les côtes méditerranéennes françaises (13), espagnoles (14) et marocaines. Pour la bogue, la croissance pondérale enregistrée sur les côtes tunisiennes (7) paraît plus rapide que celle observée sur les côtes méditerranéennes marocaines. Pour le rouget de vase, les relations tailles-poids évoquées dans d'autres régions permettent de constater que les valeurs en poids enregistrées restent relativement approchées sur les côtes méditerranéennes marocaines et tunisienne (9); en revanche, sur les côtes méditerranéennes espagnoles (15), la croissance pondérale paraît plus rapide. Pour le cas du merlu blanc, les valeurs de poids enregistrées dans les différentes régions marquent des différences peu sensibles dans l'intervalle de tailles allant de 0 à 50 cm. Au-delà l'écart entre les différents résultats se creuse. En comparant nos résultats avec ceux des autres auteurs, on remarque que ceux-ci sont supérieurs aux nôtres.

Tableau 1 . Paramètres de croissance linéaire absolue et de relation taille-poids estimés par espèce. *(a et b : constantes de la relation $W= a.L^b$).*

espèce	K	L∞	T0	a	b	effectif	taille
pageot	0.43	24,01	-0,210	0.015	3.10	130	9-21
bogue	0,28	31,50	0,956	0.023	2.84	104	11-29
rouget	0,23	22,05	-1,809	0.07	3.34	197	10-20
merlu	0,081	96,76	-1,146	0.05	3.02	423	14-60

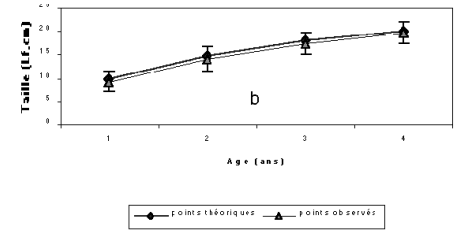

Fig. 1. Croissance linéaire du pageot

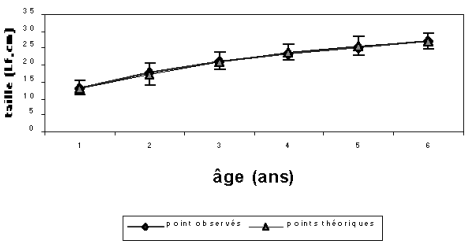

Fig. 2. Croissance linéaire de la bogue

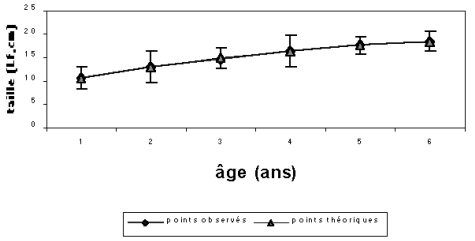

Fig. 3. Croissance linéaire du rouget

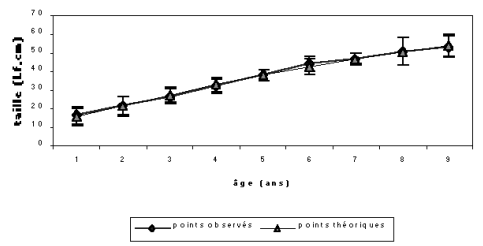

Fig. 4. Croissance linéaire du merlu blanc

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Comité

Environnement littoral

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VARIATIONS A COURTE ECHELLE DES POPULATIONS MICROPLANCTONIQUES AU NORD DU LIBAN

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Résumé

Dans une tentative d'étudier la distribution des populations microplanctoniques à courte échelle, des traits de filets (52μm) ont été réalisés, dans 26 stations équidistantes de 400m, le 29-9-1999, en surface et entre 15-0 m, selon un axe parallèle à la côte nord du Liban. La distribution des différents groupes étudiés, en fonction des différentes conditions du milieu environnant et la distance géographique, s'est montrée plus hétérogène chez les espèces phytoplanctoniques que les espèces zooplanctoniques. Les densités moyennes des différents groupes, à l'exception des mollusques, ont présenté des valeurs plus élevées en filet de surface qu'en vertical. La variabilité quantitative et qualitative du microplancton marin est notée, dans ce cas étudié, à une échelle assez petite qui est de 400m.

Mots clés : Bassin levantin, plancton, eaux côtières, échelle réduite.

Introduction

Plusieurs études ont montré que le plancton est distribué d'une façon hétérogène, variable avec les conditions du milieu étudié surtout dans les zones littorales et côtières, et l'environnement pélagique peut être considéré comme une mosaïque de divers micro-habitats (1 - 5). Connaissant les facteurs qui peuvent influencer la distribution planctonique des eaux marines côtières, reste à déterminer l'échelle dimensionnelle du microhabitat dans l'espace.

Matériel et méthodes

Vingt-six stations distantes de 400 mètres (profondeur de l'eau dépassant les 15 mètres), ont été parcourues le 29-9-1999, de 9 heures du matin à midi, parallèlement à la côte, entre 2 villes, entre les coordonnées géographiques suivantes : N 34° 15.515' et E 035 39.060' et N 34° 09.310' et E 035 37.554'. Sur la côte et à partir du bout Nord, on note une usine d'engrais chimiques, des ports de pêcheurs, des zones balnéaires et d'autres activités urbaines. La sortie a été précédée de 3 jours de beau temps avec un vent faible et une mer plate. La mesure de la température et de la salinité de l'eau ont été faites à l'aide d'un "S/T/D/ sensor 3230" Andera. Le dosage des ions ortophosphates a été réalisé suivant la méthode de (6). Celui des nitrites, suivant la méthode de (7) et des nitrates, selon la méthode de (8). Les populations planctoniques, fixées au formol, ont été collectées par deux traits de filets (52 μm de vide de maille), l'un le volume d'un filet en surface (H) et l'autre vertical entre 15 et 0m (V). Après homogénéisation, un volume de 2cc du filet vertical et tout le volume du filet de surface ont été comptés sur un microscope inversé du type Leica suivant la méthode (9). Quatre espèces abondantes sur 15 trouvées et le total du genre *Ceratium* (microphytoplancton dominant durant cette période (10)), les groupes zooplanctoniques, 5 espèces abondantes sur 36 trouvées et le total des tintinnides, les foraminifères, les mollusques, les copépodes et les différentes larves de crustacés (nauplii divers) ont été comptés.

Résultats et discussion

Les résultats ont montré que les paramètres hydrologiques et les sels nutritifs ont présenté des variations importantes au début et à la fin du transact, et que la densité est plus élevée en surface chez les espèces phytoplanctoniques étudiées, les copépodes et les différentes espèces des tintinnides, et moins élevée seulement chez les nauplii divers et les foraminifères. Les copépodes et les mollusques ont montré une tendance croissante en allant vers le sud, par contre les tintinnides totaux et les espèces *E. brandti* et *C. schabi*, beaucoup plus abondants en surface, ont montré une tendance contraire dans les 2 niveaux prospectés. Les statistiques descriptives résumant les variations de tous les paramètres étudiés figurent dans le tableau 1. Les coefficients de variations (C.V.) des nitrites et des nitrates sont presque le double de celui des orthophosphates, ce qui a influé sur le rapport N/P et par conséquent, probablement sur les espèces du genre *Ceratium*.

Les C.V. pour ces espèces sont presque comparables dans chaque niveau mais > que celui du total. Chez les tintinnides, animaux à courtes générations, les C.V. sont, en général, moins élevés que chez *les Ceratium* et presque comparables aux deux niveaux. Les valeurs des coefficients de corrélations entre les différents paramètres environnementaux et biologiques obtenus sont significatives à P<0.05. Des corrélations significatives positives et négatives en surface ont été notées entre la distance d'une part et la température (r = 0.764), les nitrates (-0.387), les orthophosphates (-0.592), *Ceratium tripos* et *C. pulchellum* (r=0.459 et –0.345), les copédodes (r=0.479), mollusques (r=0.774), foraminifères (r=0.397)et les tintinnides *Epiplocylis brandti, Tintinnopsis beroidea* et *Eutintinnus lusus* successivement (r= -0.521, 0.454 et –0.448) d'autre part; entre T°C et S‰ (-0.335) ; T°C et *C. tripos* et *C. bohemi* (0.414 et–0.509) et entre T°C et les mollusques (r=0.615); entre S‰ et *C. pullchellum* et les mollusques (r=0.356 et –0.377) et enfin entre les phosphates et les copépodes et les mollusques (r=-0.391 et –0.409). Notons que le nombre d'espèces a été plus élevé dans les régions côtières au Nord, mais les variations quantitatives ont été notées sur toute la ligne étudiée.

Tableau 1: Statistiques descriptives des échantillons de surface (1ère ligne) et de profondeur (2ème ligne). (Les sels nutritifs en µatg/l et les différents groupes en cellules/ m^3)

Paramètres/	Moyenne	Ecart type	Minimum	Maximum	C.V. %
Température °C	27.89°	0.16	27.45°	28.21°	0.56
Salinité ‰	39.38	0.08	39.19	39.46	0.2
Nitrites (µatg/l)	0.034	0.052	0	0.179	152
Nitrates (µatg/l)	0.69	0.76	0.105	3.345	110
Orthophos. (µatg/l)	0.35	0.16	0.216	0.835	54
N/P	2.35	2.435	0.5	11.3	103
	13483	6856	80	32160	50
C.tricoceros	8447	4487	3124	17892	53
	1481	1221	80	6333	82
C. bohmi	1368	605	568	3266	44
	1026	902	0	3562	87
C. teres	1008	557	142	2414	55
	899	700	0	2000	77
C. pulchellum	442	353	71	1562	80
	18109	7980	160	40000	44
Tot. *Ceratium*	11285	5838	5467	48706	52
	33342	36114	400	158640	108
Copépodes	15396	11279	5467	48706	73
	17025	7767	80	33280	45
Nauplii divers	18091	4986	9656	29749	28
	1717	1046	320	4080	61
Mollusques	1529	2693	142	14058	176
	960	553	80	2240	57
Foraminifères	1005	412	213	1988	41
	17268	7875	7200	39680	45
E. brandti	3935	1859	1633	8307	47
	18474	5810	3600	27280	31
C. schabi	6237	3430	1775	14129	55
	2834	1127	560	4640	40
R. elegans	849	369	355	1704	44
	7388	3522	80	17120	47
T. beroidea	2086	865	639	3621	42
	1077	765	160	3360	71
E. lusus	295	166	71	781	55
	49512	16875	18880	81280	34
Tot. tintinnides	14722	5825	7313	28826	40

En résumé, les résultats obtenus par cette étude ont montré qu'une variabilité quantitative et qualitative du microplancton marin est notée, dans ce cas étudié, à une échelle de 400m. Cette variabilité, remarquée en surface et légèrement moins en profondeur, peut être due aux moindres variations physico-chimiques dans l'eau qui impliquent des variations biologiques surtout que la sortie a été réalisée après 3 jours de mer calme, ce qui a eu pour effet de favoriser des microhabitats et le développement des espèces à courtes générations.

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LE PHYTOPLANCTON, RÉPARTITION ET STRUCTURE DES POPULATIONS DANS LA SALINE DE SFAX. LES PRODUCTEURS PRIMAIRES S'ADAPTENT-ILS AUX CONDITIONS EXTRÊMES DU MILIEU?

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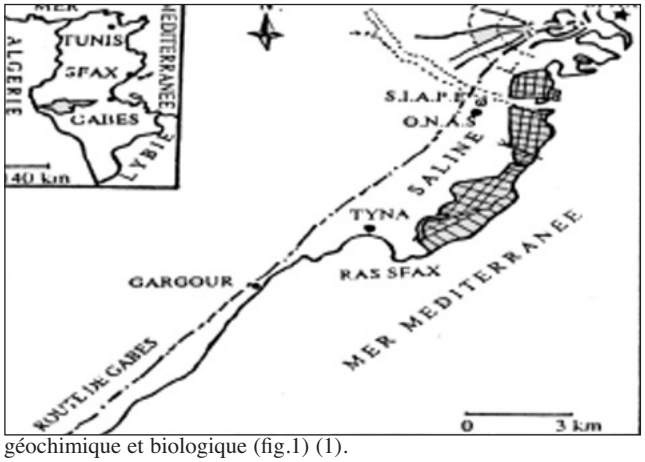
Résumé

Cette étude qui s'intéresse à quelques paramètres abiotiques et biotiques d'un écosystème lagunaire artificiel: la saline de Sfax, qui s'étend sur une plate-forme de 1500 ha située au Sud-Est de la Tunisie, nous a permis de confirmer le caractère oligotrophe des eaux des bassins. La distribution spatio-temporelle des populations phytoplanctoniques montre une diversification et une zonation particulière; avec développement des Diatomées dans les premiers bassins dont la salinité ne dépasse pas 70 ‰, auxquelles succèdent les Dinoflagellés qui tolèrent des variations considérables de salinité. Les autres classes algales sont présentes mais en très faibles densités. L'étude de la structure des populations, par le biais des diagrammes rang - fréquence, de ce sous-système algale, témoigne d'une bonne organisation. L'indice de diversité spécifique de Shannon-Weaver demeure faible…

Mots clés: lagune - salinité - phytoplancton - Diatomées - Dinoflagellés

Les saumures constituent un domaine complexe. La saline de Sfax, milieu paralique artificiel de 1500 ha, est un site favorable à l'étude



géochimique et biologique (fig.1) (1).

Figure 1 : Localisation de la saline de Sfax

Dans ce présent travail, nous avons suivi les paramètres physico-chimiques des saumures (salinité, température, matières en suspension), la répartition spatio-temporelle ainsi que la structure des populations phytoplanctoniques dans sept bassins différents de la saline.

Nos résultats montrent que la salinité croit de l'eau de mer jusqu'aux confins les plus éloignés: les tables salantes; la température augmente selon un gradient croissant de salinité; les teneurs en matières en suspension varient d'un bassin à un autre au cours de toute notre étude. Ces matières en suspension sont d'origine biogène dans les bassins où on assiste à un maximum de développement des protozoaires (2) et des bactéries hyperhalophiles (3) et dans les bassins sur salés, elles sont minérales. Ce même phénomène est aussi observé dans la saline de Giraud (4).

Nous avons recensé 39 genres phytoplanctoniques appartenant à différentes classes algales. Ainsi, les Diatomées sont les plus importantes surtout dans le premier bassin à tendance marine, ceci corrobore avec les observations de Campbell et Davis (5); puis ce sont les Dinoflagellés qui les succèdent dans les bassins à forte salinité. Dans les derniers bassins sur salés, on assiste au développement de la Chlorophycée *Dunaliella salina* qui abonde le milieu.

Nous assistons à des associations algales dans le même bassin et synchrones. La compétition interspécifique pour l'utilisation des ressources minérales (azote et phosphore) est importante, surtout qu'on sache qu'elles sont très limitées. Les teneurs en ces éléments sont faibles (figs. 2,3). Les eaux sont oligotrophes.

L'étude de la structure des populations dans deux bassins de salinités différentes: A1 (70 ‰) et C2-1 (130 ‰), par le biais des diagrammes rang-fréquence (6) et l'indice de diversité spécifique, illustre que les algues s'adaptent bien même dans les bassins sur salés et constituent des entités autonomes. Ces bassins constituent de véritables "microcosmes" au développement des algues.

L'indice de diversité spécifique est généralement faible (fig.4).

Les populations phytoplanctoniques sont en parfait équilibre malgré les conditions contraignantes du milieu; elles arrivent à se maintenir à

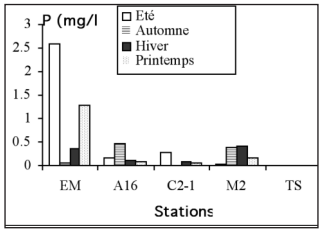


Figure 2 : Evolution spatio-temporelle des teneurs en phosphore total dans la saline de Sfax

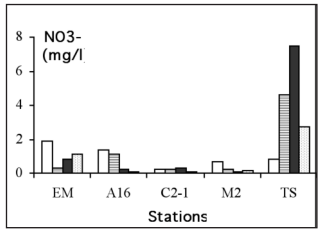


Figure 3 : Evolution spatio-temporelle des teneurs en nitrate dans la saline de Sfax

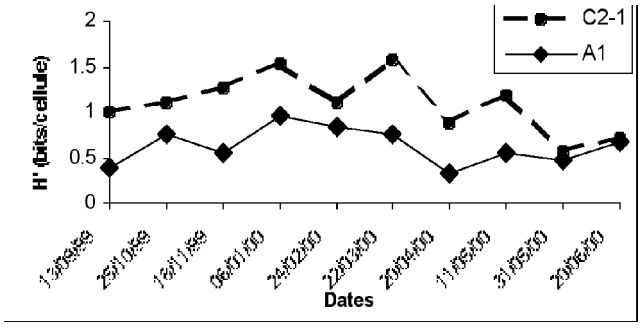


Figure 4 : Variation temporelle de l'indice de diversité spécifique H' dans les bassins A_1 et C_{2-1}, de la saline de Sfax.

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THE STUDY OF DIVING TOURISM TO SUPPORT THE ADAPTIVE MANAGEMENT IN AN ITALIAN MARINE PROTECTED AREA (USTICA ISLAND)

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Abstract
The conservation of natural resources present in a marine protected area (MPA) can provide a high element of natural attractiveness for diving-activities. The present contribution is an approach to the study of scuba-diving tourism in the Italian MPA of Ustica Island and considers some influencing factors of the dive sites such as the biologic aspects, depth, distance from the main harbour and spatial distribution of the divers presence through the application of a GIS technology. The applied approach seems to be useful in yielding a concise vision on the phenomenon and in identifying the main polarising aspects for diving tourism in support of management activities.

Key words : Marine parks, GIS, Coastal management.

Introduction

The Marine Protected Areas' (MPAs) objectives are centred on marine biodiversity conservation, the maintaining of productivity and the contribution to economic and social welfare (1, 2). To obtain and maintain the integration between the environmental protection and the development of local economies, MPAs need clearly articulated management plans and these should be adaptive (i.e. the management should be set up as a verifiable scientific experiment) (3).

Scuba-diving is one of the most important tourism activities in MPAs and represents one of the major ways to directly appreciate the effects of the protection on marine environments but this activity should be regulated so as to be really compatible with the conservation of natural resources (4- 7).

This aspect is very important in Italy where 15 MPAs are established and national legislation foresees the establishment of 50 MPAs.

To approach the adaptive management of scuba-diving activities, a preliminary study was started in the Ustica MPA (Italy) which currently represents one of the major national destinations for recreational diving tourism. Established in 1986, this MPA is characterized by three different protection zones and diving activities are forbidden only in Zone A. This scenario justifies the need to investigate the degree of tourism distribution (8), with particular attention to its underwater component so as to obtain management indications (4).

Materials and methods

The study on scuba-diving tourism was carried out with the aim of characterizing the scuba-diving industry, to identify the tourist attractiveness of dive sites and to analyse the divers' spatial distribution in Ustica. Data concerning the diving-centres (organisation, equipment, staff, kind of activities, number of divers and their temporal distribution, localization and characteristics of dive-sites) was collected through data-forms completed by the operators of scuba-diving centres.

The tourist attractiveness of the more important dive sites located in Zones B and C, were identified through interviews with the relative stakeholders and an analysis of specialized reviews on scuba-diving tourism. The dive sites were characterised identifying "environmental" priorities affecting the tourist demand such as: the range of depth where the dive is more interesting, fish species with high density of specimens or with high frequency of sighting, species that are present with large individual and benthic species of tourist relevance for recreational dive. The latter information was obtained through data-forms for each dive site completed by a panel of scuba-diving experts present in the MPA (field guides of the area and representatives of scuba-diving centres).

Data on spatial distribution was collected during 25 day-time surveys, conducted between July 1st and August 30th 2000 by the MPA personnel, who recorded the number of boats, the estimated number of scuba-divers and the geographical location of each site on specifically formulated questionnaires. Basic cartographic information was obtained by digitising the nautical map of Ustica island (9), and information on benthic assemblages' distribution was extracted form previous studies (10).

Location of the scuba-diving sites was implemented in the GIS and appropriately repositioned with respect to their average depth. All the above data was elaborated and integrated with GIS software packages ESRI Arc/Info and Arc View.

Results and discussion

The diving centres working in Ustica are six and the spatial distribution of divers shows that 63.6% of the dive sites are in Zone C and 36.4% in Zone B. The characterisation of dive sites resulting from the analysed environmental parameters indicates that in general, the percentage of site-use increases with their richness, as shown by the fact that 65.8% of the divers' presence is concentrated in only 3 sites that are characterized by high values for all of the considered parameters. Nevertheless, other aspects, as the distance from the main harbour and marketing strategies are also important as suggested by the recorded low diver presence (3%) in one area, which is potentially very interesting but which is distant from the main harbour and is thus not very publicised to the divers.

The combination of information related to the dive-sites and the benthic assemblages indicates that an approximate 48.3% of dive-sites are deemed of interest due to the presence of photophylic assemblages while 21.1% is characterised by sciaphilous assemblages, and approximately 30.5% is characterized by the presence of *Posidonia oceanica* meadows.

The present study suggests and applies a method that includes environmental and tourist aspects. The implemented GIS is particularly useful in this regard to integrate and analyse different kinds of information. The utility of GIS should be stressed with the increasing number of variables considered affecting diving demand for each site such as: distribution of detailed benthic assemblage, fish populations, presence of endemic species, sea-currents, exposure to marine meteorological conditions, sea-geomorphology, and the presence of wrecks or historical vestiges.

The applied approach appears useful in order to yield a concise vision of the phenomenon and to identify the main polarising aspects for diving tourism. The approach should be applied to support management activities devoted to increase the valorisation of dive sites that are currently less exploited and to suggest new sites, thus reducing the tourist pressure on those most visited and in order to allow an effective conservative management of this important activity.

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ESTIMATION DU TAUX DE CONTAMINATION DE *POSIDONIA OCEANICA* PAR LE MERCURE DANS LA BAIE DE BOU ISMAÏL (ALGERIE) : RESULTATS PRELIMINAIRES

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Résumé

L'analyse du mercure (Hg) total a été réalisée dans les écailles et les rhizomes de *Posidonia oceanica* par Spectrophotométrie d'absorption atomique (SAA) au niveau de deux sites situés dans la baie de Bou Ismaïl. Les écailles et les rhizomes ont été analysés en fonction des années lépidochronologiques. Les premiers résultats révèlent que les concentrations en mercure des écailles et des rhizomes de *Posidonia oceanica* de Bou Ismaïl sont supérieures à celles enregistrées à l'anse de Kouâli. Par ailleurs, l'accumulation du mercure est plus importante au niveau des rhizomes.

Mots clés : Posidonia oceanica, mercury, algerian basin

Posidonia oceanica, phanérogame marine endémique de Méditerranée, constitue un bon bioindicateur de la contamination par les métaux traces. Son utilisation permet d'évaluer l'importance et la variation de la qualité et/ou de la contamination du milieu marin. Cette première étude se fixe pour objectif de comparer les niveaux de contamination de *Posidonia oceanica* par le mercure et ce, dans deux sites soumis à des conditions environnementales différentes.

Matériel et méthodes

Dans la baie de Bou Ismaïl située à 80 km à l'ouest d'Alger et orientée SW-NE, deux sites ont été choisis (Fig. 1), l'un faisant face au front de mer de Bou Ismaïl, est sujet aux rejets urbains et industriels des localités environnantes, le second, l'anse de Kouâli, située dans la partie occidentale de la baie, est considéré comme zone de référence (1), en atteste la présence d'un récif-barrière. Les prélèvements ont été réalisés sur un cycle annuel

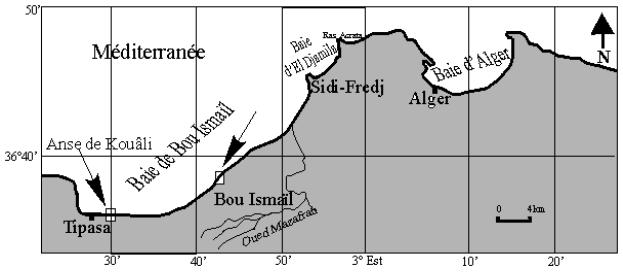

Figure 1: Localisation des stations

(de mai 1996 à février 1997) avec un pas d'échantillonnage saisonnier.

Dans chaque site, à 10 m de profondeur, 45 faisceaux orthotropes, séparés d'une distance minimale de 1 m, sont récoltés en scaphandre autonome. A l'issue de la récolte, les faisceaux sont séparés en 3 lots de 15 faisceaux qui seront analysés séparément. Dans ce travail qui comporte également le dosage du mercure dans les feuilles adultes, intermédiaires et les bases, seuls les rhizomes et les écailles sont pris en compte. Après dissection selon la méthode lépidochronologique (2) les écailles et les rhizomes sont groupés en fonction de l'année à laquelle ils appartiennent et minéralisés. 1 g d'échantillon est minéralisé par 10 ml d'acide nitrique ($HN0_3$ 69% Suprapur) (3 ; 4) puis analysé par SAA (Perkin Elmer, modèle 2380) par la méthode des vapeurs froides.

Résultats et discussion

Les concentrations en mercure des rhizomes de *P. oceanica* montrent des variations significatives en fonction de la saison d'échantillonnage; ces variations saisonnières des concentrations métalliques ont déjà été rapportées (5). Toutefois ce phénomène ne s'observe pas particulièrement au niveau des écailles (Tableau 1). Bien que différentes, les teneurs en mercure des écailles et des rhizomes suivent une évolution similaire. Au niveau des deux structures, les valeurs notées au printemps et en été sont plus importantes que celles enregistrées en automne-hiver. Le même schéma de l'accumulation du mercure a déjà été observé (5).

Par ailleurs, l'accumulation du mercure est plus importante dans les rhizomes que dans les écailles. Cette accumulation préférentielle au niveau des rhizomes a déjà été signalée et pourrait s'expliquer par la durée de vie importante de ces organes (2), ou par la capacité de *Posidonia oceanica* à absorber le mercure par son système racinaire (6). Selon (7), en l'absence de pollution massive, les particules auxquelles se fixe le mercure, une fois interceptées par les feuilles de *Posidonia oceanica*, vont sédimenter dans l'herbier ; le mercure présent dans le sédiment sera capté par les racines et les rhizomes. D'autre part, les concentrations obtenues dans les écailles analysées à Bou Ismaïl sont relativement importantes, ceci pourrait être le reflet d'un degré d'anthropisation plus élevé dans ce site.

Les valeurs enregistrées à Bou Ismaïl sont significativement supérieures à celles relevées à l'anse de Kouâli (Fig. 2). En effet, il y a une corrélation

Tableau 1 : Concentration en mercure (ηg/g) dans les écailles et les rhizomes de *Posidonia oceanica* en fonction des saisons. Les intervalles de confiance sont indiqués.

Sites	Tissus	Printemps	Eté	Automne	Hiver
Anse de Kouâli	Ecailles	51.2 ± 11.2	73.6 ± 18.1	39.8 ± 10.0	31.5 ± 7.2
	Rhizomes	96.5 ± 20.4	104.1 ± 14.6	76.2 ± 21.2	37.4 ± 10.7
Bou Ismaïl	Ecailles	128.7 ± 17.1	174.7 ± 29.3	86.3 ± 16.9	47.0 ± 6.5
	Rhizomes	120.3 ± 38.3	235.0 ± 38.9	98.3 ± 36.2	42.5 ± 7.3

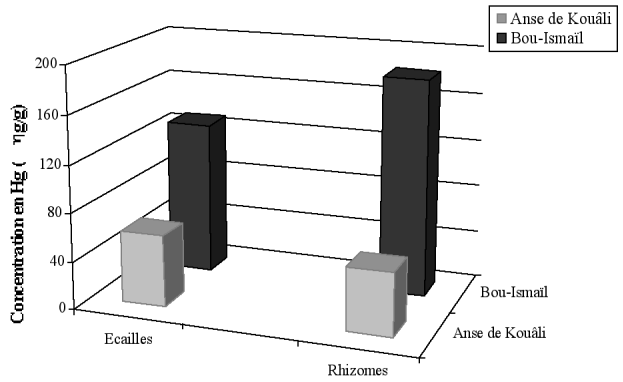

Figure 2 : Concentration annuelle moyenne en mercure (hg/g) des écailles et rhizomes de *Posidonia oceanica* à l'anse de Kouâli et Bou Ismaïl.

entre les teneurs en mercure accumulées chez *Posidonia oceanica* et celles présentes dans le sédiment ou dans l'eau (8, 9).Comparées aux teneurs en mercure fournies par la littérature, les valeurs notées à l'anse de Kouâli sont du même ordre de grandeur que celles signalées pour des sites non pollués; en revanche, les concentrations relevées à Bou Ismaïl sont analogues à celles enregistrées dans des sites à faible pollution.

Conclusion

Il semble que le phénomène d'accumulation du mercure dans les écailles et les rhizomes de *Posidonia oceanica* n'est pas aléatoire et qu'il est le résultat de l'influence de plusieurs paramètres dont le niveau de contamination du site, la nature du tissu et la période de l'année où a été effectué le prélèvement. Malgré le caractère préliminaire de ce travail, les concentrations en mercure enregistrées à l'anse de Kouâli semblent être représentatives d'un site non pollué, en revanche à Bou Ismaïl, il semble que le site soit soumis à une faible pollution.

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EVOLUTIONARY MODEL OF A MICROTIDAL AND WAVE-DOMINATED COASTAL WETLAND SYSTEM IN SICILY (ITALY)

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Abstract

The Vendicari region is a good example of a coastal wetland system in a microtidal, wave-dominated and bed-rock confined environment, influenced by a dry Mediterranean climate. The study area has attained a near balance of accretion and relative sea-level rise rates, thus it can persist even if coastal wetlands are commonly perceived as sediment sinks destined to a final infilling. The aim of this study is to investigate the Vendicari region from a geological viewpoint, relating the evolution of this natural wetland with the adjacent coastal dune system, thus giving a rationale contribution to integrated coastal wetland management in Mediterranean.

Keywords : Lagoons, geomorphology, coastal models, sea level, shoreline evolution

Introduction

The coast of south-eastern Sicily is mostly terraced with active and abandoned cliffs and shore platforms, incised in Pleistocene carbonate-cemented sandstones and Holocene aeolian sandstones, situated on the eastern sector of the Iblean carbonate Plateaux (1).

Local conditions encourage accumulation forms such as sandy barrier beaches, pocket beaches and coastal wetlands, all ephemeral landforms on a geological time scale (2).

The Vendicari coastal wetland system was declared "Natural Reserve" in 1984 and, at present it is a site of international importance for Ramsar criteria, because it is a particularly good example of a natural Mediterranean wetland.

Material and methods

For the reconstruction of its temporal evolution, the present study advanced with two different methodological approaches: at long-term temporal scale, in the last 125,000 years, the Pleistocene and Holocene littoral deposits of the Vendicari region are described and analysed to investigate processes of wetland formation, and at short-term temporal scale, in the last 50 years, the coastal wetland system is described and monitored to evaluate its future tendency.

In addition, recent morphological changes have been observed in the barrier beach of Vendicari comparing aerial photographs (1943, 1977, 1987 and 1997) with topographic maps (1867, 1968 and 1977) and field data (1998-2000) collected during a seasonal monitoring (3).

Results

From a morphological viewpoint, the study area is characterised by a fine sand barrier beach about 3 km long, wedged between carbonate rocky headlands and a coastal wetland system, locally used as "salina" since Greek-Roman Age.

It is characterised by different wetland types (3):

- *Pantano Piccolo*, a coastal lake, not communicating with the sea, typical habitat of present lacustrine systems, hyperhaline and permanently flooded;
- I, a sabkha, typical habitat of present palustrine systems, hyperhaline and seasonally flooded, excavated and used in ancient times as "salina";
- *Pantani Roveto-Sichilli*, two partially closed lagoons, typical habitat of present estuarine systems, hyperhaline, permanently flooded and seasonally dried, interconnected with the sea through a single channel;
- *Ex-Pantani Balsamo, Chiatale, Scirbia e Cittadella*, all typical examples of ancient palustrine systems, saturated and locally manmade farmed.

The coastal dune system is characterised by sand ridges, partially vegetated and locally stabilised by wooden slats with hollows, incipient blow-outs and overwash fans. The adjacent bay includes at its centre a little carbonate rocky island, that became attached to the mainland some fifties years ago with a *tombolo*. In the Vendicari Bay, fine sandy bottoms prevail on *Posidonia oceanica* meadows and offshore rocky platforms.

Different scenarios have been reconstructed in the Pleistocene and Holocene, applying the transgressive barrier evolutionary model (4) to ancient and recent coastal and marine accumulation forms, at present eroded or with traces situated at different altitude.

The barrier beach and coastal wetland had different models of response at sea-level rise: stationary (overstepping), erosional and translational (rollover). The overstepping was particularly effective in the Vendicari region, because early diagenesis in beachrock and aeolian sandstones prevented mobility of barrier or a portion of it in presence of a warm and dry climate.

Greek-roman sites and individual structures, such as rock-cut features and pool-like depressions, positioned along the coast of Vendicari, provided additional data to confirm a relative sea-level rise in the last 2,500 years. Besides, it has been possible to locate, along the Scirbia stream, traces of the "Naustatmo", the ancient Roman channel-port (about 2,200 years BP) cited by Cicerone (3).

Rates of erosion and deposition were estimated along the beach, and the results confirm that, at a short-term temporal scale, comparing aerial photos between the 1977 and the 1997, accretion dominates in the southern sector and retreat is most significant in the northern sector, where the absence of *Posidonia oceanica* meadows and the bedrock produce an insufficient sediment redistribution mainly in correspondence of the ancient tombolo.

Conclusions

Although coastal wetlands are commonly viewed as sediment sinks, designated to be filled by continental, coastal and marine sediments (5), the Vendicari coastal wetland system has reached an accretionary balance with sediment accumulation rate adjusting to varying rates of relative sea-level rise.

In a microtidal, wave-dominated and bed-rock confined coastal wetland system, such as the study area, coastal variability results strongly influenced by inherited geological factors, which have controlled the evolutionary processes of the Vendicari region, where the sandy barrier beach continues to exert a double action on the adjacent wetlands, mitigating the influence of the sea and delivering fine sands into it.

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COASTAL WETLAND INVENTORY FOR SUPPORTING DECISION MAKERS IN SICILY (ITALY)

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Abstract
The analysis of the coastline in Sicily led to the individuation of different coastal wetlands of great ecological, social and economic value. Most of these areas are protected, at present, but they are dominated by processes that need to be constantly monitored. The aims are: 1) to summarise the information on coastal wetlands of Sicily; 2) to realise, on the basis of the Mediterranean Wetland Database (MWD), an inventory in order to assess the status of existing coastal wetlands in Sicily; 3) to promote awareness of the values of wetlands amongst decision makers.

Keywords : Lagoons, geomorphology, coastal management, coastal systems, sedimentation

Introduction

Coastal wetlands are transitional ecosystems between terrestrial and aquatic systems, where the land is covered by shallow water and the factors determining the sedimentary characteristics are mainly mechanical, due to the action of waves, littoral currents and wind. However, in areas characterised by Mediterranean climates, such as in Sicily, also chemical agents may exert a role (e.g., hyperhaline conditions due to high evaporation).

During this century, many coastal wetlands in Sicily have been anthropogenically modified or reclaimed for intensive agricultural practice and building of roads and houses. Some of them, however, are still in a status of good-health.

In the present study, we analysed the available information on coastal wetlands of Sicily using the guidelines of the Mediterranean Wetland Database (MWD) and the methodology developed under MedWet Project, undertaken jointly by the Instituto da Conservação da Naturaleza (ICN) and Wetlands International (1). The present study also summarised the large amount of data obtained by the "Sicilian beaches Atlas", 21 maps published in scale 1:100,000 and sponsored by National Research Council (C.N.R.) and Italian Minister of University and Scientific-Technological Research (M.U.R.S.T.).

Wetland inventory

The approach proposed distinguishes coastal wetland areas on the basis of habitat description system hierarchy proposed by MedWet Project (2), employing five system names (marine, estuarine, riverine, lacustrine and palustrine) with different subsystem, class and subclass names and an unspecified number of dominance types (3).

At the most detailed level, it was necessary to complete wetland habitat description, applying additionally three important parameters (water regime, salinity and artificial modifiers) according to the presence of human activities and to the duration and timing of surface inundation. The total length of the Sicilian coastline, excluding the minor islands, is about 1,104 km, of which about 32% is characterised by beaches, about 55% by cliffs, rocky platforms and terraces and about 13% by pocket beaches (4).

Along the beaches, of which about 54% are sandy, about 18% are sandy-gravelly and about 28% are gravelly, there are different depositional coastal forms: alluvial plains (about 5.5%), narrow valleys (about 15.5%), wide beaches with coastal dune systems (about 7.5%) and coastal wetlands and salines (about 3.5%).

In northern Sicily, the coast is characterised by steep cliffs with deep and narrow valleys and pocket beaches usually gravelly near the torrential stream mouths. The presence of coastal wetlands is limitated to Capo Tindari and Capo Peloro, where longshore sediment transport originated barrier spits surrounding some permanently flooded pools and lakes.

In the eastern sector of the island, the coast is often low-lying, with some alluvial plains. Seasonally flooded wetlands are present only next to river mouths.

In the south-eastern sector of the island, the coast is mostly terraced, with cliffs and rocky platforms and pocket beaches. Seasonally and permanently flooded wetlands as marshes, sabkhas, salines, coastal lakes, are present mainly in the Vendicari region.

In southern Sicily, the coast is generally low-lying, with wide sandy beaches, weakly incised by poorly developed hydrographic systems and locally include sand dune systems. Different coastal wetlands are distributed along the coast, chiefly in correspondence of some torrential streams and coastal sandy ridges.

In the western sector of the island, the coast is generally steep and rocky with terraces. Many coastal wetlands are man-made and used as salt exploitation sites.

In minor islands, where often active or extinct volcanoes have contributed to coastline changes, reshaping the topography, with lavas and pyroclastic materials of successive eruptions and explosions, there are no coastal wetlands.

Conclusions

In Sicily, many natural wetland habitats have been modified by human activities, and so it is necessary an improvement of environmental awareness of the local communities, because the social context is scarcely sensitive to natural heritage issues.

More information about the coastal wetlands are required for essential actions as effective planning, management, training, education and public awareness programmes.

The approach proposed to describe coastal wetlands, together with other social and economic information, may represent a guideline for local decision makers to better manage coastal wetlands, as well as other Mediterranean areas.

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COLONIZATION PATTERN OF THE INFRALITTORAL HARD SUBSTRATE COMMUNITY IN THE NORTH AEGEAN SEA (CHALKIDIKI, GREECE). PRELIMINARY RESULTS

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Abstract

The present study aims to examine the colonization of hard substrata. Blocks from two different materials, cement and ceramic, are fixed on vertical rocky substrate, at a depth of 25 m and sampled every 3 months for a period of two years. The data analysis indicates that no significant differences exist between the two different materials, while there is a quite clear change in community structure during time. This change was more severe during the first stages of succession and became smoother after the first year.

Keywords: infralittoral, Aegean Sea, colonization, hard substrate

During the last years much effort has been devoted to the study of succession in marine communities (1,2,3,4,5), which is related to the protection and recovery of natural assemblages as well as to the development of artificial reefs (6,7,8). Cement and ceramic blocks have been immerged in northern Aegean Sea and fixed on natural rocky substrates. The main purpose was to examine the succession stages with time and material used. In this report we present the preliminary results of a 2-year survey.

Materials and methods

Twenty-four cement and twenty-four ceramic blocks (30x30 cm^2) were set by scuba divers on vertical natural rocky substrate, at a depth of 25m, in spring 1998, in a small natural port, Porto, Koufo, located in Sithonia at Chalkidiki peninsula. Every three months 3 blocks from each material were collected by divers and transferred to the laboratory, where the surface of each block was scrapped and all organisms were preserved in 10% formalin. Overall samples are available for 3, 6, 9, 12, 15, 18, 21, 24 months. All organisms were counted and identified at species level. The numerical abundance of the main taxa (polychaetes, mollusks, branchiopods, amphipods and tanaidaceas) per sampling month were analyzed using cluster and multidimensional scaling techniques, based on the Bray-Curtis similarity and 4-transformed numerical abundances, using PRIMER (9,10). The significance of the multivariate results was assessed using ANOSIM test (10).

Results and discussion

Overall 5.486 individuals were counted belonging to 105 species. 980 polychaetes were classified to 27 species, 3724 mollusks to 60 species, 34 branchiopods to 2 species and 511amphipods 15 species. The results of cluster and MDS analysis are shown at figure 1. The stress value for the 2 dimensional MDS plot was 0.12, indicating good group separation. Nevertheless because this value is >0.1, any conclusions must be crosschecked by the superimposition of cluster groups (10). The results of ANOSIM (R= 0.804, significance level is 0,4%) indicate discrimination between the groups of samples and therefore the cluster is confirmed. From these figures we observe two main groups: 3 and 3c and all the remaining months combined. The latter group was composed of months 6 to 12 for both material and another one from 15 to 24. A clear separation of the samples from the first 3 months of immersion (3 and 3c) at a 35% similarity level is obvious. We can also select 6 main groups determined at 55% similarity level. From the above it is evident in terms of species composition that no significant differences exist among the cement and the ceramic blocks. Some differences that were observed during the pioneer stages of the recruitment started to disappear after the first 9 months. A gradual change towards increasingly higher similarities during time is detectable. All samples derived from 18 to 24 months were classified together whereas the earlier samples were more dissimilar among each other and formed 5 different groups. In other words, the relatively high dissimilarity that occurred during the first months of the colonization process decreased gradually with time. Especially after the first year, as the assemblage attained a more complex synthesis in terms of diversity (Table 1.), all samples became more similar, something that is expected to continue until it reaches the final climax stage (5,6,7,8).

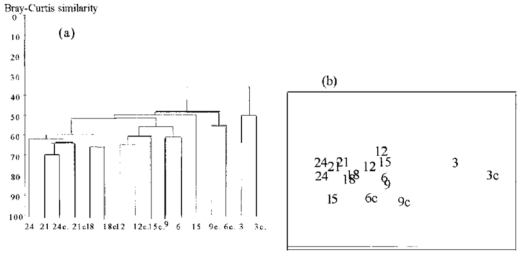

Figure I. Results of (a) cluster analysis and (b) multidimensional scaling, based on Bray-Curtis similarity index, of cement and ceramic(c.) blocks immerged in spring of 1998 and sampled every 3 months during 2 years of survey. The numbers correspond to the months that the blocks were immerged.

Table 1. Groups of samples occurred from the multidimensional scaling, where the species richness and the Shannon-Weaver index of diversity are calculated per group.

Group	Samples	Shannon intlex	Specles richness
1	3, 3c	1,947	21
2	6c, 9c	1,282	24
3	6, 9, 12, 12c, 15, 15c	1,004	42
4	18, 18c, 21, 21c, 24, 24c	1,078	58

Table 2. Species found from a 2-year survey, where the symbol * indicates the material (c: cement and cer: ceramic) from which each species has been collected.

Taxa (species	c	ce
Laetmonice hystrix (Savigny, 1820)		*
Harmothoe areolata (Grube, 1860)	*	*
Chrysopetalum debile (Grube, 1855)	*	*
Phyllodoce madeirensis (Langerhans, 1880)	*	*
Kefersteinia cirrata (Keferstein, 1862)	*	*
Grubeosylbs limbata (Claparede, 1868)		*
Sphaerosyllispirifera Claparede, 1868	*	*
Syllis hyalina Grube, 1863	*	*
Syllisprolifera Krohn, 1852	*	*
Nereis zonata Malmgren, 1867	*	*
Platynereis dumerilli (Audouin & MilneEdwars, 1833)		*
Glycera tesselata Grube, 1863	*	*
Dorvillea rubrovittata (Grube, 1855)	*	
Eunice vittata (delle Chiaje, 1929)	*	*
Lysidice ninetta Audoum & Milne Edwars, 1833	*	*
Nematonereis unicornis (Grube, 1840)	*	*
Scoletomupunchalensis (Kinberg, 1865)	*	*
Polyophthalmuspictus (Dujardin, 1839)	*	*
Terebella lapidaria Linnaeus, 1767		*
Amphiglena mediterranea (Leyding, 1851)	*	*
Hydroides norvegica Gunnerus, 1768	*	*
Placostegus crystalinus sensu Zibrowius, 1968		*
Pomatoceros triqueter (l.innaeus, 1865)	*	*
Serpula concharum Langerhans, 1880	*	*
Spirobranchuspolytrema (Philippi, 1844)	*	*
Vermilliopsis tnfundibulum (Gmelin, 1788)	*	*
Spirorbis sp	*	*
Acanthochitonafasciculans Risso, 1826		*
Chiton (Rhyssoplax) olivaceus Spengler, 1797		*
Arca tetragona Poli, 1795	*	*
Musculus (Modiolaria) costulatus (Risso, 1826)	*	*
Modiolus barbatus (Linnaeus, 1758)	*	*
Modiolus adriaticus (Lamarok, 1819)	*	*
Lissopecten hyalinus (Poli, 1795)	*	
Chlamys vana (Linnaeus, 1758)	*	*
Lima (Mantellum) inflata (Link, 1807)	*	*
Spondylus gacderopus Linnaeus, 1758	*	*
Anomia ephippium Linnaeus, 1758	*	*
Myrtea spinifera (Montagu, 1803)	*	*
Acanthocardia aculeata (Linnaeus, 1758)	*	*
Dosiniai (Pectunculus) exoleta (Linnaeus, 1758)	*	*
Irus irus (Linnaeus, 1758)	*	*
Lenhdium mediterraneum (Costa, 1839)	*	*
Hiatella archca (Linnaeus, 1767)	*	*
Acmaea virginea (Mueller, 1776)	*	*
Emarginula octaviana Coen, 1939	*	
Anatoma crispata Fleming, 1828	*	*
Haliotis lamellosa Lamarck, 1822		*
Clanculus corallinus (Gmelin, 1791)	*	*
Gibbula magus (Linnaeus, 1758)	*	*
Jujubinus exasperatus (Pennant, 1777)	*	*
Homalopoma sanguineum (Linnaeus, 1758)	*	*
Bittium latreillei (Payraudeau, 1826) *		*
Alvania cimex (Linnaeus, 1758)	*	*
Alvania discors (Allan, 1818)		*
Alvaniapaupercula (Jeffreys, 1867)	*	*
Manzonia crassa (Kanmacher, 1798)	*	*
Pusillina radiata (Philippi, 1836)	*	*
Setia turriculata Monterosato, 1884	*	*
Rissoina hrugueri (Payraudeau. 1826)	*	*
Caecum trachea (Montagu, 1803)	*	*
Vermetus triquetrus Bivona Ant, 1832	*	*
Payraudeauha intricata (Donovan, 1804)		*
Monophorusperversus (Linnaeus, 1758)	*	
Metaxia metaxae (Delle Chiaje, 1828)	*	
Cerithiopsis tuberculans (Montagu, 1803)	*	*
Epitonium commune (Lamarck, 1822)	*	
Melanella polita (Linaeus, 1758)	*	*
Muricopsis cristata (Brocchi, 1814)	*	*
Pollia dorbignyi (Payraudeau, 1826)	*	*
Nassarius incrassatus (S`troern, 1768)	*	*
Vexillum tricolor (Gmelin, 1791)	*	*
Bela nebula (Montagu, 1803)	*	
Mangelia attenuata (Montagu, 1803)	*	
Mangelia vauquelini (Payraudeau, 1826)	*	
Haedropleura septangulans (Montagu, 1803)	*	
Mitrolumna olivoidea (Carnraine, 1835)	*	*
Raphitoma echinata (Brocchi, 1814)	*	*
Raphitoma leuiroyi (Michaud, 1828)	*	*
Omalogyru atomus (Philippi, 1841)	*	*
Folinella excavata (Philippi, 1836)		*
Cylichnina umbilicata (Montagu, 1803)	*	*
Haminoca navicula (Da Costa, 1778)	*	*
Philine aperta (Linnaeus, 1767)	*	*
Umbraculum wnbraculum (Roeding, 1798)		*
Discodoris atromaculata Bergh, 1880	*	
Gwynia capsula (Jeffreys,)	*	*
Megathiris detruncata (Gmelin)	*	*
Microdeutopus anomalus (Rathke, 1843)	*	*
Dexamine spiniventris (NCosta, 1853)	*	*
Dexamine spinosa (Montagu, 1813)	*	*
Lysianassa caesarea Ruffo, 1987	*	*
Lysianassa costoe Milne Edwards, 1830	*	*
Penoculodes l.longimanus (Bate & Westwood, 1868)	*	*
Synchelidium longidigitatum Ruffo, 1947	*	*
Metaphoxus gruineri Karaman, 1986	*	*
Metaphoxus simplex (Bate, 1857)	*	*
Stenothoe ca~fimana Chevreux, 1908	*	*
Stenothoe monoculoides (Montagu, 1815)	*	*
Caprella acanthifera Leach, 1814	*	*
Caprella rapax Mayer, 1890	*	*
Phtisica marina Slabber, 1769	*	*
Unidentified sp. I	*	*
Leptochelia savignyi (Kroyer, 1842)	*	*
Cerithium vulgatum (Bruguiere, 1792)	*	*

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THE COLONIZATION OF EXPERIMENTAL ARTIFICIAL REEFS, FROM THE SERPULIDS POLYCHAETES, IN THE N. AEGEAN SEA (GREECE). PRELIMINARY RESULTS

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Abstract

This study presents the preliminary results concerning the fouling community of Serpulid polychates on an artificial reef deployed in the coastal waters of Fanari in October 1999, at a depth of 25 m. The reef was formed of cubic concrete blocks arranged in pyramids. The samplings were performed seasonally and the survey of the reef is still in progress. The analysis of the first 2 sampling periods shows a clear dominance of Serpulids among the faunistic components and a great amount of similarity between all samples in terms of numerical abundances.

Keywords: artificial reefs, Aegean Sea, polychaeta

The establishment of artificial reefs consists worldwide an important measure for the management of coastal marine ecosystems (1,2). The artificial reefs during the last ten years proved to be a very effective mean for the protection and the increase of local fish stocks (3,4). In Greece in July 1998 the first experimental reefs were deployed (5) and during October 1999 the first extensive protective zone with artificial reefs occupying an area of 6 Km^2, was constructed and deployed at cape Fanari (Vistonikos gulf).

Materials and Methods

The artificial reefs. The deployment area was selected after an extended pilot study of the broader coastal area (figure 1). The sea-bed of the study area is covered by a well-developed and continuous *Posidonia oceanica* meadow containing patches of completely degrading area, where the meadow is replaced by sandy sheets with organic detritus characterized by the presence of *Turitella communis* (6). The reefs were formed of cubic concrete blocks (2 x 2 x 2 m) arranged in pyramids. Each pyramid is made by 5 blocks, 4 at the base and I at the top (3). At the sides of the blocks holes of different diameter were created. In order to study the colonization of the reef from invertebrates, square concrete plates (35 x35 cm2) were placed at the 2 upper corners at each side of each block. A total of 9 pyramids were established at a depth of 25m in an area occupying 3 500m2 together with other types of artificial reefs, creating the nucleus of the protective zone.

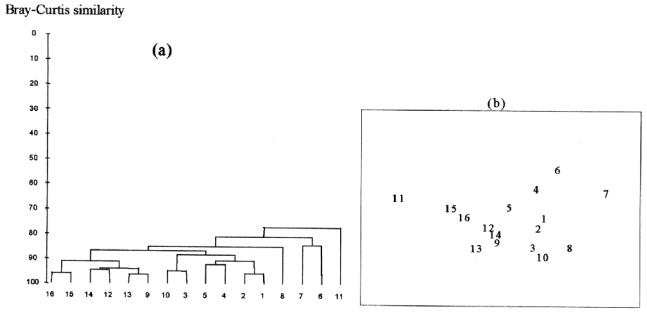

Figure 1. Results of (a) cluster and (b) multidimensional scaling (stress value = 0.106), based on Bray-Curtis similarity index, of the cement blocks immerged in autumn of 1999. From 1-8 are the samples during March (5 months of submersion) and from 9-16 are these during May (7 months of submersion).

Data collechon and analysis. The reefs were visit seasonally and 8 plates (35x35 cm^2) were collected by divers and transferred to the laboratory, where the surface of each block was scrapped and all selected organisms were preserved in 10% formalin. All faunal elements were counted and identified at species level. Specifically the Serpulids proved to be the main taxon representing more than 80% of the fauna in terms of numerical abundance. Consequently the study of reef colonization was restricted to family Serpulidae. These faunal data were analyzed using one way-ANOVA, cluster and multidimensional scaling techniques, based on the Bray-Curtis similarity and >1 transformed numerical abundances, using PRIMER (8,9). The significance of the multivariate results was assessed using ANOSIM test (9).

Results and Discussion

Overall 5.044 Serpulids were counted belonging to 6 species (Table l). We can easily detect that the two most important species, in terms of numerical abundance and dominance are *Spirobranchus polytrema* and *Pomatoceros triqueter*. The number of species is higher during the first period (March 2000 - 6 species and May 2000-4 species), probably due to different biotic factors (mainly intra-specifique competition, reproductive strategies). The deployment area was highly productive, so the limiting factor was the availability of hard substrate. As the species compete each other in order to occupy the free space and with the addition of different

Table 1. Distribution of Serpulids found on the plates of the artificial reef during the two sampling periods, *(Mab = mean abundance, Mdom = mean abundance).*

Species	March 2000 Mab	March 2000 Mdom	May 2000 Nlab	May 2000 Aldom
Serpula vermiculans	12.50	4.45	18.38	5.26
Placostegus tridentatus	3.13	1.11	0.00	0.00
Hydroidespseudouncinata	11.00	3.91	11.50	3.29
Pomatoceros triqueter	47.38	16.85	127.88	36.60
Spirobranchus polytrema	207.00	73.63	191.63	54.85
Vermilliopsisinfundibulum	0.13	0.04	0.00	0.0

growth rates, a replacement of the most vulnerable occur (7). These two dominant species seems to be the best adapted during these first stages of colonization process. The results of cluster and MDS are shown at figure 2. The stress value for the 2- dimensional MDS configuration was 0.106 indicating good group separations with no real prospect of a misleading interpretation (8). The results of ANOSIM (R= 0.74, significance level is 0.1%) indicate discrimination between the groups of samples, so the cluster is confirmed. We can detect 5 main groups. The 2 major ones, group together the samples of each period with the exception of 6 and 7 that form a unique cluster, the sample 8 that discriminates alone and the samples 10 and 11 that form the 5~ cluster. A strong degree of similarity between samples seems to occur. The perform of one-way ANOVA (F=4.894, p=0.04 1) indicates the rejection of the null hypothesis: no differences among samples exist in terms of numerical abundance, at 95% significant level. The artificial reef was deployed at a eutrophic area, which explains the dense colonization from Serpulids that are typically filter-feeder organisms. Moreover Serpulids have proved to be the first organisms of fouling that settle after the development of the bacterial film (10). This may be an explanation of the observed high level of similarity. In addition, the time period in-between the 2 samplings were only 2 months and no truly seasonality was detected from the main abiotic factors. This suggests that the differences among the microhabitats are not significant and so the development of the reef is expected to be uniform. The survey of the reef is still in progress.

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PHYTOPLANKTON COMMUNITY SIMILARITY INDICES: A NEW METHODOLOGY FOR DETECTING EUTROPHICATION TRENDS IN COASTAL MARINE ECOSYSTEMS

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Abstract

Four similarity indices based on phytoplankton community structure were examined for their sensitivity to assess different levels of eutrophication. Two phytoplankton data sets, one from an open coastal system and one from a semi-enclosed gulf, associated with different nutrient dynamics and circulation patterns were used for evaluating the indices. The results have indicated that similarity indices, measuring interspecific association and resemblance of phytoplankton communities between discharged areas and control sites, were effective for detecting spatial and temporal dissimilarities in coastal marine ecosystems.

Keywords: Eutrophication, phytoplankton, coastal waters, Aegean Sea.

The changes in phytoplankton communities that can be used for water quality assessment depend on the initial structure of the community and its response to exogenous stress factors [1]. Consequently, the development of analytical procedures for the study of phytoplankton community structure should take into account both the significance of the baseline information collected from unimpacted (control) sites and the divergence between these reference levels and data from affected areas. The main objective of the present work was the evaluation of the effectiveness of four similarity indices, measuring interspecific association and resemblance of phytoplankton communities between polluted and control sites, in order to generate a sensitive methodology that detects eutrophic trends and classifies properly different pollution levels.

Study areas

The first study area was the gulf of Gera, Island of Lesvos, Greece, a semi-enclosed water body surrounded by an intensively cultivated and inhabited watershed. The experimental procedure and further details concerning ecosystem's properties have been described elsewhere [2]. Data collection was based on seventeen cruises that were carried out on a monthly basis from June 1996 to October 1997. Samples have been collected from eight sampling stations [GG1] to [GG8], that are shown in Figure 1; six stations [GG3]-[GG8] were located inside the gulf, whereas the rest two were situated in the entrance (station [GG2]) and outside of the gulf (station [GG1]), the latter used as control site. The second data collection was carried out on a monthly basis during May 1983-April 1984 at ten stations (Fig. 1) situated along the coastal area of the city of Rhodes, Island of Rhodes, Greece, as detailed described in a previous paper [3]. Stations [RH3], [RH4] and [RH5] were located in the vicinity of harbours, defining the upper eutrophication limits in the area. Two stations ([RH7] and [RH9]) located about one mile offshore (in an area with intense circulation and depth greater than 200 m) were chosen as the control sites (the baseline information of the system); the remaining stations were spaced out nearshore used for swimming and other recreational activities.

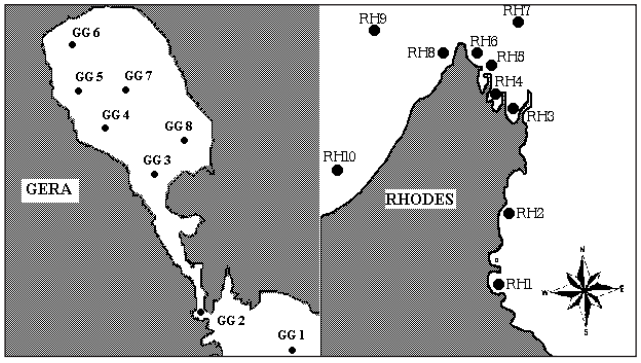

Figure 1. The gulf of Gera and the coastal area of the city of Rhodes: station locations.

Phytoplankton community similarity indices.

Four similarity indices, quantifying the contribution of each species to the total phytoplankton biomass, were used as estimators of the resemblance among discharged areas and control sites. These similarity indices were [4]:

$$SI_{RU} = \frac{\sum_{i} \min(x_i, y_i)}{\sum x_i + \sum y_i - \sum \min(x_i, y_i)} \qquad SI_{CA} = \sum_{i} \left[\frac{|x_i - y_i|}{(x_i + y_i)} \right]$$

$$SI_{EL} = \frac{\sum_{i \in T} \min(x_i + y_i)}{2.\sum_{i \in U} x_i + 2.\sum_{i \in V} y_i - \sum_{i \in T} (x_i + y_i)} \qquad SI_{BC} = \frac{\sum_{i} |x_i - y_i|}{\sum_{i} (x_i + y_i)}$$

where x_i, y_i the abundances of the ith phytoplankton species in the two sampling sites, T the subset of species occurring in both samples, U and V those occurring in one or other only. These indices represent wider categories of resemblance measures, varying in terms of a) the assigned priorities in the deviations among the abundant (i.e. Ruzicka's index) and rare (i.e. Camberra metric) species or b) the different (i.e. Ellenberg's index) or the same (Bray-Curtis' index) processing of the common and non-common subcategories. Cluster analysis was applied for each index to study the grouping of the stations. The Euclidean distance was used as a similarity measure and the group average distance was chosen as the clustering algorithm, since this clustering technique introduces relatively little distortion to the relationships between stations.

Results and discussion

The application of the similarity indices in the specific areas, which in fact implies the comparison of the discharged stations in terms of their resemblances to the control sites, is illustrated in Figure 2. This representation involves the classification results derived from Ellenberg's, index, but analogous inferences could be extracted from the rest similarity measures. It can be seen that the internal stations of Gera have formed two distinct groups: the group of the stations [GG5], [GG6], [GG7] located at the northwestern part of the gulf and the group of the stations [GG3], [GG4], [GG8] characterizing the southeastern spatial compartment of the area, whereas the station [GG2] at the entrance of the gulf exposed a discrete performance of its phytoplankton community. This clear-cut grouping of the internal stations is attributed mostly to the differences of the nutrient discharges from the respective segments of the watershed in combination with the circulation pattern of the gulf that leads to an inadequate renewal of the seawater of the inner parts, especially during the periods of limited exchanges with the open sea. In a similar way, the classification patterns of the coastal area of Rhodes indicated a clear distinction between polluted sites [RH3], [RH4], [RH5] near the harbour and the sites used for swimming and other recreational activities [RH1], [RH2], [RH6], [RH8], [RH10] which were clumped into a single group at a mean level of 40 to 50 % of similarity. Conclusively, the similarity indices, as measures of the deviations among affected and control sites, seem to be a sensitive methodology for water characterization that enables the generation of rational hypotheses concerning spatial dissimilarities in the structure of phytoplankton communities.

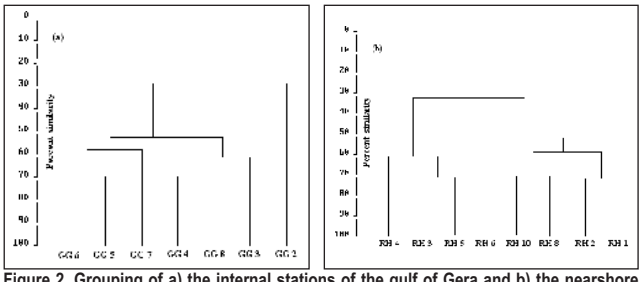

Figure 2. Grouping of a) the internal stations of the gulf of Gera and b) the nearshore stations of Rhodes. The resemblance measure among the stations and the reference site was Ellenberg's index.

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AMPHIPODES DES SABLES FINS ET POLLUTION SUR LA CÔTE ALGÉRIENNE

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Résumé

L'étude des Amphipodes du peuplement des sables fins (SF) des baies d'Alger, Bou Ismaïl et du golfe de Jijel, a été abordée par la diversité et l'abondance. En considérant l'urbanisation, l'industrialisation, le flux des eaux usées, la baie d'Alger est une zone polluée, tandis qu'en baie de Bou Ismaïl la pollution est négligeable; le golfe de Jijel est une zone naturelle. La diversité, particulièrement la représentativité spécifique, révèle une relation étroite entre les populations d'Amphipodes et le degré de pollution du milieu, relation mise en évidence par la densité, la dominance et la fréquence. La présence ou l'absence des Amphipodes dans le cortège des espèces principales, et leur dominance, sont des éléments révélateurs de la qualité du milieu. Il apparaît à travers les analyses des populations d'Amphipodes que la baie d'Alger est la plus polluée, avec existence d'un gradient de pollution décroissant d'Ouest en Est, le golfe de Jijel indemne de toute perturbation et la baie de Bou Ismaïl très proche d'un milieu naturel.

Mots clés : Amphipodes, pollution, peuplement des sables fins, Algérie.

Ces dernières années, le littoral algérien est soumis à une urbanisation et une industrialisation intenses, touchant essentiellement les baies et golfes. Les eaux usées urbaines et industrielles arrivent directement (émissaires urbains) ou indirectement (oueds) sur les fonds côtiers des sables fins (0 à -25 m) colonisés par un peuplement macrobenthique spécifique. Ces flux d'eaux usées ne sont pas sans conséquences sur ce peuplement. Les investigations sur les fonds meubles de la côte algérienne ont permis de localiser, d'identifier et de caractériser ce peuplement des SF; une attention particulière est accordée aux baies d'Alger, Bou Ismaïl et au golfe de Jijel. L'analyse des richesses spécifique et numérique du peuplement des SF et particulièrement de l'un de ses compartiments, les Amphipodes, permet d'évaluer l'impact des activités humaines sur ces fonds côtiers. L'analyse de la diversité, la dominance et la fréquence des Amphipodes du peuplement des SF constitue un outil fort appréciable pour l'évaluation de l'état d'un milieu (1).

Matériels et méthodes

Milieu : La baie d'Alger et son arrière-pays sont les secteurs les plus urbanisés et industrialisés d'Algérie: 12% de la population soit environ 3.5 Millions d'habitants et 22% des activités industrielles. Les eaux usées de la région algéroise sont drainées vers la mer par de nombreux émissaires et deux oueds (El Harrach et Hamiz). Dans cette baie, la population et les industries sont concentrées dans le secteur Ouest, et beaucoup moindre dans le secteur Est : existence d'un gradient de pollution décroissant d'Ouest en Est. Le peuplement des SF occupant les fonds de 0 à -25m est soumis aux pollutions urbaines et industrielles. La baie de Bou Ismaïl est très faiblement urbanisée et non industrialisée : région à vocation agricole. Le golfe de Jijel est une des rares régions naturelles d'Algérie: urbanisation très faible, industrie inexistante.

Echantillonnage : Quatre stations (-10m) en baie d'Alger ont été retenues: la station 1 dans le secteur Ouest, le plus affecté par la pollution, la station 4 dans le secteur Est, le moins pollué, et les stations 2 et 3 dans le secteurs Centre, secteur intermédiaire entre les deux précédents. A chaque station, $1m^2$ est prélevé avec une benne Van Veen mensuellement de novembre 1984 à octobre 1985, puis par saison de décembre 1985 à septembre 1986. Pour Bou Ismaïl (août 1988- 10 stations) et Jijel (juillet 1986- 19 stations), les prélèvements ($0.5m^2$) sur les fonds de sables fins (-8 à –25m) sont réalisés avec une benne Van Veen. Le sédiment est tamisé sur maille de 1mm.

Méthodes : Pour le traitement des données et leur expression, les indices retenus sont : la diversité des Amphipodes au sein du peuplement et son expression en pourcentage par rapport à la diversité totale, la dominance des Amphipodes, et leur présence dans le cortège des espèces principales du peuplement, la fréquence (F): espèces constantes (F=100%) ; espèces très communes ($75 \leq F<100\%$); espèces communes ($50 \leq F<75\%$) ; espèces peu communes ($25 \leq F<50\%$) ; espèces rares F<25%; espèces épisodiques (espèces récoltées une seule fois).

Résultats

Baie d'Alger : La diversité des Amphipodes est presque identique aux stations 1,2 et 3 respectivement 19, 20 et 21 espèces, diversité remarquable à la station 4 : 36 espèces. La représentativité des Amphipodes au sein de la diversité totale du peuplement se caractérise par des valeurs croissantes de la station 1 vers la station 4 : valeurs très proches aux stations 1 et 2 (9.01 et 9.94%), valeurs légèrement supérieure à la station 3 (10.77%) et nettement élevée à la station 4 (14.94%). Sur le plan quantitatif, la station 2 se distingue par une faible densité (18 ind./m^2), appréciables et très proches: 38, 40 et 47 ind./m^2 pour respectivement les stations 1, 3 et 4. La dominance des Amphipodes est minimale à la station 2 (1.29%), et maximale aux stations 3 et 4 (3.54 et 3.35%), intermédiaire à la station 1, (2.88%). La représentativité numérique des Amphipodes faible ou très faible se répercute sur la composition du cortège des espèces principales du peuplement: aucun Amphipode espèce principale aux stations 1 et 2, *Pariambus typicus f. armata* seul Amphipode dans le cortège des stations 3 et 4, présence bien modeste au vu de ses dominances: 2.27% à la station 3 et 1.34% à la station 4. Les Amphipodes se caractérisent par leur rareté dans le temps aux stations, qui s'atténue de la station 1 vers la station 4 : 80% des Amphipodes espèces rares ou épisodiques à la station 1, 69.44% à la station 4, 68.42% et 71.42% pour respectivement les stations 2 et 3. Aucun Amphipode n'est espèce constante à Alger. *Pariambus typicus f. armata* est espèce très commune aux stations 3 et 4, ou espèce commune aux stations 1 et 2. Les espèces communes sont *Atylus swammerdami* à la station 1, *Ampelisca spinipes* aux stations 3 et 4, et *A. sarsi* à la station 4. Les espèces peu communes sont deux à la station 1, 4 ou 5 aux stations 2, 3 et 4.

Baie de Bou Ismaïl : 39 Amphipodes sont recensés dans le peuplement des SF (17.81% de la diversité totale). Leur densité, 183 ind./m^2, correspond à une dominance de 21.5%. Dans le cortège des espèces principales, existent quatre Amphipodes : *Urothoë brevicornis, U. poseïdonis, U. grimaldii, Ampelisca brevicornis*, ayant une dominance cumulée de 11.49%. *Ampelisca brevicornis* et *Lembos spiniventris* sont des espèces communes, *Ampelisca diadema, A. sarsi, Urothoë poseïdonis, U. grimaldii, Siphonoecetes dellavallei, Lembos angularis et Phtisica marina* des espèces peu communes ; 77% des Amphipodes sont des espèces rares ou épisodiques.

Golfe de Jijel : Les 30 Amphipodes du peuplement des SF représentent 20.98% de la diversité totale, pour une densité de 373 ind./m^2 soit une dominance de 52.57%. La moitié des espèces principales sont des Amphipodes : *Ampelisca brevicornis* (espèce leader), *A. spinipes, A. sarsi, A. diadema, Lembos spiniventris, Urothoë poseïdonis, U. brevicornis*, ayant une dominance cumulée de 49.98%. Les Amphipodes sont fréquents dans le peuplement : espèces très communes *Ampelisca brevicornis* et *Urothoë poseïdonis*, espèces communes *Lembos spiniventris, Ampelisca sarsi, Urothoë brevicornis*, espèces rares ou épisodiques 76.66% des Amphipodes.

Discussion - Conclusion

Les populations d'Amphipodes du peuplement des SF d'Alger, Bou Ismaïl et Jijel par leurs caractéristiques qualitatives et quantitatives reflètent l'impact des activités humaines sur le milieu marin: la représentativité des Amphipodes au sein de la diversité totale augmente d'Ouest en Est en baie d'Alger en relation avec la réduction de la pollution, représentativité minimale en baie d'Alger, maximale pour Jijel (milieu naturel) ou élevée pour Bou- Ismaïl (milieu à pollution négligeable); il y a absence d'Amphipodes dans le cortège des espèces principales pour les secteurs fortement pollués (stations 1 et 2), présence minimale dans les zones polluées (station 3 et 4), maximale dans la zone naturelle comme Jijel (moitié des espèces principales) et Bou Ismaïl; la dominance des Amphipodes est maximale (moitié des effectifs) à Jijel, ou élevée (quart des effectifs) à Bou Ismaïl, minimale à Alger (<3.6%) avec une augmentation d'Ouest en Est (gradient de pollution décroissant); les fréquences des Amphipodes sont maximales pour les régions de Jijel et Bou Ismaïl, minimales en baie d'Alger. La comparaison des caractéristiques des populations d'Amphipodes du peuplement des SF des baies d'Alger, Bou Ismaïl et du golfe de Jijel, révèle une relation étroite entre ces indices et le degré de pollution du milieu. La raréfaction ou la grande diversité des Amphipodes sont autant d'informations sur la qualité du milieu. Ces constatations sont en accord avec les observations effectuées en d'autres aires soumises à pollution (2 et 3). De nombreuses études ont montré la sensibilité des Amphipodes (1) . Cette sensibilité signalée par certains auteurs (2 et 3), fait d'eux d'excellents indicateurs biologiques, caractère que leur mode de reproduction direct, l'insularité de leur population (3) renforcent.

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DIVERSITÉ DE LA MACROFAUNE DES SABLES FINS DE LA CÔTE ALGÉRIENNE

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ISMAL, Sidi- Fredj - Staoueli- Alger

Résumé

La macrofaune des sables fins des golfes et des baies de la côte algérienne : Arzew, Bou Ismail, Alger, Béjaia, Jijel et Fetzera, se caractérise par une grande diversité (548 espèces) où les Polychétes représentent la moitié des espèces, les Crustacés le quart et les Mollusques 20%. Cette hiérarchisation des groupes zoologiques se retrouvent au niveau de chaque région étudiée. Pour toutes les régions, la diversité de la macrofaune est à peu prés similaire, excepté pour la baie d'Alger ayant une diversité maximale (380 espèces). Les Polychétes sont en effectifs le groupe dominant à Alger, Bou Ismail, Arzew et Béjaia, tandis que les Crustacés le sont à Jijel et Fetzera. Les espèces principales sont des Polychétes (*Lumbrineris impatiens, Owenia fusiformis*) et des Mollusques (*Spisula subtruncata, Venus gallina*) en baie d'Alger, essentiellement des Polychétes à Arzew (*Hyalinoecia bilineata, Chaetozone setosa*) et à Bou Ismail (*Chone filicaudata)*, des Polychétes (*Ditrupa arietina*) et Crustacés (*Urothoë poseidonis*), et essentiellement des Crustacés Amphipodes à Jijel (*Ampelisca brevicornis*, *Lembos spiniventris*) et à Fetzera (*Urothoë grimaldii, Siphonoecetes dellavellei*).

Mots clés : Macrofaune, diversité, sables fins, Algérie .

Par le passé, la macrofaune des fonds meubles du plateau continental algérien a fait l'objet de très peu de travaux, travaux fragmentaires et dispersés dans le temps et l'espace (1- 4). Depuis la fin des années 1970, une nouvelle impulsion est donnée aux recherches sur cette macrofaune pour une meilleure connaissance de ses caractéristiques (répartition, diversité, densité, biomasse). Une attention particulière a été accordée à la macrofaune des sables fins de l'ensemble de la côte algérienne: baies d'Alger, de Bou Ismaïl, de Fetzera, d'Oran, golfes d'Arzew, de Béjaïa, de Jijel. Cette étude a pour objectif d'identifier et de caractériser le peuplement des sables fins (SF): structure et organisation des ensembles faunistiques, diversité globale, diversité des groupes zoologiques. Le présent travail se limitera aux aspects qualitatif (diversité) et quantitatif de la macrofaune des sables fins.

Matériels et méthodes

Les zones d'étude sont les principaux golfes et baies d'Algérie: Arzew, Bou Ismaïl, Alger, Béjaïa, Jijel, Fetzera. Les sables fins occupant le fond de ces baies et golfes s'étalent généralement de 0 jusqu'à 20-25m de profondeur. Pour chaque zone, une série de prélèvements quantitatifs couvrant l'ensemble des sables fins a été réalisée. Le sédiment est tamisé sur maille de 1 mm.

Résultats

L'inventaire systématique de la macrofaune des sables fins de l'ensemble des baies et golfes étudiés révèle un total de 548 espèces.

La figure 1 montre un grand déséquilibre dans la répartition des espèces entre les divers groupes zoologiques: les Polychètes groupe leader avec presque la moitié de la diversité totale (43.3%), les Crustacés et les Mollusques groupes principaux avec respectivement 29.74 et 19.52% des espèces, les Echinodermes groupe de second plan (4.38% de la diversité totale), les Cnidaires, les Pycnogonides, les Procordés, les Poissons, les Sipunculidiens et les Phoronidiens, groupes accessoires avec moins de 1% de la diversité totale. Cette hiérarchisation des groupes zoologiques principaux est également valable pour la macrofaune de chacune des zones étudiées. Les diversités des régions étudiées sont assez proches: 196, 164, 157, 143, 134 espèces pour respectivement Bou Ismaïl, Arzew, Béjaïa, Jijel et Fetzera, sauf pour Alger qui se distingue avec 380 espèces. Sur le plan quantitatif, la baie d'Alger se caractérise par une forte densité (1386 ind./m^2), Bou Ismaïl et Béjaïa par des densités moindres respectivement 875 et 942 ind./m^2, densités plus faibles à Jijel et Arzew (712 et 612 ind./m^2), et minimale à Fetzera (386 ind./m^2). L'analyse de la répartition des individus selon les groupes zoologiques met en évidence quatre cas de figure: 1er cas-Baie d'Alger: dominance très nette des Polychètes (61.76%) suivi des Mollusques (26.76%), Crustacés (4.90%) et Phoronidiens (4.47%); 2ème cas - Golfe d'Arzew et de Béjaïa: dominance écrasante des Polychètes (78.89% - 76.3%) avec en seconde position les Crustacés (9.46% - 20.40%), suivi des Mollusques (8.48% - 5.07%) et des Echinodermes (2.93% - 0.52%); 3ème cas - Baie de Bou Ismaïl: dominance des Polychètes (34.63%) suivi de près par les Crustacés (29.48%) et les Cnidaires (21.71%) et loin derrière les Echinodermes (7.08%) et des Mollusques (6.62%); 4ème cas - Golfe de Jijel et baie de Fetzera: dominance des Crustacés (54.74% - 36.52%) suivi des Mollusques (23.36% - 31.65%), des Polychètes (17.04% - 27.11%) et des Echinodermes (4.18% - 0.97%). La composition spécifique du cortège des espèces principales est le reflet de la structure zoologique du peuplement des SF pour chaque zone. Les espèces leaders sont: en baie d'Alger les Polychètes *Lumbrineris impatiens, Owenia fusiformis*, les Mollusques *Spisula subtruncata, Venus gallina, le Phoronidien Phoronis psammophila*; à Arzew les Polychètes *Hyalinoecia bilineata, Chaetozone setosa, Ditrupa arietina;* à Bou Ismaïl une Actinaire indéterminée, le Polychète *Chone filicaudata*, l'Echinoderme *Amphiura chiajei*, les Crustacés *Apseudes latreilli mediterraneus, Urothoë poseïdonis et U. grimaldii*; à Béjaïa le Polychète *Ditrupa arietina*, les Crustacés *Amphipodes Urothoë poseïdonis* et *U. grimaldii*; à Jijel les Amphipodes *Ampelisca brevicornis, Lembos spiniventris, Urothoë poseïdonis*, les Mollusques *Spisula subtruncata* et *Venus gallina*, et à Fetzera les Amphipodes *Urothoë grimaldii, Ampelisca brevicornis, Siphonoecetes dellavallei*, les Mollusques *Axinulus subovatus, Tellina fabula*.

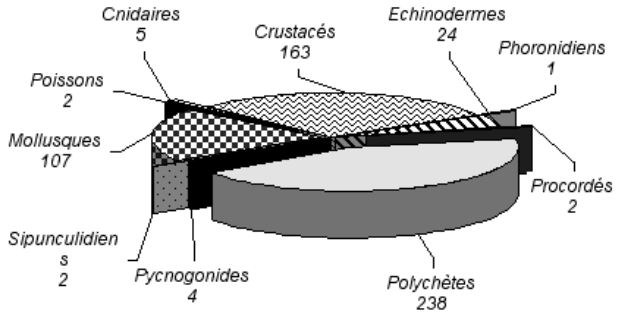

Fig. 1. Peuplement des sables fins de la côte algérienne : diversité par groupes zoologiques

Discussion - Conclusion

De manière globale, le peuplement des SF des côtes algériennes se caractérise par une grande diversité; cependant les groupes zoologiques sont très inégalement représentés: les Polychètes presque la moitié des espèces, les Crustacés un peu plus du quart des espèces et les Mollusques environ 20% des espèces. Les Polychètes et les Crustacés représentent environ les trois quarts de la diversité totale, et avec en plus les Mollusques 92.69%. Cette structure de la diversité se retrouve au niveau de chaque zone étudiée. Les diversités des baies et golfes sont très proches, excepté pour Alger où la diversité élevée s'expliquerait par la longue période d'échantillonnage ou/et la richesse des matrices eau et sédiment en matières organiques. La baie d'Alger présente la densité maximale et Fetzera la densité minimale, les densités des autres zones sont intermédiaires. A Alger, les Polychètes et les Mollusques constituent 80% des effectifs; à Arzew et Béjaïa les Polychètes les trois quarts des effectifs, suivi des Crustacés; à Bou Ismaïl les trois groupes principaux: Polychètes, Crustacés, Cnidaires, ont des effectifs à peu près équivalents; pour Jijel la moitié des effectifs sont des Crustacés Amphipodes qui avec les Mollusques constituent les trois quarts des effectifs; ces Crustacés dominent légèrement à Fetzera, suivi des Polychètes et des Mollusques de même importance. Les espèces principales sont des Amphipodes à Béjaïa, Jijel et Fetzera, ou des Crustacés à Bou Ismaïl, des Polychètes à Arzew et Alger. Ces conclusions sont en partie en accord avec les observations sur les peuplements des sables fins des côtes de Provence (5). Les diversités notées: 103, 106 et 132 espèces pour respectivement la Côte de Camargue, l'Anse de Verdon et la baie de Bandol, sont bien inférieures à celles des côtes algériennes, par contre les densités sont beaucoup plus élevées (respectivement 3227, 2121 et 1464 ind./m^2). Sur le plan de la diversité zoologique, les structures sont identiques entre les côtes de Provence et les côtes algériennes; les structures numériques des peuplements des côtes de Provence sont identiques à celle d'Alger mais nettement différentes de celles des autres régions.

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CARACTERISATION PHYSICO-CHIMIQUE DES EAUX DE LA LAGUNE DE SMIR EN ETE

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Résumé
La lagune de Smir est sujette à une salinisation progressive et a tendance à évoluer d'une lagune de type estuarien à une lagune de type neutre. La réduction de l'arrivée des eaux douces et la permanence de la communication avec la mer donnent une distribution homogène des paramètres physico-chimiques durant le flot. Pendant le jusant, cette distribution est différenciée et est marquée par les eaux venant du chenal des marais qui sont plus chaudes, plus salées et bien oxygénées.

Mots clés : Lagoons, Salinity, Temperature, Oxygen, Alboran sea

Située à une vingtaine de kilomètres au sud du détroit de Gibraltar, la lagune méditerranéenne de Smir est la lagune la plus occidentale du bassin méditerranéen. Elle a une surface de 0.5 km^2, une profondeur maximale de 2.5 m et reçoit les eaux provenant des marais localisés au sud de la lagune et de façon réduite les eaux de l'Oued Smir retenues par un barrage. Cet écosystème communique avec la mer par un goulet et subit de façon régulière la marée dont l'amplitude moyenne est de 1 m.

Les résultats obtenus avec les différents paramètres sont présentés sous forme de cartes de distribution.

Salinité.

L'intérieur de la lagune et les eaux qui sortent du chenal des marais sont plus salées (40‰) (Fig. 1); une partie des eaux marines qui ont envahi ce chenal pendant le flot se sont évaporées. En revanche, une auréole de dessalure est mise en évidence à la débouchée de l'oued Smir dans la lagune témoignant d'arrivée d'eaux douces.

Température.

Les eaux de la lagune sont marquées par les eaux chaudes venant du chenal des marais qui se dirigent vers le goulet (Fig.1). La température du sédiment prise à 5 cm de profondeur dans le substrat se superpose de façon remarquable avec la répartition des isothermes de l'eau avec des températures variant de 24 à 28°C. L'intérieur de la lagune présente les plus faibles températures.

Oxygène dissous.

Les eaux venant du chenal des marais se distinguent aussi par des valeurs élevées en oxygène témoignant du rôle joué par la végétation des marais dans l'oxygénation de ces eaux sortantes (Fig. 1). Ces courbes d'oxygène se superposent de façon évidente avec les isothermes mÍme si la température est élevée, car cette zone, qui s'étend jusqu'au goulet, est occupée par une prairie dense de phanérogames qui enrichissent le milieu en oxygène. L'intérieur de la lagune faiblement couvert de végétation montre des valeurs relativement faibles en oxygène dissous.

Depuis la construction du barrage sur l'Oued Smir en 1991, la physico-chimie de la lagune de Smir est marquée par une salinisation progressive des eaux. En effet, en 1988, la salinité était bien moindre et variait selon les saisons entre 0.3 et 24‰ (1). L'augmentation de la salinité influence de façon nette la composition, la structure et le fonctionnement du compartiment biologique qui se modifie graduellement, ce qui se traduit par l'installation croissante d'espèces marines dans la lagune et de formations végétales halophytes dans les marais (2).

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N.B. : Travail réalisé dans le cadre du projet MECO du Programme INCO-DC

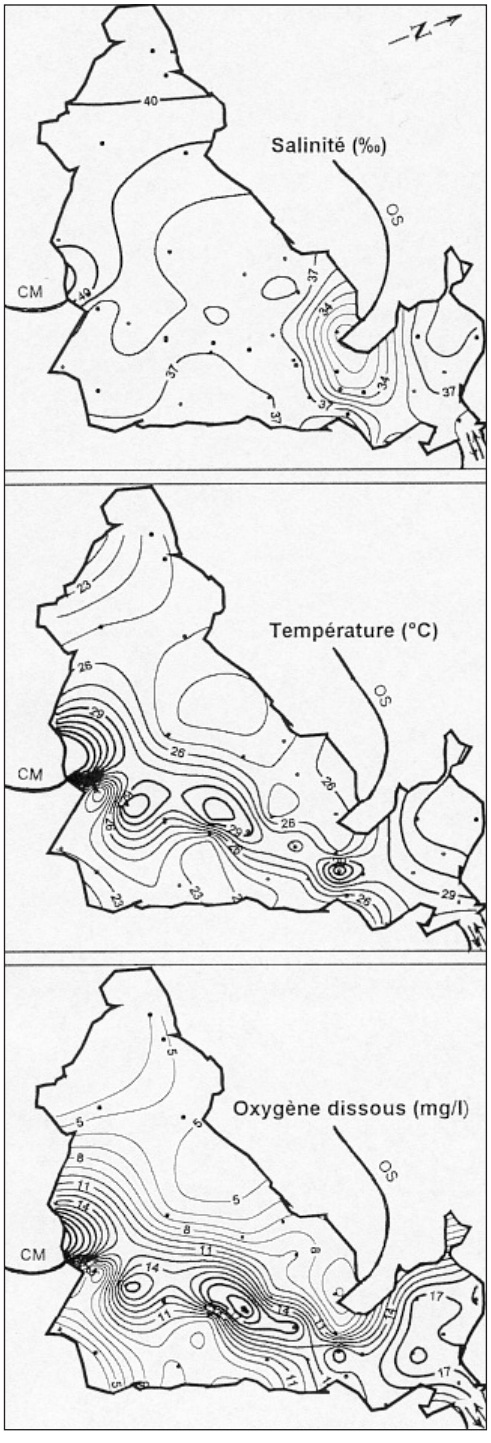

Figure 1 : Répartition de la salinité, température et oxygène dissous des eaux de la lagune de Smir pendant le jusant en septembre 2000. OS : Oued Smir; CM : Chenal des marais.

ETAT DE SANTE DES PEUPLEMENTS BENTHIQUES DE LA LAGUNE DE MERJA ZERGA (MAROC)

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Résumé

Les états de dégradation de la faune macrobenthique de Merja Zerga sont identifiées à l'aide d'un modèle de distribution des groupes d'espèces de polluo-sensibilité différente. Les peuplements intertidaux sont plus dégradés que ceux du subtidal. Ceci est en rapport avec les processus hydrodynamiques et sédimentaires différents dans les deux zones. La prise en compte uniquement de la matière organique totale n'est pas suffisante pour rendre compte de la diversité des situations observées.

Mots clés : Lagoons, Polychaeta, Pollution, Western Mediterranean

Introduction

La lagune de Merja Zerga (Fig. 1) est un milieu côtier semi-fermé où les apports de matière organique ont la possibilité de se sédimenter. De nombreuses sources de pollution sont identifiées (1). La macrofaune benthique est certainement le meilleur outil biologique pour refléter les déséquilibres de l'écosystème, liés aux surcharges en matière organique (2). Le présent travail est une tentative de bioévaluation des structures benthiques de la lagune de Merja Zerga.

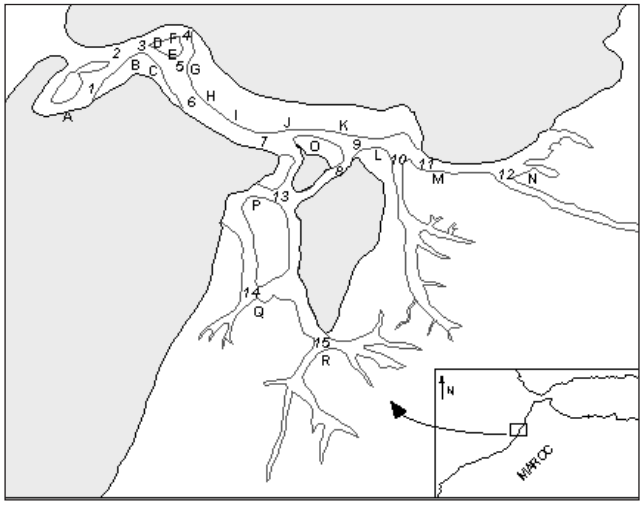

Figure 1 : Situation géographique de la lagune de Merja Zerga et localisation des stations d'échantillonage. *Les lettres de A à R correspondent aux stations intertidales; les chiffres aux stations subtidales.*

Materiel et méthodes

La présente étude s'appuie sur l'analyse de 18 stations intertidales, échantillonnées mensuellement, et 15 stations subtidales, prospectées une fois par trimestre entre février 1994 et février 1995 (Fig. 1). L'évaluation de l'état de dégradation des peuplements benthiques est réalisée à l'aide de la méthode des groupes écologiques (GE) et indices biotiques (IB) (3). Les espèces de Polychètes présentes, sont réparties en 5 groupes de polluo-sensibilité différente : sensibles (GE I), indifférentes (GE II), tolérantes (GE III), opportunistes de second ordre (GE IV) et opportunistes de premier ordre (GE V). Le calcul des proportions respectives des différents groupes permet de définir sept états de dégradation ou indices biotiques. L'IB 0 indique une situation normale, l'IB 2 un premier déséquilibre, les IB 4 et 6 signifient que les milieux sont respectivement pollués et très pollués. Les IB impairs indiquent des situations de transition (écotones). Au niveau de chaque station, les pourcentages des groupes écologiques de Polychètes sont calculés en moyennant les données obtenues sur l'ensemble des campagnes d'échantillonnage.

Résultats et discussion

La figure 2 montre une carte où chaque station est représentée par son indice biotique. En zone intertidale, les stations K, M et N sont en déséquilibre évident (IB 2). La station L montre la suprématie des groupes III et IV (IB 2-4). Les stations E, G, I, J, P, Q et R montrent une pollution évidente (IB 4). Au niveau des stations A, B, C, D, F, H et O, la présence significative des espèces du groupe II est un premier signe de perturbation (4), d'où l'IB 0-2.

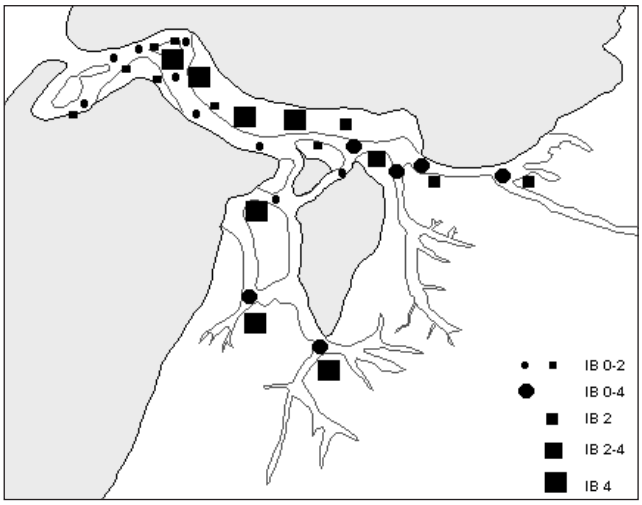

Figure 2 : Carte de dégradation des peuplements benthiques de la lagune de Merja Zerga. *Chaque station est représentée par son indice biotique. Les carrés indiquent les stations intertidales, les cercles les stations subtidales*

En zone subtidale, aucun état de pollution évident n'y est défini (IB 4 et/ou IB 6). Dans la partie aval de la lagune (stations 1, 2, 3, 4, 5, 6, 7, 8 et 13), les espèces du GE II sont dominantes, d'où l'IB 0-2. Plus en amont (stations 9, 10, 11, 12, 14 et 15) les espèces indifférentes montrent une régression en faveur des opportunistes (GE IV et V), d'où l'IB 0-4.

En absence de zones en condition normale (IB 0), les peuplements benthiques de la lagune montrent des états de déséquilibre et de dégradation. De manière générale, les états de dégradation correspondent à des taux élevés de matière organique totale (MOT). Toutefois, les états les plus dégradés ne correspondent pas aux taux les plus élevés de MOT. La station K présente un taux de MOT de 10% et un IB égale à 2, alors que la station Q montre un taux de MOT inférieur (5%), mais son IB atteint 4. La prise en compte uniquement de la MOT, même si c'est le facteur principal, est insuffisante pour rendre compte de la diversité des situations observées (5). En effet, d'autres facteurs interviennent comme le brassage des masses d'eau sus-jacentes, la matière organique dissoute dans ces eaux, la turbidité, l'état de dégradation de la matière organique, etc. Par ailleurs, les peuplements intertidaux sont plus dégradés que leurs homologues subtidaux. Ceci est à mettre en relation avec les processus hydrodynamiques et sédimentaires différents dans ces deux zones.

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DONNEES NOUVELLES SUR DES ELEMENTS DU MACRO BENTHOS MARIN DE TUNISIE

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Résumé

Des missions de prospections du macro benthos littoral (1) des eaux tunisiennes, entreprises depuis Avril 1999, dans 50 stations différentes, ont permit de constater des déséquilibres écologiques au niveau de certaines biocénoses benthiques. Ce travail a permit de mettre en évidence des mortalités importantes chez les gorgonaires et quelques éponges spécialement dans la région du Cap Bon et à Tabarka, qui pourraient être liées à la persistance de température élevées sur toute la colonne d'eau. En outre, ces prospections ont aussi permit de se rendre compte de la présence de deux caulerpes, souvent considérées comme invasives, en Tunisie.

Mots Clés : Cnidaire, Mortalité, Spongiaires, Infralittoral, Circalittoral,

Des missions de prospections entreprises depuis Avril 1999 dans 50 différents sites de la Tunisie (26 stations au nord, 14 à l'est et 10 au sud), par plongée en scaphandre autonome (70 observations), ont permit de visiter les étages infra et circalittoral de ses sites, jusqu'à la profondeur limite de – 62 m et de constater l'existence d'un phénomène de mortalité affectant des populations de densité variable (tableau 1) de *Eunicella singularis* et *Eunicella. cavolinii*, dans la région Nord de la Tunisie. Parmi les autres espèces touchées par cette mortalité, figurent deux éponges *Cacospongia mollior* et *Sarcotragus muscarum* (Dictyoceratida, Demospongiae, Porifera). Ce travail a aussi mis en évidence à la fois la présence de *Caulerpa racemosa* dans de nouvelles stations tunisiennes et la persistance de *Caulerpa taxifolia* à Sousse.

Tableau 1 : Densité de gorgonaires dans les zones d'études (colonies/m^2)

Espèces	Population (colonies/m^2)					
	Cap Bon	Est (faille entre Zembra et Zembretta)	Zone de Sidi Daoud	Sud-est Zembretta	Ouest Cathédrale (Zembretta)	Tabarka
Eunicella singularis	8 à 10	17 à 25	50	40	35	70
Eunicella cavolinii	2 à 3	3 à 5	25	15	Absente	Absente
Lophogorgia ceratophyta	-	4	5	4	2	2
Ellisella sp	-	-	5	-	-	-

Le phénomène de mortalité à intéressé la zone du Cap Bon et celle de Tabarka. Le taux d'individus nécrosés est calculé par m^2 et le pourcentage de nécrose individuel a été estimé. La hauteur des colonies atteignait, dans certaines stations, 50 cm chez *E. singularis*, et ne dépassait pas 30 cm dans d'autres, alors qu'elle dépassait rarement 25 cm chez *E. cavolinii* et *L. ceratophyra* et atteignait 120 cm chez Ellisella sp.

Les populations de *E. singularis* sont les plus touchées par cette pathologie, puisque 50% à 80% des individus souffraient d'une nécrose partielle des tissus, alors que ce taux n'atteignait que 40% chez *E. cavolinii*. La nécrose totale n'affectait que des individus de *E. singularis* et pouvait intéresser 50 % d'un peuplement. Par contre, le taux de nécrose individuel variait entre 30 à 60 % chez les deux anthozoaires.

Cependant, à Tabarka, cette mortalité n'a touché que *E. singularis*, avec des nécroses partielles de tissus chez 70% du peuplement et des mortalités totales de l'ordre de 30%.

Ce phénomène n'atteint pas la même virulence chez les éponges. Nous avons rencontré au Cap Bon (au nord ouest de Zembra, à Kélibia) et au large du Golfe de Gabès, des individus de *Cacospongia mollior* et *Sarcotragus muscarum*, affectés par cette pathologie. Le taux de nécrose individuel, dépassait rarement 50%, cependant quelques rares individus pouvaient être affectés à 100%.

Ce travail de terrain a aussi permit de constater les données suivantes :
- Certaines stations ; parfois très proches de stations affectées, maintiennent un peuplement sain et dense de gorgonaires (Faille de Zembra Zembretta; sud est de Zembretta ; Sidi Daoud).
- Nous n'avons pas remarqué de mortalité chez d'autres groupes de Cnidaire (Hydraires, Hexacoralliaires) ni chez d'autres embranchements d'invertébrés (Bryozoaires et Tuniciers notamment).
- D'autres Gorgonaires n'ont pas été affectés par cette mortalité, comme *Leptogorgia sarmentosa* et *Ellisella sp*, dont c'est la première signalisation en Tunisie.
- La pathologie semble être liée à la persistance de températures élevées dans toute la colonne d'eau: Pendant l'apparition de cette mortalité, la température de l'eau se situait constamment autour de 22 à 23 °C, depuis la surface jusqu'à la profondeur de -60 m. Alors que les plongées effectuées pendant l'année 2000 permettait de remarquer la présence d'une thermocline vers - 25 m de profondeur, faisant passer la température de l'eau de 23°C à 16 °C.
- Pour ce qui est des Caulerpales, la présence de *Caulerpa taxifolia* en face de la ville de Sousse (3) a été vérifié encore une fois. Cette algue colonise aussi bien des substrats meubles mis à nu par l'action de chaînes d'ancres, souvent en présence de *Caulerpa prolifera* et de *Flabellia petiolata*, que l'herbier de posidonie. Sa densité dans les zones infectées pouvant atteindre 26 à 45 frondes/m^2. Quant à *Caulerpa racemosa*, et en plus des stations tunisiennes déjà mentionnées (4), nous la signalons aux Iles Cani jusqu'à 10 m de profondeur, au sud est de Zembretta à 42 m de profondeur, à Sidi Daoud jusqu'à – 45 m de profondeur, à El Haouaria à 33 m de profondeur et enfin au Sud est des îles Kerkennah, à 45 m de profondeur.

Conclusions

L'apparition de ce phénomène de mortalité chez les invertébrées marins a touché l'ensemble du bassin occidental Méditerraéen (2). De tels phénomènes ne sont plus rares actuellement en Méditerranée (2, 5, 6, 7, 8, 9). Mais que cette mortalité ce manifeste dans une région de la Méditerranée connue pour la richesse de sa diversité spécifique, la beauté de son paysage sous marin, et son intérêt comme élément important du patrimoine naturel Méditerranéen (1, 10, 11) doit nous interpeller; d'autant plus que *C. racemosa* y est à proximité et que *C. taxifolia* est déjà très bien installée à Sousse.

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CARACTERISATION DES PEUPLEMENTS PHYTOPLANCTONIQUES D'UNE LAGUNE DU SUD TUNISIEN: LA MER DE BOUGRARA (TUNISIE)

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Résumé

La lagune de Bougrara, constitue une étendue d'eau relativement fermée où les apports polluants sont importants et où le renouvellement des eaux est insuffisant pour assurer l'évitement des zones de confinement, considérées comme des zones favorables aux pullulations des espèces phytoplanctoniques. L'analyse des résultats met en évidence la diminution de la diversité spécifique globale en même temps qu'une augmentation accrue de la charge microalgale du milieu. Cette tendance à l'accroissement de l'eutrophisation est indéniablement due à la prolifération monospécifique du dinoflagellé *Gymnodinium cf nagasakiense*. Le rapport dinoflagellés / diatomées traduit bien la dominance du milieu par les dinoflagellés au détriment des diatomées.

Mots clés : Lagune – phytoplancton – eutrophisation

Matériels et méthodes

Peu profonde et s'étendant sur 50000 ha, la lagune de Bougrara, située au sud tunisien, communique avec la mer par le canal Ajim-Jorf, large de 2.2 km, et par une petite ouverture de 12m de largeur, située sous le pont de la chaussée romaine dans le bassin d'El Kantara, (fig. 1).

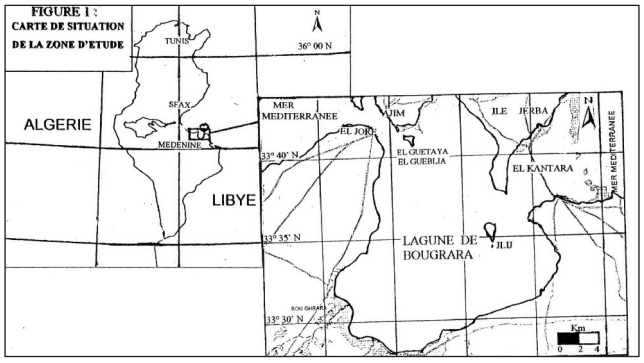

Figure 1. Carte de situation de la zone d'étude.

Une vingtaine de stations couvrant l'ensemble de la lagune ont été prospectées durant les mois d'août 1999, de décembre 1999, de février 2000 et de mai 2000. Les échantillons prélevés, au moyen de bouteilles de capacité 1 litre sont immédiatement fixés par du formol neutre et du lugol. La détermination et le comptage du phytoplancton sont réalisés moyennant un microscope inversé type Leitz Diavert, à partir d'un volume sédimenté correspondant à 25 ml.

Résultats

L'examen des prélèvements nous a permis d'inventorier 66 taxons se répartissant dans 8 classes, dont 38 diatomées et 14 dinoflagellés. La faible diversité spécifique touche l'ensemble des groupes et plus particulièrement celui des dinoflagellés qui est, toutefois, le groupe le plus représenté quantitativement.

L'analyse du schéma général de l'évolution dans le temps des dinoflagellés, détectés dans plus de 80 % des stations, fait apparaître deux pics principaux :

- l'un estival correspondant à une importante densité cellulaire (6.3 $.10^6$ cell./l) observée à la station 14 située au centre est de la lagune. Cette efflorescence est engendrée par la prolifération monospécifique de l'espèce *Gymnodinium cf nagasakiense*, qui est capable de limiter la croissance d'autres phytoplanctontes, notamment les diatomées (1).
- l'autre hivernal, de l'ordre de $6.9.10^6$ cell/l, enregistré à la station 3, située au sud ouest de la lagune. A cette période, les dinoflagellés ont occupé massivement la zone sud ouest avec un gradient décroissant allant du sud ouest au nord est.

Bien que classées en deuxième position après les dinoflagellés, les diatomées n'ont pu constituer de véritables poussées. Ce n'est qu'en période estivale, à la station 19, située à l'est de la lagune que les diatomées, à travers le développement de *Rhizosolenia setigra*, ont atteint une densité maximale de $1.3.10^6$cell./l. Au printemps, les diatomées se sont manifestées un peu partout dans la lagune, avec un développement, très inférieur à celui estival, au niveau du secteur sud ouest ($0.5.10^6$cell.)/l). Ce sont surtout *Rhizosolenia setigra* et *Nitzschia closterium* qui se sont épanouis dans le milieu.

Le rapport dinoflagellés /diatomées, met en évidence l'envahissement du milieu par les dinoflagellés. En effet, ce rapport prend de très fortes valeurs surtout en période estivale, au profit de la classe des dinoflagellés, (fig. 2). Ainsi les dinoflagellés, qui occupaient, en ordre d'abondance, la deuxième place après les diatomées (2), se sont trouvés en première place.

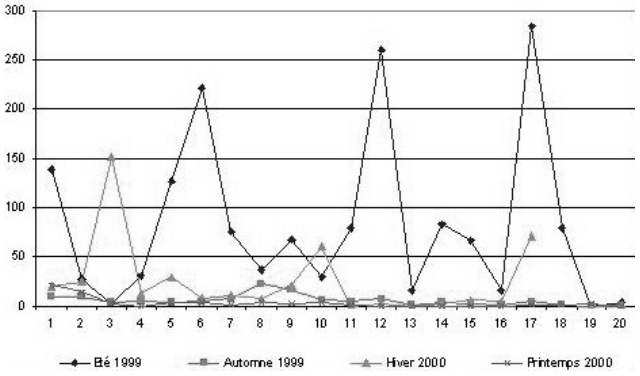

Figure 2. Variations du rapport dinoflagellés / diatomées.

Comparativement aux travaux antérieurs, l'appauvrissement du milieu en espèces, l'augmentation de la densité microalgale et l'envahissement de l'ensemble de la lagune par l'espèce toxique *Gymnodinium cf nagasakiense* (3), à l'origine de plusieurs eaux colorées, constituent bien des symptômes de l'accroissement de l'eutrophisation et de la dégradation du milieu.

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VARIABILITE DES FACTEURS ABIOTIQUES DANS LES EAUX D'UNE LAGUNE MEDITERRANEENNE LE LAC SUD DE TUNIS (TUNISIE)

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Résumé

Le lac sud de Tunis a été étudié de mai 1995 à avril 1997. Durant cette période, 156 séries d'observations sur le terrain et plus de 3600 mesures de paramètres hydrobiologiques (température, salinité, pH, saturation en oxygène, Matière en suspension...) ont été effectuées. Celles ci sont complétées par environ 5000 analyses de laboratoire (sels nutritifs, chlorophylle a).Les résultas des prospections montrent que le lac se caractérise par la grande variabilité et l'instabilité spatio-temporelle de la plupart des paramètres abiotiques. Ces facteurs subissent des variations nycthémérales, saisonnières et interannuelles . La détérioration de la qualité des eaux est amplifiée par la faible bathymétrie de la lagune, l'hydrodynamisme très atténué et les apports continentaux (eaux usées industrielles et urbaines) fortement chargés en polluants de natures diverses.

Mots clés : Lagons – Pollution – Eutrophication – « Blooms ».

Introduction

Le lac sud de Tunis est situé au nord de la Tunisie, au fond du golfe du même nom (Fig. 1). Bien que se trouvant au voisinage immédiat de la mer , le lac communique avec celle ci de façon artificielle. Il couvre 1120 hectares , se caractérise par une faible bathymétrie (< 1m) et un hydrodynamisme très atténué [1, 2]. Du fait de sa proximité de la capitale et de ses grands centres industriels, le lac se trouve aujourd'hui dans une situation écologique préoccupante [3, 4]. Notre étude servira d'état initial et d'échelle objective pour l'évaluation des impacts écologiques du projet de restauration environnementale de ce milieu.

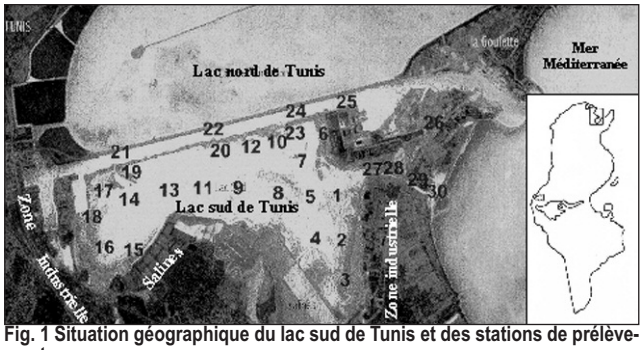

Fig. 1 Situation géographique du lac sud de Tunis et des stations de prélèvement.

Matériel et méthodes

Pour cerner au mieux les conditions écologiques du milieu, trente stations de prélèvement réparties d'une manière homogène couvrant l'ensemble du système lacustre ont été prospectées mensuellement (Fig. 1).

Résultats et discussions

A l'instar des écosystèmes côtiers peu profonds, les températures des eaux de surface du lac suivent intimement les températures de l'air ambiant. La température moyenne est de 20,6°C. Les valeurs extrêmes sont 9,8°C et 34,6°C. Les températures de l'eau connaissent également des variations nycthémérales de plus faibles amplitudes. La moyenne annuelle des salinités se situe entre 29,9 ‰ et 43,6‰ avec des valeurs extrêmes de 1,4 ‰ et 51,9 ‰. Les fluctuations de ce paramètre sont essentiellement tributaires des apports continentaux. Le pH des eaux subit de grandes fluctuations (7,9 à 9,3). Les valeurs extrêmes sont respectivement de 6,7 et de 10,5. La répartition spatiale du pH évolue suivant un gradient de dilution au fur et à mesure que l'on s'éloigne des sources de pollution. Sa fluctuation suit un rythme nycthéméral, la phase nocturne correspond à un effondrement du pH, la phase diurne est tributaire de l'importance du couvert végétal. La teneur moyenne des eaux de surface en O_2 dissous montre que ce paramètre ne constitue pas un facteur limitant (le milieu est généralement sursaturé en O_2 : taux >98 %). Les extrêmes sont 0 et 319 %, la valeur maximale a été relevée au mois de juin à la station 14, lors d'un important « bloom » phytoplanctonique et correspond à une teneur excessive de chlorophylle a (416,3 μg/l de poids humide). Le milieu est d'autant plus oxygéné que l'ensemble des conditions de l'environnement sont défavorables [3]. Les valeurs moyennes de l'oxygène dissous subissent de très fortes fluctuations saisonnières et interannuelles. Seuls les taux nocturnes permettent d'apprécier l'état du milieu, le suivi nycthéméral a permis de mettre en évidence un effondrement nocturne du taux d'oxygène pouvant aboutir à une situation d'anoxie. Les teneurs mensuelles moyennes des eaux en chlorophylle a connaissent des variations temporelles et spatiales très importantes et oscillent entrent 12,1 et 76,1μg/l de poids humide (Fig. 2). Les anses est et ouest sont le siège d'un développement phytoplanctonique quasi permanent mais d'inégales importances. Les valeurs extrêmes sont 0 et 587,1μg/l de poids humide. Les variations mensuelles de la M.E.S. montrent que celles ci oscillent entre 13,4 et 244,9 mg/l. Les eaux du lac sont relativement chargées en matériel particulaire, les valeurs extrêmes sont de 0,7 et 390,8 mg/l. Les valeurs mensuelles moyennes de l'azote minéral total ont évolué de 79 à 2645 μg/ l. Les valeurs extrêmes sont 3 et 5949,4 μg/ l et dénotent d'une richesse excessive du milieu. Ce paramètre fluctue avec la pluviosité et suit un rythme saisonnier bien déterminé malgré les variations absolues extrêmement importantes et les différences interannuelles(Fig. 2). Le phosphore est présent en surabondance dans la lagune sud de Tunis. Les teneurs mensuelles moyennes oscillent entre 22,2 et 340,3 μg/l (Fig. 2). Les valeurs extrêmes sont de 1 et 1107,3 μg/l. Le lac sud de Tunis est aujourd'hui un milieu très instable fortement euryhalin, eurytherme; hypereutrophe et extrêmement fragilisé.

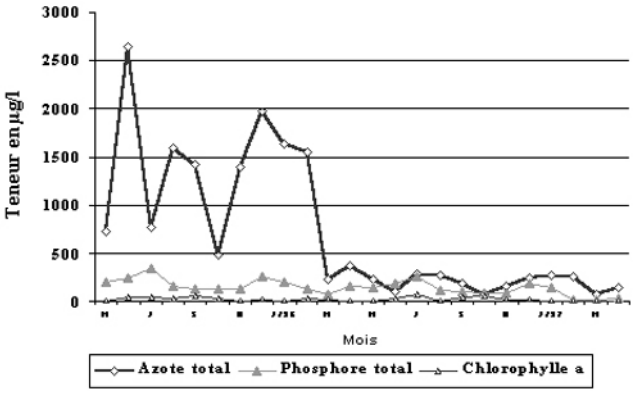

Fig. 2 Fluctuations mensuelles des teneurs moyennes des principaux indicateurs d'eutrophisation.

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INVENTAIRE DE LA POPULATION DE *PATELLA FERRUGINEA* GMELIN, 1791 DES ÎLES HABIBAS (OUEST ALGÉRIEN)

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Résumé

Une première évaluation scientifique du potentiel biologique des îles Habibas est réalisée durant l'été 1997. *Patella ferruginea* a fait l'objet d'une étude particulière, et ce en raison de sa valeur patrimoniale et de la densité exceptionnelle rencontrée au niveau de ce site, estimée à 4.5 individus par mètre linéaire de côte. L'étude de sa biométrie a permis de formuler l'hypothèse de l'existence des deux formes de *Patella ferruginea* : *rouxii* et *lamarcki* (la forme la plus abondante). L'analyse de la structure de la population par classes de taille a montré la prédominance des individus de grande taille.

Mots clés : Mollusca, Gastropods, Patella ferruginea, îles Habibas, Algeria.

Patella ferruginea Gmelin, 1791 est une espèce endémique à la Méditerranée occidentale, inféodée au médiolittoral des côtes rocheuses de mode battu. L'espèce, autrefois très répandue (1), semble aujourd'hui se cantonner essentiellement sur les côtes insulaires de Méditerranée : en Corse (2) ; en Sardaigne dans l'archipel de la Maddalena (3) ; à l'île de Zembra en Tunisie (4), à l'île de Rachgoun dans l'Ouest algérien (5). Dans le cadre de la création d'une réserve marine protégée au niveau des îles Habibas, un inventaire des écosystèmes littoraux est entrepris durant le mois d'août 1997. Ce travail est le résultat de l'étude quantitative de *Patella ferruginea*, qui y constitue une importante population.

Matériel et méthodes

Les îles Habibas se situent au large de la côte ouest algérienne, à l'ouest de la baie d'Oran (Figure 1). Les dénombrements de *P. ferruginea* sont réalisés en août 1997, dans plusieurs secteurs. Les individus de *P. ferruginea* sont dénombrés sur des éléments de côte rocheuse de 10 m de long, choisis arbitrairement, selon le protocole de (6). Pour chaque élément de côte sont notés la pente du substrat (en degrés : 0° = plancher horizontal ; 90° = paroi verticale) et l'hydrodynamisme, selon une échelle subjective allant de très calme à très battu. Chaque individu dénombré a fait l'objet de mesures in situ, à savoir la longueur (L) (grand diamètre), la largeur (l) (petit diamètre) et la hauteur (H) de la coquille.

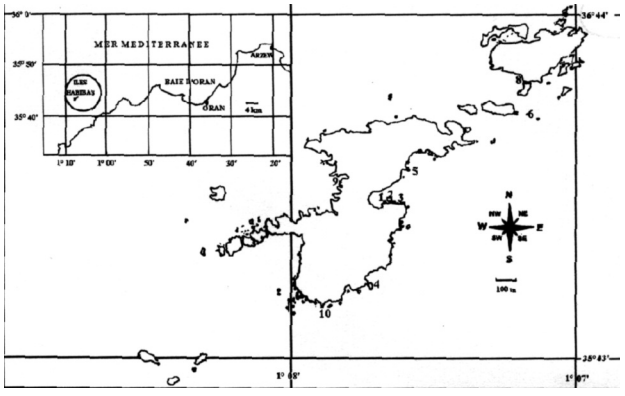

Figure 1. Situation géographique des îles Habibas et localisation des stations.

Résultats

Distribution spatiale et densité des populations de Patella ferruginea

Les individus de *P. ferruginea* sont localisés au niveau de la partie inférieure de l'étage médiolittoral. Les deux formes *lamarckii* et *rouxii* sont identifiées. La forme *lamarkii* présente une coquille bombée et des côtes peu saillantes, c'est la variété la plus abondante. La variété *rouxii* présente quant à elle une coquille déprimée avec des côtes très saillantes. Le rapport de la hauteur sur la longueur de la coquille (H/L), qui constitue l'un des critères d'identification du genre Patella (7), est calculé pour chacune des deux formes. Les valeurs obtenues sont de 0.3 ± 0.03 pour *lamarckii* et de 0.5 ± 0.1 pour *rouxii,* valeurs significativement différentes (test de Student). Ces valeurs sont du même ordre de grandeur que celles obtenues par (3). Par ailleurs, et bien que la présence des deux formes ait été constatée et les abondances respectives évaluées, nous avons en définitive considéré P. *ferruginea* comme présentant une seule forme, et ce afin d'éviter tout risque de confusion entre les individus juvéniles des deux variétés. Le petit nombre de relevés réalisés, 10 au total, n'a permis qu'une première estimation de la densité moyenne de la population de P. *ferruginea* des îles Habibas. Un total de 452 individus a été dénombré sur 100 m de linéaire de côte, soit une moyenne de 4.5 patelles par mètre de côte, avec un maximum de 130 individus au niveau du relevé 4. Cette station est caractérisée par un substrat sub-horizontal avec de nombreuses anfractuosités qui semblent propices à l'installation de P. *ferruginea*; de plus cette station est très exposée aux vents dominants. La valeur de densité obtenue est très importante par rapport à celles enregistrées dans d'autres îles méditerranéennes. A l'île de Zembra, la densité moyenne est de 0.7 individus par mètre de linéaire de côte (4). Des dénombrements de P. *ferruginea* effectués dans plusieurs secteurs de Corse montrent également des valeurs en deçà de celles obtenues, même dans des secteurs protégés comme la réserve naturelle des îles Lavezzi où seulement 0.1 individu par mètre sont retrouvés (2) ; la même densité est retrouvée au niveau du Cap Corse (8). La répartition de P. *ferruginea* dans les différents secteurs étudiés n'est pas homogène. En effet, cette espèce semble préférer un hydrodynamisme assez fort plutôt que des modes calmes. Quant à l'influence de la pente du substrat sur la densité, aucune corrélation n'a pu être établie. Cette même observation a été faite à Zembra (Tunisie)(4).

Structure de la population par classes de taille

La structure de la population de P. *ferruginea* par classes de taille observée en août 1997 présente un histogramme de fréquence de type bimodal (Figure 2), suggérant l'existence de deux cohortes. Les petits individus, dont la taille est inférieure à 50 mm, représentent 35 % de l'effectif total. Inversement, les individus de grande taille sont très fréquents aux îles Habibas.

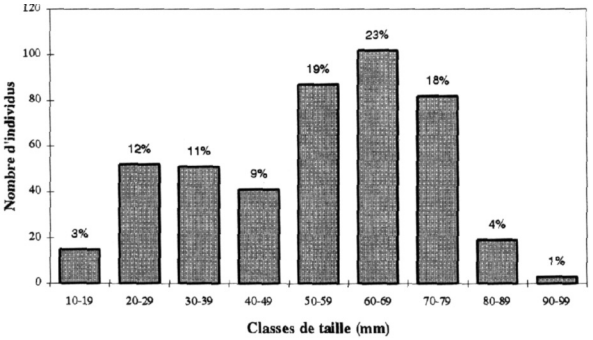

Figure 2 : Histogramme des fréquences des classes de la longueur de la coquille de *Patella ferruginea*. Les classes vont de 0-10 à 90-99 (N = 452 individus).

Conclusion

L'étude réalisée aux îles Habibas révèle des densités de P. *ferruginea* supérieures à celles rencontrées en Méditerranée, une étude étalée dans le temps permettrait une meilleure connaissance de la dynamique de cette population. Quant à l'hypothèse de l'existence des deux formes de P. *ferruginea* : *lamarckii* et *rouxii,* celle-ci mérite d'être confirmée ou infirmée par une analyse caryologique et électrophorétique, comme préconisé par (3). Par ailleurs, il est indispensable de préserver les îles Habibas, afin d'éviter que cette espèce disparaisse comme ce fut le cas dans de nombreux sites en Méditerranée.

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MAN-MADE EVOLUTION OF COASTAL BIOTA

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Abstract.
We examined the health parameters of different species from foraminifera to fish, especially Mediterranean molluscs. The parameters included measurements of (1) activity of anti-xenobiotic defense mechanisms; (2) cell and tissue viability; (3) frequencies of DNA and chromosome damages; (4) frequencies of cyto- and histopathological alterations. All studied species exhibited similar numerous anti-xenobiotic defense mechanisms, particularly transport systems for xenobiotics' elimination in external epithelia. Their activities mediate effects of pollutants and the health of biota. Selection of the most protected phenotypes of molluscs and fishes dwelling in the polluted sites shows a possible direction of this man-made evolution.

Keywords: population dynamics, export pumps, selection

Everybody knows that all living organisms protect themselves against microscopic enemies but only few scientists know that all organisms protect themselves also against xenobiotics. Anti-xenobiotic defense mechanisms, especially export pumps in aquatic species are studied very fragmentarily (1-5). Therefore, we studied these anti-xenobiotic defense mechanisms and main health parameters in specimens and populations from sites with different pollution history using specific fluorescent probes and novel pilot devices, particularly contact microfluorometers (6,7). Briefly, we detected *in vivo* the activities of main anti-xenobiotic defense mechanisms, signs of cell viability, frequencies and intensity of cytogenetic, cyto- and histopathological alterations in selected marine molluscan and fish species from the North Sea, Baltic Sea and especially Mediterranean Sea (2,3,7). Also Mediterranean benthic foraminifera and fishes from the Israeli stream, Yarqon River, were examined (3,8). All investigated species exhibited similar numerous anti-xenobiotic defense mechanisms. The first line of anti-xenobiotic defense was formed by multisubstrate transport systems for xenobiotic elimination (export pumps) in external epithelia. The multixenobiotic resistance-mediated transporter (MXRtr) pumps out numerous lipophilic and amphiphilic xenobiotics; system of active transport of organic anions (SATOA) eliminate hydrophilic anionic xenobiotics and by-products (1-8). The mean activities of the MXRtr and SATOA in external epithelia of molluscs and gill epithelium of fishes were significantly higher in animals from the polluted sites then from the clean sites. The activities of MXRtr and SATOA in molluscs and fish closely correlated with their environmental health parameters, particularly frequency of chromosome break (2,3).

The export pumps are well studied in cancer cells and some mammalian tissues (1, 9). However, some homologous export pumps and corresponding gene families were also detected in bacteria, protozoa, sponges, coelenterates, worms, molluscs, insects and lower vertebrates (1-9).

The frequency polygon of MXRtr activities in *D. trunculus* from the clean site was the widest with a maximum at the low activities. The specimens from very polluted sites exhibited narrower polygons with the maximum at higher activity, i.e. a shift of the maximum proportional to level of pollution. Frequency polygons of gill SATOA activities in *D. trunculus* from the same sites showed similar regularities. Marked shifts on frequency polygons for MXRtr were detected in the Mediterranean gastropod *P. coerulea* from the polluted sites and in the Red Sea bivalve *C. florida* and gastropod *C. rota* from the polluted site.

Kinetic analysis demonstrated a decreased K_M and increased V_{max} in *D. trunculus* from the polluted sites. All mentioned data demonstrate an "industrial selection" of certain MXRtr and SATOA phenotypes in the molluscs from the polluted sites along the Mediterranean and Red Sea shores. Similar selection of the most protected phenotypes was detected also in the fishes from the polluted sites (7).

It is known that environmental pollutants can select some allozyme phenotypes in molluscan and fish populations (10,11). Our results provide the first direct evidences that "industrial selection" produced general resistance of populations to environmental xenobiotics. Laboratory studies of acute sensitivity of molluscs to high concentrations of pollutants and field experiments with transplantation of the molluscs confirmed this conclusion.

Thus, specimens and species with high activities of the export pumps can survive in polluted environment with or without some alterations of their health and form the multixenobiotic-resistant populations. Such multixenobiotic-resistant biota, especially bacteria, protozoa, worms and insects may be more dangerous for human health than direct action of pollutants and decreased biodiversity.

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SEASONAL DISTRIBUTION OF HYDROGRAPHIC CHARACTERISTICS AND PHYTOPLANKTON IN THE KARSTIC ZRMANJA ESTUARY (EASTERN ADRIATIC SEA)

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Abstract

The abundance of phytoplankton and concentrations of nutrients were analyzed in relation to thermohaline conditions in the lower reach of the karstic Zrmanja River estuary, eastern Adriatic coast, Croatia, in the period from June 1998 to October 2000. The Zrmanja Estuary is highly stratified, shallow, oligotrophic estuary, dominated by marine phytoplankton. It is characterized by extremely low ortophosphate concentratios, and the distinctive summer minimum of inorganic nitrogen, as a result of exhaustion of the water column after the spring phytoplankton development, and a negligible anthropogenic influence.

Key-words: Estuary, phytoplankton, nutrients, Adriatic Sea

The increased primary production in estuaries is influenced by nutrients brought by the river discharge. The karstic rivers that discharge into the eastern Adriatic Sea and have been investigated to date (1) are extremely oligotrophic. The small karstic river Zrmanja discharges into the sea (fig.1) forming highly stratified estuary (2). High stratification is maintained, due to the relatively high volume of river discharge and low tides (3). The Zrmanja river is 69 km long with the annual mean outflow of 38 m s-1, but may be as high as 456 and low as 0.09 m s^{-1}. The surrounding area is scarcely inhabited. In the upper reach of the estuary there is only a settlment Obrovac with 1200 inhabitants.

Materials and methods

Water samples for the analyses of phytoplankton were collected at station Z2 (Fig. 1), in monthly intervals, in the period June 1998 to October 2000. We devided the water column in two layers: above (0-1 m) and below (2-4 m) the halocline.

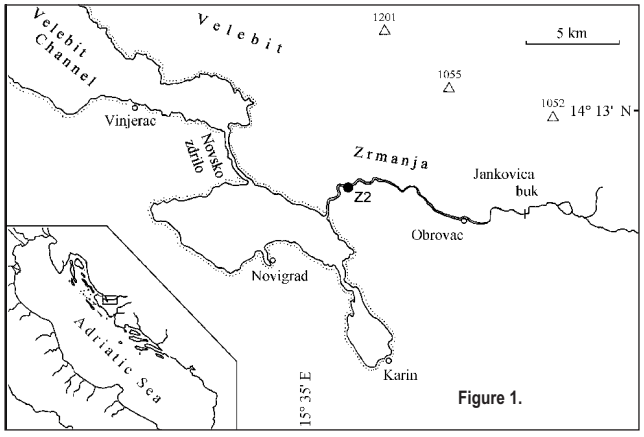

Figure 1.

Phytoplankton was sampled using 5-liter Niskin bottles at one-meter intervals of the water column. Samples were preserved in a 2 per cent (final concentration) neutralized formaldehyde solution. The cell counts were obtained by the inverted microscope method (4). Thermohaline properties were determined using a conductivity, temperature and depth profiler (SEA Bird Electronics Inc. USA), and by the argentometric titration. Nutrient concentrations were measured using standard method (5).

Results and discussion

The seasonal distribution of salinity values (Fig. 2) shows high stratification, during most of the year, especially during rainy period (November to May). The reduced river discharge in summer (June to September) resulted in the higher salinity (up to 22.4) above the halocline. The salinity of the marine layer varied between 13.4 and 34.1. The temperature ranged between 7.6°C in February and 24.5°C in August (at the surface). The extremely low ortophosphate concentratios varied between 0.01and 0.13 μmol l^{-1}. The concentrations of total inorganic nitrogen provided distinctive summer minimum, as a result of the exhoustion of the water column after the spring phytoplankton development, and the negligible anthropogenic influence. In comparison to nitrogen concentrations, phosphates were determined to be limiting growth factor for the phytoplankton growth in the estuary.

Silicate concentrations were mostly bellow 10 μmol l^{-1} in the marine layer. The higher concentrations vere detected above the halocline (maximum 35.9 μmol l^{-1} in October 1998) during the rainy season.

The phytoplankton in the estuary was represented mostly by marine species. The increased abundances of marine diatoms were registered (bel-

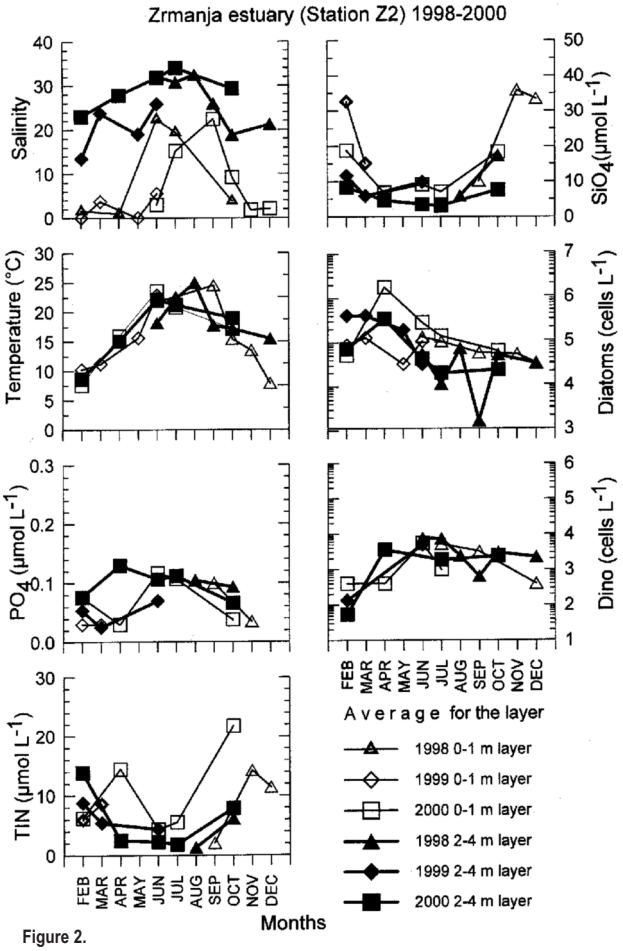

Figure 2.

low the halocline) in spring. Sporadic spring maxima could be determined above the halocline (April 2000). The maximum abundance of diatoms reached not more than 1.8 10^6 st. l^{-1} (April 2000), probably as a consequence of poore enrichement of seawater with nutrients. Dinoflagellates usually dominate after the peak development of diatoms (due to the mixotrophic potential of dinoflagellates).

Low concentrations of nutrients and relatively low abundance of phytoplankton indicate ecological stability (without serious anthropogenic influence) in the oligotrophic waters of the Zrmanja Estuary.

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ALLOZYMIC GENETIC DIVERGENCE IN THE BIVALVE *MYTILASTER MINIMUS* FROM BRACKISH-WATER AND MARINE HABITATS IN THE WESTERN SARDINIAN COAST (ITALY)

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Abstract

The genetic relationships among 11 samples of the bivalve *Mytilaster minimus* from brackish-water and marine habitats along western Sardinian coast were studied by allozyme electrophoresis. Results obtained for 15 loci showed high levels of both within- and between-population genetic heterogeneity. The positive and significant value of the inbreeding coefficient indicated a general departure from HW equilibrium due to deficiency of heterozygotes. The observed patterns of genetic variability result from the superimposition of two main evolutionary forces: 1) the diverse selective regimes in the different habitat-types and 2) the different history of colonisation and/or geographical distribution.

Keywords: bivalves, brackish water, genetics, Western Mediterranean

Most animal species often show a subdivision into local populations (1). If local populations are exposed to contrasting environmental conditions appreciable populations differentiation may arise determined by genotype-environment interactions (1). Theoretical works provide that populations from unpredictable environment, present a general reduction of genetic variability (2, 3). In order to provide insights on the relationship between genetic structure and habitat type of animal populations we investigated the degree of allozyme genetic divergence between individuals of *Mytilaster minimus* Poli, 1795 (Mollusca, Pelecypoda). *M. minimus* is a small bibalve with maximum shell length of roughly 2 cm, distributed on hard bottoms in lagoons and marine sites of the intertidal belt in the Mediterranean and eastern Atlantic. Life cycle has a planktonic larval stage but larval morphology and life-span are unknown, so that its potential for dispersal cannot reliably be inferred.

Eleven samples (about 40 specimens each) were collected in four different brackish-water basins in western Sardinia (Italy) and in the nearest rocky shore. Whenever possible, more samples were collected within each basin from the inner part of the ponds toward the sea. Five of eleven samples have been collected in the ponds, 3 in the sea and 3 in intermediate sites. Allozyme cellulose acetate electrophoresis, carried out using the procedures outlined in a previous study (4), gave the allele frequencies at 15 presumptive loci. The genetic variability was estimated by the average expected heterozigosity over loci (*H*). The genetic structure of the whole set of populations was analysed by *F*-statistics. Unbiased estimators were obtained by jackknifing across loci and tested for difference from zero by permutation tests. The level of genetic distance between populations was estimated with Nei's (5) unbiased index, *D*. Multidimensional scaling (MDS) was applied to the matrix of genetic distances.

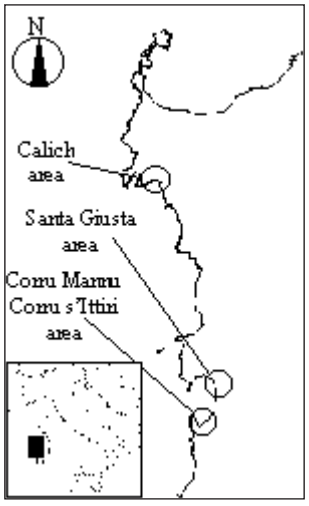

Figure 1. *Mytilaster minimus*. Location of sampling areas. Within each area samples from brackish-water, marine and intermediate habitats were collected.

Our results showed a general deviation from Hardy-Weinberg expectations at all loci over all populations (F_{IS}=0.532, P< 0.001). Approximately, the observed heterozigosity is one half of the expected one. Deficiency of heterozygote individuals has been commonly observed in allozyme studies on marine and brackish-water bivalves and reflect a trend characteristic to invertebrates with high rate of reproduction and high dispersal capability (6, 7. 8). In the MDS plot the straight line clearly separates the Santa Giusta samples from the others (Fig. 2) while dotted lines separate three groups of samples that are consistent with the gradient pond-sea (Fig. 2). The divergence of Santa Giusta samples from the others could be a consequence of ecological peculiarity of that site and/or depend on the effect of genetic drift after recurrent summer dystrophic crises. The genetic distances found between M. minimus samples are below the values detected for congeneric species (for a review see 9). The highly significant value of the coancestry coefficient (F_{ST}=0.239, P<0.001) referred to the eleven populations remark their high degree of genetic divergence. The occurrence of genotypes typical of each habitat-type accounts for the observed genetic divergence. Furthermore a number of habitat-private alleles were detected. In addition, in some instances the most frequent allele present in brackish-water samples is the less common in marine samples and *vice versa*. Our results can be explained in terms of adaptation and local selection. The selective forces acting in each habitat-type favour the different genotype and the genetic divergence observed. On the other hand, geographical distance and/or history of colonisation contributed to the present patterns of genotypic variability. Thus the observed pattern results from the superimposition of two main types of forces that influenced population differentiation in a process of local adaptation since the first colonisation events of brackish-water habitats.

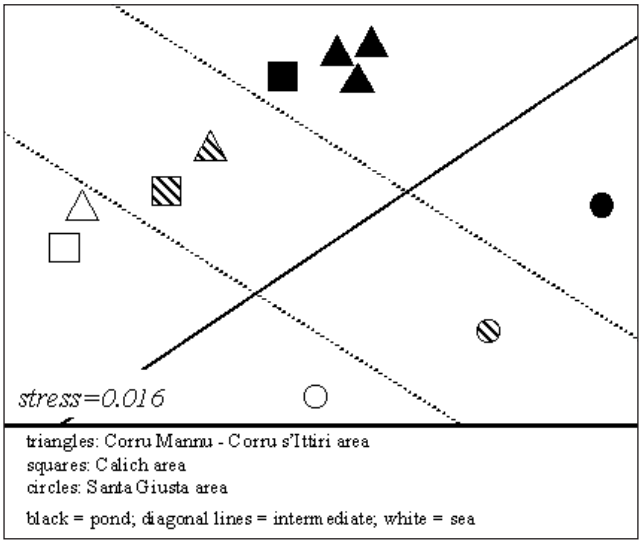

Figure 2. . Multidimensional scaling of Nei's genetic distances. The low value of stress indicates that distances among samples on the plot represent the genetic distances accurately.

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PRODUCTION PRIMAIRE ET COMPOSITION ÉLÉMENTAIRE DE *POSIDONIA OCEANICA* EN RELATION AVEC LES CARACTÉRISTIQUES GÉOCHIMIQUES DU MILIEU

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Résumé

La production primaire et la composition élémentaire (C,N,P) d'un herbier à *Posidonia oceanica* sont mesurées en Sardaigne, ainsi que toute une série de paramètres physico-chimiques. Si les caractéristiques géochimiques semblent indiquer un milieu relativement riche en nutriment (proximité d'un fleuve), les valeurs de production primaire de la plante et les teneurs en azote dans les tissus épigés et endogés sont particulièrement faibles. Aussi, plus que la teneur moyenne dans le milieu, c'est la disponibilité de la forme préférentielle d'azote (ammonium), liée aux processus biogéochimiques, qui conditionnerait la production primaire.

Keywords : Posidonia, primary production, geochemistry, river input.

Au cours de ces deux dernières décennies, les études portant sur la régression des phanérogames marines suggèrent que l'enrichissement en nutriments pourrait affecter la vitalité de ces formations (1). De même, il semblerait qu'il existe une relation étroite entre les teneurs en nutriments du milieu et la composition élémentaire (carbone, azote et phosphore) de la plante d'une part, et son niveau de production primaire de l'autre (2). De plus, la géochimie du sédiment (*e.g.* carbonaté ou terrigène) intervient dans la disponibilité des nutriments, de même que sa granulométrie (3). Dans cette étude, la production primaire et la composition élémentaire d'un herbier à *Posidonia oceanica,* ont été mises en relation avec le niveau des nutriments et les caractéristiques biogéochimiques de l'environnement.

Matériel et méthodes

Le site d'étude, dans le Golfe d'Oristano, est caractérisé par la présence de sédiments terrigènes en provenance d'un fleuve (Tirso). Deux stations, situées à 10 m de profondeur, sont étudiées en scaphandre autonome. Station 1: sous influence directe du fleuve, fonds dépourvus de végétation; Station 2 : vers l'extérieur du golfe (~ 3.5 km), fonds recouverts par un herbier à *P. oceanica*. Plusieurs paramètres sont pris en considération (Tab. 1)

Tableau 1: Plan d'échantillonnage et méthodes utilisées (entre parenthèses).

	Station 1	Station 2
Nutriments dissous (analyses colorimétriques)		*Mensuel* NO_3^-, NO_2^-, NH_4^+, PO_4^{-3}
Phosphore lié au sédiment (4)	*Eté, hiver* P_{TOT}, P_{ORG}, P_{IN}, P_{EX}	*Eté, hiver* P_{TOT}, P_{ORG}, P_{IN}, P_{EX}
Granulométrie (granulomètre laser)	*Eté, hiver* fraction <63µm	*Eté, hiver* fraction <63µm
Matière organique (par brûlage à 550°)	*Eté, hiver*	*Eté, hiver*
Carbonate (5)	*Eté, hiver*	*Eté, hiver*

L'étude phénologique de *P. oceanica* permet d'évaluer la densité des faisceaux et le recouvrement de l'herbier (10 mesures chaque mois avec un quadrat de 40 cm de côté), puis la biométrie foliaire et le Leaf Area Index sur 15 faisceaux orthotropes récoltés mensuellement. Les paramètres lépidochronologiques (nombre de feuilles formées, vitesse de croissance des rhizomes) sont également estimés à partir de ces rhizomes. De même, la biomasse des feuilles adultes les plus âgées (rang 1) est mesurée (pétioles et limbes). La composition élémentaire est mesurée aux quatre saisons, pour deux tissus (faisceau foliaire et rhizomes). Le carbone et l'azote ont été mesurés à l'aide d'un CHN analyser, le phosphore a été déterminé par oxydation forte ($K_2S_2O_8$) (3) et mesure colorimétrique.

Résultats

Les teneurs en nutriments dissous sont relativement faibles, à l'exception des nitrates (Tab. 2). La géochimie du sédiment présente de fortes disparités entre les deux stations. La Station 1 est caractérisée par un sédiment terrigène vaseux, avec une concentration élevée en matière organique et une teneur en Phosphore (total et extractible) importante ; la Station 2 est caractérisée par un sédiment carbonaté, avec une teneur beaucoup plus faible en P (Tab. 3).

Tableau 2. Teneurs en nutriments dans la Station 2 (Moyenne annuelle + IC).

	NO_3^-	NH_4^+	$PO4_3^-$
Colonne d'eau (µM)	5,1 (±0.8)	nd	0,1 (±0.1)
Eau interstitielle (µM)	4,0 (±1.1)	1,8 (±1.1)	0,4 (±0.2)

Tableau 3. Caractéristiques géochimiques du sédiment (Moyenne Eté/hiver + IC)

	<63µm (%)	Carbonate (%)	Mat. Org. (%)	P_{TOT} (mg/Kg)	P_{IN} (mg/Kg)	P_{ORG} (mg/Kg)	P_{EX} (mg/kg)
St. 1	100 (±0)	37 (±2)	16.8 (±3.1)	668 (±62)	356 (±31)	311 (±78)	29.6 (±7.7)
St. 2	31 (±9)	65 (±8)	4,0 (±1.0)	223 (±19)	120 (±11)	103 (±21)	13,7 (±1.9)

Les principales caractéristiques de l'herbier à *P. oceanica* sont regroupées dans le tableau 4.

Tableau 4. Paramètres phénologiques et production primaire de l'herbier à *P. oceanica*

Paramètres phénologiques		Production primaire	
Densité de l'herbier	293 ±12.7	Nombre feuilles produites/an	7.5
Recouvrement (%)	18.9 ± 4.8	Production foliaire (g /m^2)	304.9
Leaf Area Index (m^2 / m^2)	4.3 ± 1.2	Production rhizome (g/m^2)	22.2

La composition élémentaire varie en fonction du tissu étudié (Tab. 5).

Tableau 5. Composition élémentaire de la plante (Moyenne annuelle + IC)

	C%	N%	P%	C:N	C:P
Faisceau foliaire	34,2 (±1.5)	1,1 (±0.3)	0,10 (±0.05)	36.7	889
Rhizomes	37,0 (±2.3)	1,0 (±0.3)	0,14 (±0.05)	43.4	640

Discussion et conclusion

Les caractéristiques géochimiques du site, et notamment du sédiment, traduisent un milieu relativement riche en nutriments. Toutefois, les valeurs de production primaire de l'herbier à *P. oceanica* du golfe d'Oristano sont relativement faibles par rapport à d'autres secteurs de la Méditerranée (6). De plus, si les teneurs en carbone et en phosphore, présentes dans les différents tissus, correspondent à des valeurs classiques (7, 8), en revanche, les concentrations en azote sont très faibles (7, 8), ce qui pourrait laisser supposer que l'azote joue un rôle de facteur limitant (7).

L'azote, à la Station 2, est principalement présent sous forme de nitrate, alors que la forme d'assimilation préférentielle de cet élément, chez *P. oceanica*, est l'ammonium (9), ceci pourrait expliquer les faibles teneurs en azote mesurées dans les tissus. Les caractéristiques géochimiques de la zone étudiée (surtout du sédiment) modulent l'équilibre $NO_3^- \leftrightarrow NO_2^- \leftrightarrow NH_4^+$ et pourraient limiter la disponibilité des nutriments pour la plante. La production primaire de *P. oceanica* dépendrait, donc, plus de la disponibilité de la forme d'azote que de sa teneur dans le milieu.

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OBSERVATIONS ON THE ELASMOBRANCH FISHES FROM THE LAGOON OF BIBANS (SOUTHERN TUNISIA, CENTRAL MEDITERRANEAN)

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Abstract.

Ten elasmobranch species are recorded in the Lagoon of Bibans, a hyperhaline brackish area located in southern Tunisia and adjoined to the Gulf of Gabes. Five of them permanently inhabit the lagoon: *Rhinobatos rhinobatos*, *R. cemiculus*, *Raja miraletus*, *R. radula* and *Dasyatis chrysonota*. The permanent occurence of *Scyliorhinus canicula* and *Torpedo torpedo* requiers further confirmation. The other inside elasmobranch captures are probably due to fortuitous events.

Key-words. - Elasmobranchii, Mediterranean, southern Tunisia, Lagoon of Bibans.

The icthyological literature provides data about the freswater elasmobranchs (1), in opposite the species living in high saline lagoons are poorly known. The faunistic lists related to the perimediterranean lagoons rarely report elasmobranch captures in these areas (2, 3). Investigations in the hyperhaline Lagoon of Bibans (southeastern Tunisia) allow to state that some species are able to develop and reproduce in the area. The Lagoon of Bibans is located in southeastern Tunisia and adjoins the Gulf of Gabes (Fig. 1).

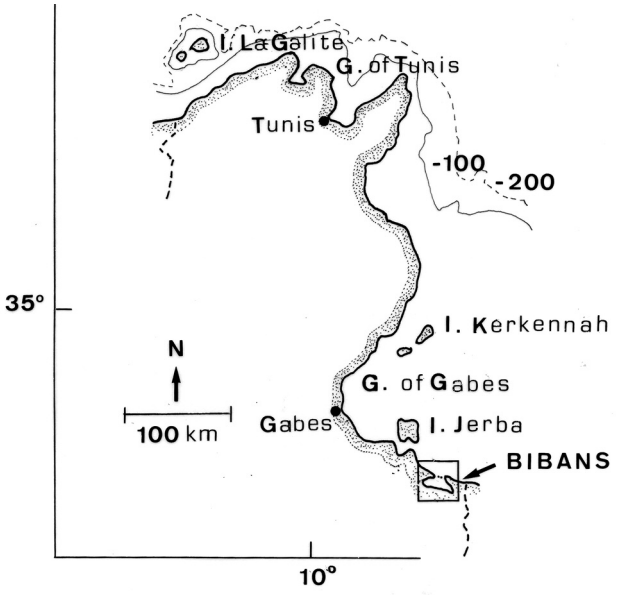

Figure 1. Map of Tunisia pointing out the Lagoon of Bibans (arrow).

Sharks, Rhinobatidae and the common torpedo observed were measured to the nearest millimetre in terms of total length (TL), skates and the marbled stingray in terms of disk-width (DW).

The common guitarfish, *Rhinobatos rhinobatos*, is considered to be abundant in the Gulf of Gabes and the Lagoon of Bibans. Size at sexual maturity occurs at 750 mm and 850 mm TL for males and females respectively. The maximal sizes for males and females are 1400 mm and 1620 mm TL respectively. Pregnant females with encapsuled eggs and embryos, but chiefly with fully developed fetuses were found in the lagoon. .

In *R. cemiculus* sizes at sexual maturity of males and of females are 1000 mm and 1100 mm TL respectively. Adult females are generally larger than males, maximal TL for males and for females are 1920 mm and 2300 mm respectively. All the year round, pregnant *R. cemiculus*, newborn with IVV (mean TL = 323.59 mm) and small free-living specimens (400 mm < TL < 500 mm) are regularly found in the lagoon.

Raja miraletus from the Lagoon of Bibans were observed at the fish-market of Tunis, they were specimens of both sexes, juveniles (45 males, 37 females) and adults (66 males, 79 females). Size at sexual maturity occurs in males and in females at 220 mm and 240 mm DW by males and by females. Females with ripe oocytes ready to be ovulated in the ovaries, and/or encapsulated eggs in their oviducts round, egg cases containing embryos were regularly found in the Lagoon of Bibans.

Several hundred *R. radula* from the Lagoon of Bibans were observed, 126 males and 158 females were measured. Sexual maturity occured for males and for females at 280 mm and 310 mm DW respectively. The largest male and female were 340 mm and 360 mm DW respectively. All the females bore ripe oocytes and encapsuled eggs.

The marbled stingray is only recorded in the shallow coastal waters of the Gulf of Gabes and in the Lagoon of Bibans Size at sexual maturity for males and for females is about 300 mm and 320 mm DW respectively. The largest male and the largest female observed were 400 mm and 440 mm DW respectively. Estimated size at birth is 118 mm DW. Gestation period lasts about three months.

The common torpedo, *Torpedo torpedo* is abundantly fished in the Lagoon of Bibans. However, it seems that specimens do not occur too far inside the lagoon. Most are caught near by the passes. The occurence of common torpedos is seasonal.

About 300 *Scyliorhinus canicula* were observed. All were adult, 56 females and 44 males were measured. Females size ranged from 450 to 500 mm TL; 24 specimens had encapsulated eggs in their genital tract. Males size ranged from 440 to 460 mm TL.

R. clavata is rarely found in the Lagoon of Bibans. A single specimen was observed. It was an adult male, 480 mm DW. This capture was accidental.

A single, *Prionace glauca* of small size was examined. It was a juvenile male, 790 mm TL, captured as it was about to leave the lagoon. A male, I, 600 mm TL, was captured in May 1980. This specimen exhibited an umbilical scar suggesting it was born during the year. From 1980 to 1990, six hammerhead sharks were observed.

Three species are recorded in the lagoon consequently to fortuitous events, strong tide and/or to take refuge. A single *R. clavata* and two sharks, *P. glauca* and *S. zygaena* were also recorded. These records concern small specimens which probably get lost.

Two marginal species were found in the Lagoon of Bibans, *S. canicula* and *T. torpedo*. These species enter the lagoon to breed during spring and/or summer. Records during winter, remain questionable, probably occasoinal. *T. torpedo* is the only backish marginal torpedinid know to date. Morevover, the common torpedo enters hypo and/or hyperhaline waters at the time to breed. Most of the gravid females observed had full-term fetuses in their uteri.

Five species occur in the locale and are abundantly caught, *R. rhinobatos, R. cemiculus, R. miraletus, R. radula* and *D. chrysonota*. Their captures in a restricted area suggest some degree of competition between them. However, the size of these species is different and they do not simultaneously occupy the same sites and same food niches. Moreover, they find sufficient food in the lagoon (4). The occurence of juveniles of both sexes, females with embryos and full-term fetuses and egg-capsules for oviparous species, means that the Lagoon of Bibans is a nursery area and/or an laying site.

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ENVIRONMENTAL CONDITIONS AND PHYTOPLANKTON IN A STRATIFIED ESTUARY OF THE OMBLA RIVER. SPRING AND SUMMER

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Abstract
The low salinity surface and saline bottom layers were delimited by a sharp halocline in the Ombla River estuary during spring and summer. Maximum nutrient values were found in the surface layer, excluding ammonia. The first peak of microphytoplankton and nanophytoplankton cell numbers and chlorophyll a concentrations was noted at the end of May, when temperatures reached 22.45°C. The second peak of microphytoplankton and nanophytoplankton cell numbers was noted at end-August, coinciding with the annual minimum of freshwater runoff and with the stabilization of thermohaline conditions. There were no significant differences in the nutrient concentrations during both phytoplankton peaks.

Key words: hydrography, stratification, phytoplankton, estuaries, Adriatic Sea

Introduction

The spring of the Ombla River is located on the Adriatic coast near Dubrovnik. The spring discharges at sea level, forming the Ombla River, and almost immediately flows into the sea to form a small, 4-km long, highly stratified estuary. The estuary's upper reach is about 6 m deep, while the lower reach is up to 25 m deep. Highly stratified estuaries are typical of areas where high volumes of river discharge combine with low tides (1). Such phenomena are well-known throughout the Mediterranean and along the eastern Adriatic coast. Estuaries are highly productive habitats and dynamic nutrient transformation zones at the interface between freshwater and marine environments (2). The physico-chemical and ecological processes at the contact zone of karstic and sea waters are generally unknown, representing an attractive area of investigation. This paper aims to determine the environmental conditions, phytoplankton abundance and taxonomic structure of the Ombla River during the period of rising and quite constant water temperatures.

Material and methods

Samples for the analysis of hydrographic, chemical and biological parameters were collected at station Ombla-2, maximum depth of 12 m, during nine cruises from March to August 2000. Water samples were taken every two meters, from surface to bottom. Parameters were determined by standard oceanographic methods (3, 4, 5). The data were processed with analysis of variance (ANOVA) and SNK tests (6).

Results and discussion

The Ombla River discharge varied from 6.8-49.1 $m^3\ s^{-1}$ during this period. A sharp halocline, frequently at 2-4 m depths, delimited the low salinity surface and saline bottom layers. Table 1 summarizes the physical and chemical properties of both two layers. Maximal nutrient values, excluding ammonia, were found in the surface layer. For most nutrients, the great differences between minimum-maximum values and the lower-upper quartile, as well as the mean and median, indicate the existence of extreme values, the so-called "outliers". These differences are the most pronounced for NO_3 and SiO_4, especially in the surface layer ($P<0.001$).

No significant differences in temperature existed between layers. Temperatures rose from March to end-May and were more or less constant until September. The surface layer salinity differed significantly with that of the bottom layer. The oxygen saturation of both layers indicated a good aeration. Secchi disc transparency varied between 5-8 m depths. A lowest transparency occurred at the end-May and end-August. It must be mentioned that nutrient concentrations in the surface layer oscillated much more than in the bottom layer. Following high nutrient values in the surface layer in March, the April values showed a concentration minimum for TIN and PO_4, and a concentration maximum for SiO_4. A probable explanation for these nutrient patterns in April could be an increase in MICRO cell number just above the halocline. In both layers, most of the MICRO population (>90%) was made up of the coccolithophorids *Syracosphaera pulchra* and *Calyptrosphaera oblonga*, and the dinoflagellate *Scrippsiella trochoidea*.

The first, greater, peak of MICRO cell numbers and Chl a concentrations, including a NANO peak occurred during end-May, a time when temperatures in both layers reached their high rising value, and when nutrient concentrations in the surface layer were high. The MICRO population in both layers was mostly composed of dinoflagellates (>89%), mainly the species *Prorocentrum triestinum* (max. 1.3×10^5 cells l^{-1}), whose intensive development has been noted before in this estuary during May (7). The contribution of dinoflagellates was mostly greater in the surface than in the bottom layers. A second, lower, MICRO peak and a greater NANO peak appeared at end-August, during a period of stable thermohaline conditions in the surface layer. In this layer, most of the MICRO population (>85%) was made up of the dinoflagellates *Scrippsiella trochoidea* and *Prorocentrum triestinum*, and the euglenophyte *Eutreptia lanowii*. In the bottom layer, the species *Oxytoxum sceptrum, Dinophysis acuminata* and *Ceratium pentagonum* were found alongside the species *Prorocentrum triestinum*.

According to our results, the intensive development of phytoplankton in May and August was strongly related on temperature and elevated nutrient concentrations.

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Table 1. Physical and chemical characteristics of the seawater in the estuary of the Ombla river.

SURFACE	Temperature	Salinity	O_2/O_2'	c(NO_3)	c(NO_2)	c(NH_4)	c(PO_4)	c(SiO_4)
MIN-MAX	13.60-23.50	25.59-37.07	0.73-1.16	0.34-7.71	0.02-0.11	0.35-1.27	0.03-0.21	1.99-16.78
Mean	20.15	33.10	1.05	3.02***	0.06	0.63	0.09	5.91***
STD	3.15	3.93	0.11	2.56	0.02	0.27	0.05	3.81
Low-Upp Q	18.61-22.43	30.31-36.19	1.01-1.12	1.18-4.94	0.05-0.07	0.41-0.71	0.05-0.12	3.13-7.21
MEDIAN	21.37	34.73	1.09	2.10	0.06	0.57	0.08	5.27
BOTTOM								
MIN-MAX	13.04-23.1	36.12-38.60	0.56-1.12	0.04-1.90	0.02-0.09	0.29-1.48	0.02-0.14	0.76-3.78
Mean	19.19	37.77***	1.03	0.38	0.05	0.63	0.05	2.11
STD	3.35	0.63	0.11	0.38	0.02	0.27	0.03	0.87
Low-Upp Q	18.22-22.10	37.39-38.30	0.98-1.08	0.15-0.49	0.03-0.06	0.42-0.74	0.03-0.07	1.42-2.70
Median	20.19	37.86	1.03	0.21	0.05	0.62	0.04	2.02

*(MIN-MAX) - range, (STD) - standard deviation, (LOW-UPP Q) - lower-upper quartile, (c) - µmol dm^{-3}, (O_2/O_2') - oxygen saturation The means in the same column followed by *** are significantly different $P<0.001$ (ANOVA, SNK-test).*

TROPHIC GROUPS AND SHORT TERM VARIATIONS IN A COASTAL CILIATE COMMUNITY

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Abstract

Day-to-day variations in abundance, biomass, vertical distribution and trophic composition of the planktonic ciliate community were investigated between 15 and 23 June 1999 in the Gulf of Naples, Tyrrhenian Sea. Abundance ranged between 780 to 10230 cells l^{-1} and biomass between 0.7 to 3.3 mg C l^{-1}; aloricate ciliates dominated abundance and biomass of the ciliate assemblage. Among the aloricate ciliates the most important group was mixotrophic ciliates that contributed more than 40% to aloricate abundance. Nanociliates (< 18 μm Equivalent Spherical Diameter, ESD) were abundant in most samples, 130 - 4550 cells l^{-1}. A negative correlation between this group and a small pleurostomatid, *Amphyleptus sp*., was found. The relative contribution of different ciliate trophic groups varied little among all samples, independently of ciliate abundance. Grazing control within the ciliate community is discussed.

Key Words: Trophic relations · Predation · Population Dynamics · Tyrrhenian Sea

Planktonic ciliates have been shown to play a much larger role than previously thought in pelagic systems in terms of biomass and carbon flow [1]. Different trophic modes can be distinguished among the ciliates. Autotrophy is found in the ciliate *Mesodinium rubrum*. Mixotrophic oligotrich ciliates, forms that retain functional plastids from ingested algae, rely on both photosynthesis and phagotrophy. Heterotrophic ciliates are a complex assemblage of tintinnids and aloricate forms; in terms of size they span from nano- to micro-zooplankton, and in terms of diet from bacterivorous to algivorous and predacious.

Materials and Methods

A station in the Gulf of Naples 2 miles offshore, 80 m depth, was sampled from June 15 to June 23 1999. Samples were collected between 10 - 11 a.m. at 1, 5, 10 and between 20 and 30 m, by means of a CTD-rosette using 12 l Niskin bottles. CTD data showed that during this period the pycnocline was positioned between 15 and 30 m depth. Microzooplankton samples, preserved in borax-buffered formalin (2% final concentration), were analysed with a Zeiss inverted microscope equipped also with epifluorescence. Ciliate biomass was calculated using the conversion factor 0.14 pg μm^{-3} for formol preserved samples [2].

Results

The ciliate assemblage was characterised by high values and pronounced variability both in terms of abundance (1329 – 10228 cells l^{-1}; Fig.1a) and biomass (1 – 33 μgC l^{-1}; Fig.1b) within the first 10 m. Below this first layer, less variability and lower values (< 2000 cells l^{-1}; < 2 μgC l^{-1}) were found.

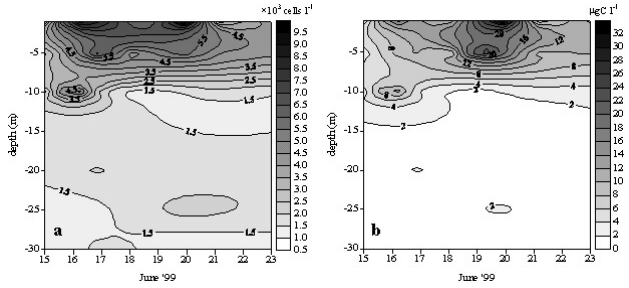

Fig. 1 : Total ciliate abundance (a) and biomass (b) versus depth between 15 and 23 June 1999

Despite these great variations in abundance and biomass the relative importance of the different trophic groups was fairly constant. Aloricate ciliates were the most abundant contributing 61±7% (p = 0.05) to total ciliate abundance (Fig.2), and among the aloricate ciliates the most important were mixotrophic ciliates, contributing 25±4% (p = 0.05) to total abundance. Nanociliates, i.e. nano-oligotrichs and scuticociliates, were the second most important group contributing 24±5% (p = 0.05) to total abundance. Prostomatids and pleurostomatids contributed less than 12%. The

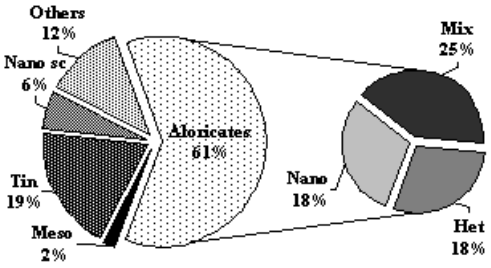

Fig. 2 : Average contributions to total abundance of the different ciliates trophic groups. Others : prostomatids and pleurostomatids; Nano sc = scuticociliates; Meso = *Mesodinium rubrum*; Tin = Ti,tinnidi; Aloricates = oligotrichs; Mix = mixotrophic oligotrichs; Het = heterotrophic oligotrichs; Nano = <18 μm ESD oligotrichs

relatively constant contribution of the different trophic groups might be explained, to some extent, by an internal control within the ciliate assemblage. To test this hypothesis we analysed the concentrations of small nanociliates (all dimensions < 20 μm) and the occurrence of the most abundant ciliate predator species encountered during the period of this study, presumably *Amphyleptus sp*. This small pleurostomatid, ≤ 55 mm, occurred only in the upper layer of the water column, 1 - 5 m, with maximum abundance of 2900 cell l^{-1}. Mean abundance in the layer 1 – 5 m of *Amphyleptus sp*. and of the small nanociliates are shown in figure 3. Low concentrations of *Amphyleptus sp*. occurred at high concentrations of nanociliates and vice versa. In fact, nanociliates showed their maximum on June 16 while *Amphyleptus sp*. reached maximum concentrations on June 20. A significant negative correlation ($r = -0.5$; $p < 0.05$; $N = 16$) was found between the small nanociliates and *Amphyleptus sp*. abundances, and an even stronger negative correlation occurred if a one-day delay in *Amphyleptus sp*. abundance was considered ($r = -0.6$, $p < 0.05$).

Discussion

The annual average of ciliate abundance and biomass vary within a narrow range, 1 - 10 cells ml^{-1} 1 - 10 ng ml^{-1} [3] in most aquatic systems of very different trophic status. Protozoan controlling protozoan has been hypothesized to explain the relatively low variability in ciliate occurrence [4; 5; 6]. The fairly constant contribution of the different ciliate trophic groups at any level of abundance and biomass, as observed in this study, might well be obtained by such protozoan grazing control. Due to the fast growth rates of ciliates they would escape, at least for short periods, the grazing control by metazoans. On the other hand, a protozoan predator having similar growth rates as its prey might closely check the prey population. Such relationship is suggested here by the negative correlation between the abundances of small nanociliates and the pleurostomatid *Amphyleptus sp*. However, the analysis of weekly microzooplancton samples over 4 years at the same station did not reveal the negative correlation encountered here between *Amphyleptus sp*. and small nanociliates, indicating weekly intervals to be too long to track the very rapid variations in ciliate abundances (Modigh, unpublished data). Grazing control within the ciliate assemblage as well as grazing by other protozoans, such as heterotrophic dinoflagellates, might explain the fairly constant trophic composition of the ciliate assemblage encountered in the Gulf of Naples.

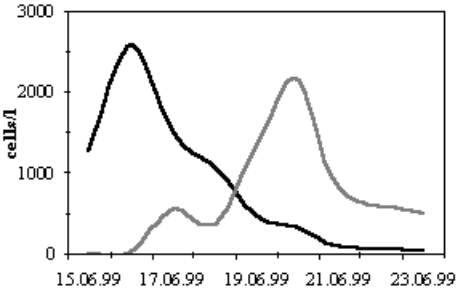

Fig. 3 : *Amphyleptus sp.* and nanociliates mean abundances in the layer 1-5 m

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A ONE-YEAR STUDY OF THE EFFECTS OF A HYPERHALINE DISCHARGE FROM A DESALINATION PLANT ON THE ZOOBENTHIC COMMUNITIES IN THE USTICA ISLAND MARINE RESERVE (SOUTHERN TYRRHENIAN SEA)

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Abstract

Sampling of the soft-bottom zoobenthic communities living near a hyperhaline discharge from a desalination plant was taken from November '96 to November '97 using a van Veen grab. The three stations being investigated showed significant differences in abundance. Major effects were recorded on polychaetes, crustaceans and molluscs decreasing in numbers at the diffuser site and on echinoderms which disappeared.

Key-words: zoobenthos, salinity, thermal pollution, Tyrrhenian Sea

Introduction

Since the end of November 1996, a desalination plant located in the Ustica Island (Southern Tyrrhenian Sea) has been furnishing potable water to the inhabitants. The plant operates through a thermal compression process: heated sea water flows through a pipe-line into an evaporator where a pressure of 0.185 bar maintains the boiling-point at less than 65°C, producing vapour (condensing in potable water) and discharging brine (70 ppt salinity, up to 3°C warmer than intake temperature) at a rate of 30.000 kg/h. The effects on benthic organisms near a brine disposal vary from changes in species composition and diversity (1, 2) to the total destruction of benthic communities (2). Various effects on marine organisms by discharge of heated effluents have also been reported (3, 4). The aim of this study was to assess the effects of the discharge on the zoobenthic communities surrounding the diffuser over a period of one year.

Materials and methods

The discharge diffuser is located at a depth of 50 m on a soft bottom characterised by strong currents. Three sampling stations were investigated: A) around the diffuser; B) 20-30 m away from the diffuser downstream; C) control site. Samples were collected in November '96, just before the plant was activated, and in July and November '97, following brine discharge. Five samples were taken at each station with a 0.1 m^2 van Veen sediment grab (5); the samples were washed on a 0.5 mm sieve and preserved in 5% formalin. Animals were identified to species and counted. Statistical analyses included comparison of sites (treatments) by analysis of variance, using total richness (R) and abundance (N) (5) computed for separate taxa (blocks: polychaetes, crustaceans, molluscs, echinoderms, sipunculans and others); ANOVA-test was repeated three times both for R and for N considering each sampling period; in order to get the observations homogeneous, R and N were weighed to one litre of sediment analysed. Shannon-Weaver diversity index (H') and evenness (J) were calculated for all stations (6). Summer and winter monitoring of temperature and salinity took place at the diffuser site, using a multiparameter probe IM 51 Idromar, before and after brine discharge was initiated. Particle grain size analysis was performed for all stations, expressed on the phi (ϕ) scale, where $\phi = -\log_2 (x)$ where x = particle size in millimetres.

Results

Mean temperatures and salinities at all stations, prior to hyperhaline discharge, were: 16-17°C and 37.9 ppt in summer; 13°C and 36.9 ppt in winter. Readings at station A, following discharge, were: 18-19°C and 49.6 ppt in summer; 16°C and 47.4 ppt in winter. The bottom was mainly composed of medium sand and characterised by the presence of encrusted Melobesiae, biodetrital and volcanic clasts, with the typical species of the biocoenosis of detritic sediments (7). A total of 310 taxa and 11.366 individuals have been recorded. In November '96 polychaetes were the most abundant group in terms of both N (43.1%) and R (48.1%), followed by crustaceans (23.3% and 30.3% respectively). Other groups were represented by low N and R values, except for sipunculans. The sipunculid *Aspidosiphon muelleri* Diesing was the dominant species at all stations; the polychaete *Lysidice ninetta* Audouin & Milne-Edwards was also well represented. During '97 summer and winter seasons, main differences were found at station A with the lowest values being recorded for all groups examined, whereas stations B and C showed closer indexes values. In July '97, echinoderms were absent at station A and the dominant species were *L. ninetta* and *A. muelleri*. In November '97, the station A was dominated by the polychaete *Pisione remota* (Southern) (18.5%) whereas *A. muelleri*, dominating the other two stations, nearly disappeared (2.3%) and occurrence of *L. ninetta* decreased at all sites. Prior to the activation of the plant, all stations recorded quite similar H' values (H'= 3.8); after its activation, station A showed the lowest value (H'= 3.2) whereas the other sites mainteined the initial value. Evenness resulted similar at all sites and seasons (J= 0.7-0.8). ANOVA-test computed for N during winter '96 showed no relevant differences among sites: the observed value (F= 1.99) is less than critical value ($F_{2,10}$= 4.1) for $p \leq 0.05$. On the contrary, major differences were recorded both in summer '97 (F= 9.27) and in winter '97 (F= 25.4). Few differences were noted among sites for R: statistical test values were very close to critical value, for $p \leq 0.05$.

Discussion

Analysis of benthic communities showed that, after one year, the hyperhaline and heated plume affected the organisms living near the diffuser. Major effects were recorded on abundance that decreased at the discharge site for all the groups examined; particularly, crustaceans, molluscs and echinoderms nearly disappeared. Although statistical analysis computed for richness did not differ significantly among sites, it should be remarked that very few species were found near the active diffuser, especially among crustaceans which decreased in numbers during both summer and winter seasons, compared to those recorded at other sites. Differences in H' values were very low; furthermore, the high values of J at all sites indicated a good distribution of the individuals among species. No relevant effects on benthic communities were noted at station B as the hyperhaline plume dilutes itself in a very few meters from the discharge mouth. The most represented polychaete *L. ninetta* seemed not to be directly affected by salinity changes. Its presence is related to that of Melobesiae in which the species lives (7). Moreover, this species has been found living inside *Posidonia oceanica* scales (8), suggesting this borer's ability to adapt to particular conditions. The dominance of *P. remota* confined only to the diffuser site in winter '97 could suggest this species suits well to the high salinity and temperature being here recorded.

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CYCLE DE REPRODUCTION ET COMPOSITION BIOCHIMIQUE DE LA PALOURDE *RUDITAPES DECUSSATUS* DANS LA BAIE D'ALGER

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Résumé

La population de *Ruditapes decussatus* dans la baie d'Alger a été étudiée de novembre 1997 à mars 1999. Le cycle reproducteur a été abordé par les techniques histologiques et l'indice de condition en relation avec la composition biochimique. L'activité reproductrice est étalée de mai à octobre et le repos sexuel est hivernal pour la majorité des individus. La maturation des ovocytes est asynchrone et la période de ponte principale est estivale (juin-août) et hivernale (janvier) pour les plus grands individus (45 mm). Les périodes de ponte ont été corrélées à deux périodes de recrutement et aux variations des composés biochimiques.

Mots clés : bivalves, reproduction, analyse biochimique

Introduction

La palourde *Ruditapes decussatus* fait l'objet d'une étude reliant l'écologie, la reproduction, la croissance et la composition biochimique depuis plusieurs années dans la baie d'Alger. La connaissance de certains aspects de la reproduction, particulièrement le nombre et la périodicité des pontes est fondamentale pour la gestion de cette ressource. Le suivi temporel de la composition biochimique (protéines, lipides, glucides) a permis de préciser la nature et l'utilisation des réserves en relation avec le déroulement du cycle sexuel.

Matériel et méthodes

Les prélèvements sont récoltés manuellement dans la région d'Alger plage, à des intervalles bimensuels réguliers, de novembre 1997 à mars 1999. Les animaux récoltés sont stockés au laboratoire dans une chambre froide, à jeun pendant 48 heures. Les individus sont mesurés selon l'axe antéro-postérieur (longueur) et pesés. L'évolution saisonnière de l'état physiologique est suivie au moyen de l'indice de condition de Mann et Glomb (1). La détermination du sexe est réalisée à partir de l'examen microscopique d'un frottis de gonade et une dizaine d'individus ont été destinés à l'étude histologique. Les analyses biochimiques ont été réalisées sur un pool d'individus (cinquante) lyophilisé. Le dosage de l'eau est déterminé par séchage à l'étuve. Le dosage des cendres est obtenu par incinération à 550°C pendant 24 heures. Le dosage des protéines, des lipides (triglycérides et cholestérol) et des glucides (glucose et glycogène) a été réalisé à l'aide d'un auto-analyseur.

Résultats

Cycle de reproduction

L'examen microscopique de la gonade a montré que l'ovogenèse et la spermatogenèse sont observées chez les individus de taille supérieure à 30 mm. Chez les femelles, le repos sexuel se déroule de novembre à mars et de septembre à février alors que chez les mâles il est avancé d'un mois pour la première période (novembre à février). La pleine maturation sexuelle s'étale de mai à août et les dernières vidanges se déroulent en août pour les deux sexes. Le suivi mensuel de l'indice de condition de la population indique une accumulation régulière de matière organique en période hivernale suivie d'une augmentation printanière rapide et l'émission des gamètes est étalée de juin à octobre. La perte de matière organique associée à une émission de gamètes est liée à la taille des individus et une ponte hivernale de faible amplitude a été observée (janvier) chez les plus grands individus de la population (45 mm).

Composition biochimique

Le poids sec de l'animal standard subit des variations saisonnières se superposant avec celles de l'indice de condition. La perte de poids maximale calculée entre juin et octobre (0.19 g) représente 40 % du poids sec initial. La teneur en eau augmente durant l'hiver, atteint une valeur minimale au début de la période de ponte pour augmenter après l'émission des gamètes. Il semble que l'animal s'engorge d'eau après la ponte pour compenser les pertes de matière organique et Ansell *et al*. (2) estiment que cette augmentation hydrique reflète un arrêt de l'activité reproductrice. Tous les composés biochimiques à l'exception du cholestérol sont liés aux variations pondérales de l'animal standard. Les protéines et les triglycérides augmentent pendant la gamétogenèse pour diminuer après l'émission des gamètes. Inversement, les glucides sont destinés à la maturation des ovocytes et une partie du glycogène sera transformé en lipides. La perte de glucose et de glycogène correspond respectivement à 4.8 et 26.5 mg d'avril à juillet (maturation sexuelle) suivie d'une augmentation jusqu'au mois d'octobre. Différents travaux montrent une présence de pics de glycogène précédant la maturation des gamètes (2) et une perte de ce composé est associée à une développement gamétogénique. La perte de glycogène (13.7 mg) durant le mois de janvier 1998 semble correspondre à une ponte hivernale déjà identifiée par le suivi de l'indice de condition des individus de 45 mm.

Discussion

La reproduction est de type saisonnier avec une importante ponte estivale correspondant à une gamétogenèse étalée sur quatre mois et une ponte hivernale rapide (un mois). Le cycle reproducteur et particulièrement le nombre ainsi que la durée de la période de ponte est influencé par la position géographique. Deux pontes (juin et août) ont été observées au nord de l'Espagne et dans l'étang de Thau (3 ; 4). Les variations saisonnières de l'indice de condition traduisent l'activité reproductrice et permettent d'identifier les périodes de ponte. La maturation sexuelle étant asynchrone, l'utilisation de l'indice de condition en fonction de l'âge permet de mieux cerner le potentiel reproducteur. Le recrutement de R. decussatus obtenu en hiver (décembre) et en été (août), quantitativement plus important, concorde avec les deux pontes identifiées. La composition biochimique varie avec les conditions physiologiques de l'animal et particulièrement avec l'activité reproductrice. Les protéines, constituants principaux des tissus interviennent dans la formation des gamètes comme source énergétique (2). Les glucides et particulièrement le glycogène représentent la majeure partie du matériel de réserve destiné à l'élaboration des produits génitaux. La connaissance des phénomènes biochimiques régissant le cycle biologique d'une espèce permet de déterminer la variabilité de la stratégie de reproduction en relation avec la température et la nourriture disponible.

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DIFFERENCIATION MORPHOLOGIQUE DE DEUX POPULATIONS MARINE ET LAGUNAIRE DE DAURADE *SPARUS AURATA* (LINNE, 1758)

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Résumé

Cette étude est consacrée à la différenciation morphologique de deux échantillons de daurade *Sparus aurata* issus de deux milieux différents du littoral Est algérien: le Golfe d'Annaba et la lagune voisine du Mellah. Les résultats obtenus montrent l'existence de deux morphotypes qui se distinguent surtout par leurs caractères métriques.

Mots clés: poissons, morphologie, lagune, Méditerranée

Malgré leur remplacement par des marqueurs génétiques de plus en plus performants, les caractères morphologiques sont toujours employés pour déterminer la divergence génique des poissons. Que ce soit en pêche ou dans une perspective d'élevage, l'identification de stocks différents au sein d'une espèce est un préalable important à la connaissance de la structure et de la biologie des populations. La daurade *Sparus aurata* est une espèce d'un grand intérêt halieutique et aquacole. Si la dynamique de ses populations et différents aspects de sa biologie ont été étudiés dans différents milieux (1 2,3), sa morphologie n'a été que récemment abordée (4,5). L'objectif de ce travail est de comparer sa morphologie, sur la base de critères morphométriques et méristiques, entre le Golfe d'Annaba et la lagune du Mellah.

Matériel et méthodes

Les échantillons traités proviennent de deux milieux différents : le golfe d'Annaba (36°54'N, 7°45'E) et la lagune du Mellah (36°50'N, 7°48'E). Ils sont composés respectivement de 167 et 95 individus, de longueurs totales comprises entre 175 et 352 mm pour le premier et entre 157 et 550 mm pour le second. Sur chaque individu, 13 caractères métriques et 3 caractères numériques sont considérés. Les différentes parties mesurées du corps sont exprimées en fonction de la longueur totale ou de la longueur de la tête. Afin de mettre de manière plus expressive les changements relatifs de ces dimensions au cours de la croissance, nous avons utilisé l'axe majeur réduit préconisé par Teissier (6) pour les études d'allométrie. Le test de conformité de cet axe nous permet de décider du type d'allométrie.

Dans le but de déceler une éventuelle différence morphologique entre les deux groupes marin et lagunaire, nous avons comparé, pour chaque caractère, les équations des droites de régression entre les deux milieux, en utilisant le test t de Student adapté aux axes majeurs réduits "tpe" (7). Chaque caractère numérique utilisé est comparé entre les deux échantillons à l'aide du test "t" de Student au seuil de probabilité a = 0,001. Lorsqu'il y a une différence entre les deux échantillons, nous avons calculé le coefficient de différence (C.D) de Mayr, Linsley, Usinger (8) pour connaître leur niveau taxonomique respectif.

$$C.D = \frac{\bar{X}_a - \bar{X}_b}{[S_a^2/Na + S_b^2/N_b]^{1/2}}$$

Lorsque 75 % des individus d'une population diffèrent par un ou plusieurs caractères de 75 % des individus d'une autre population, C.D > 0.67, on est en présence de différences raciales entre ces deux populations. Lorsque 75% des individus d'une population différent de 97% de ceux d'une autre population, C.D > 1.28, ces deux populations diffèrent subspécifiquement.

Résultats et discussion

Les résultats du tableau 1 montrent que les cas de croissance allométrique majorante sont aussi fréquents dans l'échantillon marin que dans celui d'origine lagunaire. Cependant, cette situation ne concerne pas toujours les mêmes caractères dans les deux cas. La comparaison des pentes des droites de régression indique que la moitié des caractères considérés permettent de distinguer les poissons marins des individus lagunaires. Il s'agit des longueurs à la fourche, céphalique, pré-orbitaire, pré-dorsale, pré-pectorale, de la hauteur du pédoncule caudal et du diamètre de l'œil. La daurade marine aurait, à taille égale, une forme plus effilée que celle vivant dans la lagune, avec une longueur à la fourche et une tête plus longues; en revanche, son œil serait plus petit. Par ailleurs, les paramètres mesurés dont la pente de la droite de régression est identique entre les deux échantillons, présentent tous une différence de position. Concernant les caractères numériques (tableau 2), seul le nombre de branchiospines montre des différences significatives entre les deux biotopes (t > 3,29; α = 0,001), mais le calcul du coefficient de différence correspondant indique que les différences constatées n'atteignent pas le niveau racial. (C.D < 0,67). Si les caractères numériques pris en compte n'ont pas permis de distinguer les deux échantillons, tous les critères métriques considérés montrent l'existence de deux morphotypes de daurade, marin et lagunaire. Une étude similaire réalisée chez le loup *Dicentrarchus labrax* dans ces mêmes milieux a abouti à la même conclusion (9). La question qui se pose maintenant est de savoir si cette différence est de nature adaptative, pouvant être expliquée par des facteurs environnementaux, ou serait-elle le reflet d'une différenciation liée à la divergence génétique.

Tableau 1. Comparaison de la pente et de la position des droites de régression chez *S. aurata* en fonction de son origine marine ou lagunaire *(*: différence significative)*.

Fonction	Mer	Lagune	tpe α = 0,001	tpo α = 0,001
Lf = f (Lt)	Lf = 2,28 Lt – 3,05	Lf = 1,02 Lt – 0,09	8,75*	
Ls = f (Lt)	Ls = 1,07 Lt – 0,26	Ls = 1,02 Lt – 0,17	1,14	18,71*
Lc = f (Lt)	Lc = 2,28 Lt – 3,63	Lc = 1,22 Lt – 1,20	8,68*	
Do = f (Lc)	Do = 0,51 Lc + 0,27	Do = 0,87 Lc – 0,32	4,61*	
Po = f (Lc)	Po = 0,73 Lc – 0,07	Po = 1,38 Lc – 1,25	5,00*	
po = f (Lc)	po = 0,67 Lc – 0,15	po = 0,87 Lc – 1,41	2,82	15,44*
M = f (Lc)	M = 0,82 Lc – 0,20	M = 0,97 Lc – 0,37	1,94	23,43*
Pd = f (Lt)	Pd = 1,5 Lt – 1,97	Pd = 1,25 Lt – 1,29	4,62*	
Pp = f (Lt)	Pp = 1,31 Lt – 1,34	Pp = 1,00 Lt – 0,63	8,78*	
pp = f (Lt)	pp = 1,26 Lt – 0,91	pp = 1,17 Lt – 0,74	1,20	27,17*
Pa = f (Lt)	Pa = 1,24 Lt – 0,88	Pa = 1,17 Lt – 0,72	1,02	18,74*
Hpc = f (Lt)	Hpc = 1,39 Lt – 2,05	Hpc = 1,14 Lt – 1,44	5,23*	
Hc = f (Lt)	Hc = 1,10 Lt – 0,75	Hc = 1,33 Lt – 1,20	2,21	36,79*

Lt: longueur totale; Lf: longueur à la fourche caudale; Lc: longueur céphalique; Do: Diamètre de l'œil; Po: longueur pré-orbitaire; po: longueur post-orbitaire; M: longueur du maxillaire supérieur; Pd: longueur pré-dorsale; Pp: longueur pré-pectorale; pp: longueur post-pectorale; Pa: longueur pré-anale; Hpc: hauteur du pédoncule caudal; Hc: hauteur du corps.

Tableau 2. Comparaison de quelques caractères numériques de S. aurata en fonction de son origine marine ou lagunaire (*: différence significative).

	N.R.D.D.		N.R.M.D.		N.B.	
	Mer	Lagune	Mer	Lagune	Mer	Lagune
Moyenne	11	10,90	13,29	12,94	12	11,19
Ecart type	0	0,38	0,52	0,80	1,22	1,77
Mode	11	11	13	13	11	12
Minimum	11	9	12	8	9	6
Maximum	11	12	14	14	15	14
t (α = 0,001)	1,56		3,27		5,05*	
C.D					0,26	

N.R.D.D: nombre de rayons durs de la nageoire dorsale; N.R.M.D: nombre de rayons mous de la nageoire dorsale; N.B: nombre de branchiospines

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DONNEES PRELIMINAIRES SUR LA DIVERSITE SPECIFIQUE ET FONCTIONNELLE DU ZOOBENTHOS DE LA LAGUNE DE SMIR (MAROC)

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Résumé
La lagune de Smir est la plus occidentale des lagunes méditerranéennes. Le peuplement zoobenthique y est dominé par un groupe restreint d'espèces dont les abondances sont élevées. Parmi les groupes trophiques, les détritivores et les suspensivores dominent et expriment de façon prononcée la variation temporelle de la densité totale.

Mots clés : Lagoons, Zoobenthos, Biodiversity, Alboran Sea

La lagune méditerranéenne de Smir se situe dans le Nord-Ouest du Maroc à 25 km au sud du détroit de Gibraltar et à quelques kilomètres au nord de la Ville de M'diq. Sa position géographique (35°43'N et 5°20'W) en fait la lagune la plus occidentale du bassin méditerranéen. Elle a une surface de 0.5 km^2 et une profondeur moyenne de 1.5 m. Le fond de la lagune est sablo-vaseux et est largement tapissé d'algues et de phanérogames. Cet écosystème communique avec la mer par un goulet et subit la marée dont l'amplitude moyenne est de 1 m. La salinité y varie entre 16 et 40‰ selon les saisons et la température de l'eau y oscille entre 12°C (hiver) et 32°C (été).

La macrofaune benthique est étudiée à travers 12 stations échantillonnées de façon bimensuelle entre mai 1999 et mai 2000 (Fig. 1). Les 39624 individus récoltés se répartissent en 29 taxons dominés principalement par les Crustacés (41%), Polychètes (31%) et Mollusques (17%). La dominance des Crustacés se manifeste aussi dans l'abondance où ils représentent près de 90% de l'ensemble des effectifs (Fig. 2) avec la dominance de *Cyathura carinata* et de *Melita palmata*. Parmi les Polychètes, *Hediste diversicolor* est la plus abondante. La richesse spécifique est beaucoup plus élevée au niveau des stations proches du goulet de communication avec la mer que dans les stations qui en sont éloignées. Les premières peuvent abriter jusqu'à 13 espèces à la fois et les densités peuvent y atteindre plus de 16000 ind./m^2.

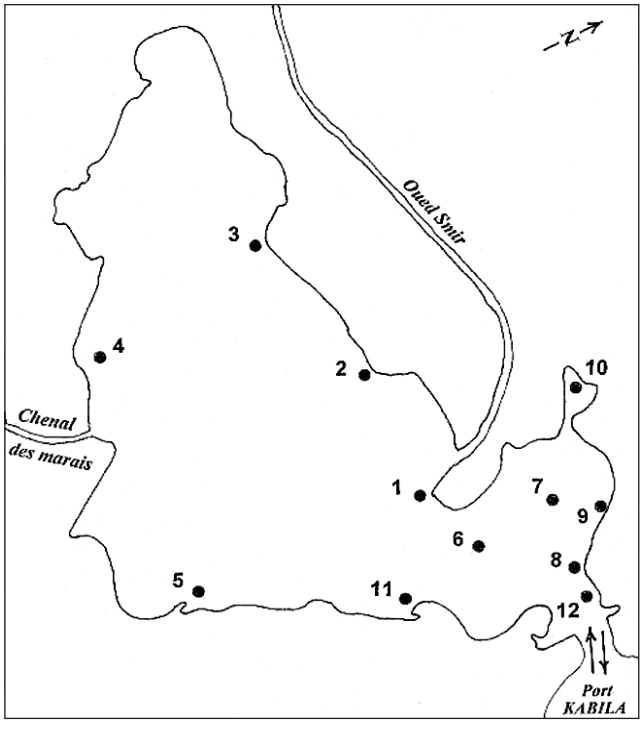

Figure 1 : Localisation des Stations de prélèvements dans la lagune de Smir

L'évolution temporelle de la densité totale du peuplement (Fig. 3) montre une tendance générale croissante, cependant, une valeur élevée (4500 ind./m^2) est notée en décembre 1999.

La diversité fonctionnelle en terme de groupes trophiques (1) de la lagune de Smir permet de reconnaître quatre entités totalisant 92% de la dominance totale (Insectes et Némertiens exclus). Les détritivores avec les Crustacés *Melita palmata* et *Cyathura carinata* et le Polychète *Hediste diversicolor* représentent en moyenne plus de 77% de la densité totale. Les suspensivores composés de *Cerastoderma glaucum* et *Corophium acherusicum* ont une dominance bien moindre ne dépassant pas 13%. Les déposivores de surface et les carnivores ont des pourcentages inférieurs à 2%.

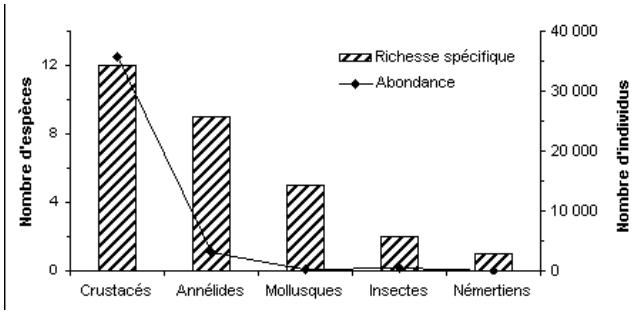

Figure 2 : Richesse spécifique et abondance totale des différents groupes zoologiques du macrobenthos

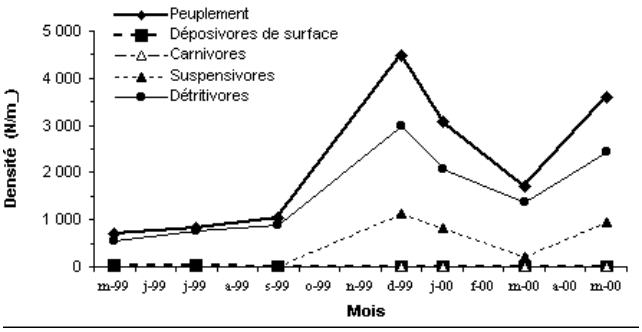

Figure 3 : Variation temporelle de la densité totale du macrobenthos, comparaison avec celle des groupes trophiques.

L'évolution de la densité totale a été comparée avec chacun des quatre groupes trophiques identifiés. La figure 3 montre des évolutions synchrones entre la densité totale et celles des détritivores et des suspensivores et qui expliquent de façon prononcée la variabilité de l'abondance totale. L'évolution parallèle de l'effectif des détritivores et des suspensivores indique une faible interaction trophique entre ces deux groupes qui n'utilisent pas la même catégorie dimensionnelle, mais partagent les ressources trophiques (2). Les premiers sont macrophages, se nourrissent de débris végétaux et sont favorisés par l'existence continue d'un tapis végétal assez développé ; les seconds sont microphages et consomment la matière organique en suspension et le phytoplancton régulièrement apportés par la marée.

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N.B. : Travail réalisé dans le cadre du projet MECO du Programme INCO-DC

APPLICATION OF THE TROPHIC INDEX (TRIX) IN ITALIAN COASTAL WATERS : PRELIMINARY EVALUATION OF TROPHIC STATE AND ASSOCIATED COASTAL WATER QUALITY

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Abstract

The present work resulted from a 4-year (1997-2000) monitoring study of Italian coastal waters, aimed at the application of the Trophic Index TRIX for a preliminary evaluation of trophic status and associated surface water quality. The results showed a fairly high spatial variability in trophic status, with highly productive waters (>5 TRIX Units) in the NW Adriatic Sea and in some locations of the Central Tyrrhenian Sea, and low trophic levels (2 to 4 TRIX Units) in the Ionian Sea and in Sicilian coastal waters.

Keywords : Monitoring, coastal waters, eutrophication.

In order to obtain a better basis for the environmental planning and management of marine coastal systems by objectives, it is necessary to improve our knowledge of current status of coastal water quality. The application of synthetic indices is particularly useful when interpreting a large number of data collected over a multi-annual period on a variety of parameters, since it introduces objective criteria in making comparisons among different spatial and temporal situations and delivers simple and straightforward results to the end-users of research and monitoring activities, such as regional and local authorities.

Eutrophication and effects of persistent organic pollutants and metals are among the most serious threats to the coastal environment. The aim of the present study is to achieve a preliminary characterisation of the trophic status of Italian coastal waters, as a part of a multi-disciplinary work, which includes the evaluation of phytoplankton taxonomic composition and biomass, the physico-chemical characterization of sediments and the assessment of bioaccumulation levels and effects of contaminants on the biota. The classification of coastal waters and sediments will then allow a comprehensive assessment of the 'ecological status' of coastal systems, as required by the Italian current legislation (D.Lgs. 152/99) and by the recent EU Water Framework Directive.

The development and validation of the Trophic Index TRIX (1) resulted from a long-term study along the NW coast of the Adriatic basin, chronically subjected to eutrophication and eutrophication-related phenomena. The TRIX Index is composed of 4 commonly measured and ecologically relevant parameters and is defined by the following equation:

$TRIX = [Log_{10} (Chl \times D\%O \times TP \times DIN) + 1.5]/1.2$;

where Chl = chlorophyll 'a' ($\mu g.L^{-1}$); D%O = deviation, in absolute value, of dissolved O2 from 100% saturation; TP = Total Phosphorus ($\mu g.L^{-1}$); DIN = Dissolved Inorganic Nitrogen ($\mu g.L^{-1}$). The Index is scaled from 0 to 10 and is comprehensive of both the actual productivity indicator log10 (Chl x D%O), and the potential productivity indicator log_{10} (TP x DIN).

By the application of the TRIX Index it is possible to derive some general characteristics of trophic status and surface water quality of the investigated site, as reported in Table 1.

Table 1. Trophic scale and associated surface water

Trophic Scale	Status	Water quality
< 4	HIGH	Low trophic level Good water transparency Absence of water discolorations Absence of subsaturation of dissolved oxygen in bottom waters
4 - 5	GOOD	Average trophic level Occasional clouding of water Occasional water discolorations Occasional hypoxias in bottom waters
5 - 6	MEDIOCRE	High trophic level Low water transparency Water discolorations Hypoxias and occasional anoxias of bottom water States of suffering of benthic organisms
> 6	POOR	Very high trophic level High turbidity Widespread and persistent water discolorations Widespread and persistent hypoxias/anoxias of bottom waters Dying off of benthic organisms Alterations of benthic communities

We evaluated the trophic levels of the entire Italian coast, with the only exception of the Sardinia Island, during 6 oceanographic surveys conducted between October 1997 and June 2000. In agreement with the monitoring strategy of other survey programmes, carried out on a Regional basis with the support of the Italian Ministry of the Environment (2), the transects were located away from the mouths of major rivers, large cities, harbours, major capes and 'reference sites', where the anthropogenic impact is considered to be minimal. Two sites per transect were chosen: at 500 m and at 3000 m off the coast. For each sampling site, we performed nutrient analysis ($P\text{-}PO_4$, $N\text{-}NH_3$, $N\text{-}NO_2$, $N\text{-}NO_3$, TP, TN) and phytoplankton analysis (biomass and taxonomic composition) in surface waters, and CTD, dissolved oxygen and fluorescence measurements in the water column.

High TRIX values (i.e. high productivity and low trophic quality) are found in the NW Adriatic Sea and in some stations of the Central Tyrrhenian Sea, mainly in association with riverine nutrient inputs. Low to moderately-productive areas (i.e. with TRIX values <5) are generally located in the Ionian Sea, along the Island of Sicily, and in the Northern portion of the Tyrrhenian Sea. As expected, we found a general decrease in trophic levels during the Summer months compared to the Fall and Spring situation (not shown), because of lower nutrient concentration in the euphotic zone and reduced phytoplankton biomass. Nonetheless, 'poor' water quality is still found in some locations of the Northern Adriatic Sea (away from the mouths of the Po and Piave rivers, see stations 115 through 118 and station 122) and 'mediocre' water quality in some stations of the Central Tyrrhenian Sea (Genoa harbour, station 1; Tevere and Garigliano rivers, stations 17 and 21, respectively) (Figure 1).

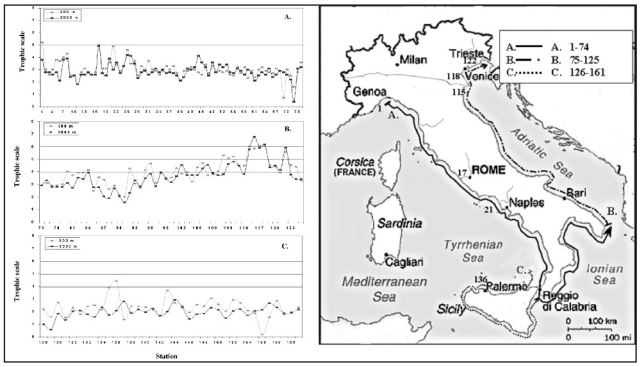

Figure 1. Trophic levels of Italian coastal waters on Summer. A. Tyrrhenian and Ionian Sea. July 1999. B. Adriatic Sea. July-August 1999. C. Sicilian coastal waters. August 2000. The numbers on the map refer to the stations in the graphs

In conclusion, the TRIX Index allows to identify coastal areas at 'eutrophic risk' or currently subjected to eutrophication, to follow their temporal evolution, and to perform a classification based on trophic characteristics. We consider such approach very informative for coastal zone management purposes, particularly for an effective planning of nutrient reduction programmes and for the assessment of the system response to remedial actions.

Aknowledgements

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ZOOBENTHOS OF THE PROBABLE DUMPING AREA IN IZMIR BAY (AEGEAN SEA)

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Abstract
The samples were collected at 18 stations in June 1992. A total of 74 species were recorded, of which *Pseudopolydora antennata* and *Aricidea mutabilis* were new to the Turkish fauna. The most dominant and frequent species in the area were *Sternaspis scutata*, *Turritella communis, Corbula gibba* and *Labidoplax digitata*. As a results it can be conclude that the study area possess typical muddy bottom fauna of the Mediterranean Sea.

Key-words: zoobenthos, monitoring, pollution, Aegean Sea, Eastern Mediterranean.

Introduction

Intense sedimentations occurred in Izmir harbour lessened water depth and resulted in hindering the ships to approach to the harbour. Because of the huge economical losses it occasionally become a requisite to deeper the approaching route of the ship by dredging.

The mud-dredging efforts were carried out near the harbour in the two periods; 1930-1976 (ca. 2.8 million m^3 of sediment off Göztepe-inner bay) and 1976-1988 (9 million m^3 of sediment off Hekim Ada-outer bay). Considering the unpredictable bad effects of the dumping efforts on the ecosystems it was planned to alter the dumping area. Finally the area in the northeast of Uzun Ada (outer bay) had been suggested for this purpose.

In the present paper it is intended to elucidate the status of the zoobenthic fauna in the probable dumping area to constitute a database for the monitoring program.

Material and methods

Benthic samples were taken by a Van Veen Grap in 18 stations in June 1992 (Fig 1). The samples were washed through sieve with 1 mm mesh size. The community indices were applied on the presence-absence and abundance data.

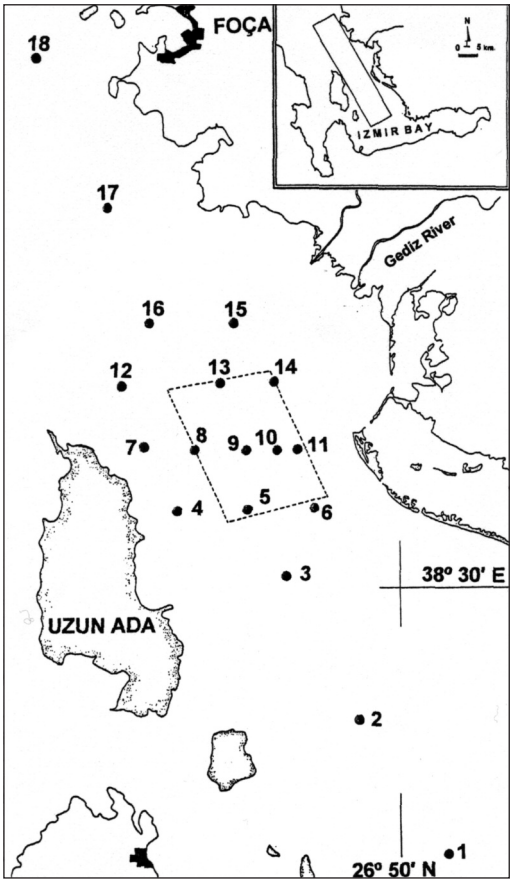

Fig 1. Map of the investigated area with location of sampling sites.

Results and discussion

A total of 74 species and 714 individuals belonging Nemertea, Sipuncula, Polychaeta, Crustacea, Phoronida, Mollusca and Echinodermata were determined, of which *Pseudopolydora antennata* and *Aricidea mutabilis* were new records for the Turkish fauna.

The most diversified group was Polychaeta with 43 species and 339 ind. (47.4%) followed by Crustacea with 13 species and 126 ind (17.7%) and Echinodermata with 8 species and 108 ind. (15.3%).

The most dominant species of the important groups and their relative dominance values are as follows; Polychaeta (*Sternaspis scutata*, 5.6%; *Terebellides stroemi*, 4%; *Prionospio fallax*, 2.9% and *Lumbrineris latreillii*, 2.7%); Crustacea (*Ampelisca sp*., 2.9%; *Apseudes latreillei*, 2.5%; *Microdeutopus sp*., 2.5% and A*thanas nitescens*, 1.6%); Mollusca (*Turritella communis*, 5.4%; *Corbula gibba*, 3.7% and *Clausinella fasciata*) and Echinodermata (*Labidoplax digitata*, 5.6%; *Amphiura filiformis*, 3.8%; *Trachythyone tergestina*, 1.9% and *Brissopsis lyrifer*a, 1.6%).

The community diversity (H') and evenness (J') indices in each site were very high (Table 1). The lowest H' value (3.66) was calculated in the station 2 where *S. scutata* was represented by high number of specimens. The species with *C. gibba* and Ia were preferential species of the sandy-mud substratum of Izmir Bay.

Table 1. Depths, community indices and dominant species of each sampling site.

Station	Depth	S	N	H'	J'	Dominant Species
1	48 m	27	38	4.62	0.97	*Terebellides stroemi* (5.3%)
2	52 m	16	27	3.66	0.91	*Sternaspis scutata* (25.9%)
3	48 m	21	30	4.25	0.97	*Turritella communis* (13.3%)
4	51 m	28	41	4.69	0.98	*Magelona papillicornis* (7.3%)
5	51 m	28	44	4.69	0.98	*S. scutata* (6.8%)
6	32 m	24	47	4.23	0.92	*Lumbrineris latreillii* (19.1%)
7	58 m	20	34	4.19	0.97	*Labidoplax digitata* (11.8%)
8	55 m	17	40	3.77	0.92	*Microdeutopus sp.* (17.5%)
9	45 m	24	44	4.32	0.94	*L. digitata* (%9.1)
10	35 m	26	39	4.61	0.98	*Phascolosoma sp.* (7.7%)
11	20 m	28	60	4.60	0.96	*L. latreillii* (8.3%)
12	59 m	29	47	4.64	0.95	*Clausinella fasciata* (8.5%)
13	45 m	17	31	3.95	0.97	*Microdeutopus sp.* (12.9%)
14	19 m	23	38	4.39	0.97	*Nephthys hombergi* (10.5%)
15	36 m	25	38	4.43	0.95	*Chaetozone sp.* (10.5%)
16	56 m	26	40	4.44	0.97	*Microdeutopus sp.* (12.5%)
17	52 m	22	42	4.21	0.94	*S. scutata* (11.9%)
18	50 m	24	34	4.50	0.98	*Aponuphis bilineata* (8.8%)

In the area 13 species were categorized as constant, 24 as common and 37 as rare. *S. scutata, T. communis, C. gibba* and *L. digitata* comprised the highest values with 100%. The finding of the constant species, *P. malmgreni* was noteworthy since it has widely been utilised as an indicator species of the organically polluted bottom. However in the sampling period it formed a scarce population as compared to that in the polluted waters.

The Cluster analysis depicted that the faunal affinities in the area were relatively high. The highest similarity was calculated between the stations 17 and 18 (67%) which were far from the probable dumping area. The stations such as 9, 10, 11, 14 and 15 which were under the influence of the Gediz River constituted a group of 45% similarity.

The former sludge dumping area was investigated by Kocatas *et al*. (1) who emphasized that the dumping activities caused less effects on the benthic biota with only one opportunistic species (*Audouinia tentaculata*). They also emphasized the dominance of *C. gibba* in the area. In this study solely *P. malmgreni* as being opportunistic species was found with low dominance but high frequency index values. The other species collected in the area are widely distributed in the undisturbed soft substratum of the Mediterranean Sea (2). In conclusion it could be pointed out that the probable dumping area was typical of sandy- mud biocenosis with a few opportunistic components.

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CARACTÉRISATION GÉOMORPHOLOGIQUE ET BIOCÉNOTIQUE DE LA ZONE PROTÉGÉE DE CAPO CACCIA - ÎLE PIANA (NO-SARDAIGNE)

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Résumé

La carte géomorphologique et biocénotique de la zone marine de Capo Caccia - Île Piana - Porto Conte, située au nord-est de la Sardaigne a été réalisée insérant aux formes géologiques des fonds marins, la distribution des plus importantes biocénoses et des espèces ayant une grande importance écologique telles que *Lithophyllum lichenoides* et *Posidonia oceanica*. Nombreux signes des chaluts dans l'herbier ont été documentés dans la baie de Porto Conte.

Mots-clés: Marine parks, sardinia, geomorphology, biodiversity, posidonia

Introduction

Dans le cadre du travail de définition de la zone marine de Capo Caccia - Île Piana - Porto Conte a été réalisée une carte physiographique et biocénotique des fonds marins. La zone d'étude se trouve entre Capo Galera et Puntetta della Ghisciera et elle comprend toute la baie de Porto Conte.

Matériel et méthodes

La carte a été réalisée grâce à des photos aériennes et à des prélèvements de campagne avec des plongées allant jusqu'à un maximum de 42 m de profondeur. On a également utilisé des images Side Scan Sonar (S.S.S.) provenant de 4 campagnes différentes (1988; 1997; deux, 1998). Les prélèvements biologiques effectués en 1997 et en 1998 ont été intégrées par des transects pourvus de caméra sous marine.

Résultats

Sur la base des données bathymétriques de 90 m sont présent des sédiments fins. Sur les roches carbonatiques ont été relevées des formations sub-verticales mesurant moins de 30 m qui ont été interprétées comme des paléo-falaises orientées N-S soulignant le contrôle tectonique de l'orogenèse alpine aux pieds des surfaces d'érosion au sommet où se trouvent des fractures, des diaclases et quelques plis; on trouve également de grands couloirs en pierre orientés E-O dont certains ressemblent aux canyons carsiques du littoral. Sur le fond, des plateformes d'abrasion en partie sous-jacentes sous des dépôts d'écroulement, marquent l'existence d'une paléo-ligne de rive à 120 m de profondeur. Vers le large, s'étendent des corps sédimentaires stratifiés avec des sables vaseux pouvant être interprétés comme des terrasses de dépôts submergés concernant le stationnement bas du stade 2 (1). A la phase de régression versilienne peuvent être attribuées des terrasses d'érosion en pierre présentes à des profondeurs moyennes de 30 m (aux pieds de la falaise de Punta Giglio et Capo Caccia).

Aux pieds de la falaise, à l'ouest de Capo Caccia (fig. 1) et au sud de Punta Giglio, le prélèvement a mis en évidence la présence de plusieurs ordres de terrasses en pierre, placées selon un système en escalier descendant vers le large, des accumulations de gros blocs de rochers (témoignage d'un recul dû à l'action abrasive du mouvement des vagues de la falaise active) et de petites zones d'herbier à *Posidonia oceanica*, parfois traversées par des sillons de sable. Les deux falaises sont intéressées par un grand nombre de cavités carsiques submergées et par de nombreuses fractures; pour certaines de ces dernières, il a été possible d'établir une corrélation avec d'importantes failles situées dans la partie continentale. La physiographie de la baie de Porto Conte possède un fond constitué par des sédiments appartenant au littoral ayant une granulométrie fine et par deux modestes corps de dépôts de graviers fluviaux; des plateformes d'abrasion marquant les sables éoliques du Pléistocène Supérieur affleurent parmi les dépôts du littoral. Les plaines sédimentaires extérieures sont caractérisées par des sédiments bioclastiques ayant différentes granulométries et concernant les différents milieux énergétiques.

Les peuplements benthiques qui s'installent sur les formes côtières peuvent être classés parmi les unités de peuplement suivantes: des sables du médio-littoral de mode battue et de mode calme, vaseux de mode calme, moyens bioclastiques de couloirs de l'inter-matte, des sables moyens intéressés par des courants de profondeur de l'infra-circalittoral, des sables fins, vaseux et des bioclastiques du circalittoral, du détritique côtier, des fonds coralligènes, des herbiers à *Posidonia oceanica* et *Caulerpa prolifera* sur sable, rochers et galets, des concrétions à *Lithophyllum lichenoides*. Ces dernières sont particulièrement développées sur les deux îles Piana et Foradada, où elles forment des trottoirs allant jusqu'à 2 m de largeur (2). *Posidonia oceanica* forme un herbier dont la limite inférieure se situe entre 20-25 m, ce qui constitue une bande à l'intérieur de la baie de Porto Conte et une présence irrégulière tout autour des îles Piana e Foradada et sur tout le versant oriental de la zone du parc. La limite supérieure est en nette érosion avec une bande qui s'étend sur 400 m à mattes mortes, témoignage du remarquable phénomène de recul (3). Le système des couloirs intra mattes montre parfaitement l'influence de l'hydrodynamisme. La limite inférieure est progressive et elle est précédée par des chaumes espacés à partir de 33 m de profondeur. Sur la zone intérieure de l'herbier ainsi que près des limites ont été documentés de graves dommages dus aux chaluts (fig. 2).

Parmi les formations intéressantes du point de vue naturel, à la base des falaises ainsi que dans certaines sèches, signalons le coralligène: celui-ci apparaît comme étant bien structuré, ayant des gorgonaires et d'autres animaux sessiles dans des peuplements bien développés.

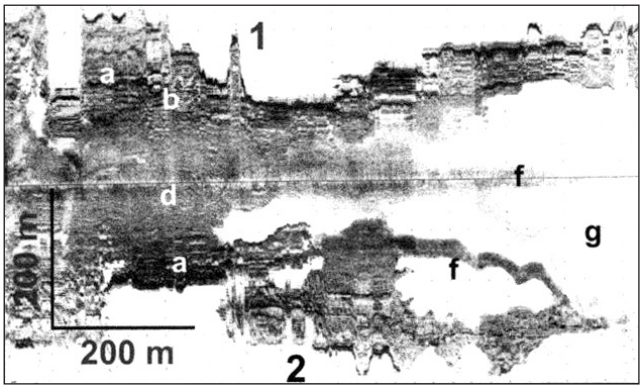

Fig. 1 : Tracé S.S.S. à 100 Khz entre l'Ile de Foradada (en bas) et Capo Caccia (en haut) *- a) pieds de la falaise, avec des biocénoses sciaphylles et du coralligène; b) blocs écroulés avec biocénoses des algues photophylles; d) herbier à* Posidonia oceanica *sur sable; f) fonds meubles à maerl; g) fonds meubles à sables bioclastiques.*

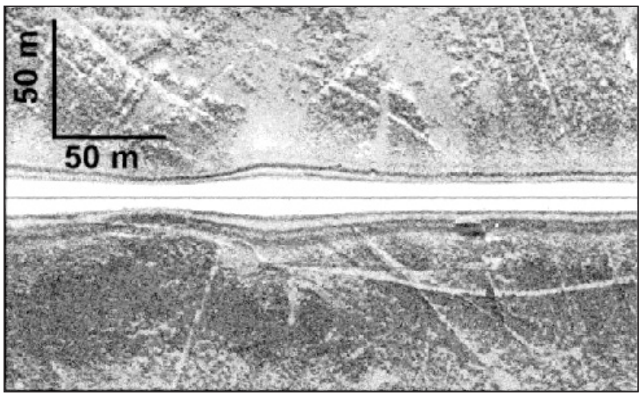

Fig. 2 : Tracé S.S.S. à 500 Khz dans la baie de Porto Conte; dans l'herbier à *Posidonia oceanica* sont évidents les nombreux sillons provoqués par la pêche à la traîne.

Particulièrement importants sont les peuplements des grottes semi-obscures, très nombreuses dans tout le périmètre des falaises, qui contiennent des biocénoses particulièrement diversifiées (4).

En conclusion, il est possible d'affirmer que ce travail permet de dresser un premier bilan géomorphologique ainsi que des principaux peuplements benthiques. Ces éléments, qui jouent un rôle important pour le milieu naturel, ont également un rôle primordial dans les relations entre la ressource représentée par l'environnement et l'utilisation de celle-ci. Ces connaissances seront utiles pour les activités de projet et d'aménagement concernant les futures activités du parc.

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VARIATIONS SPATIO-TEMPORELLES DU ZOOPLANCTON DE LA BAIE DE TUNIS COMPOSITION NUMERIQUE ET BIOMASSE

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Résumé

Deux années de monitoring du zooplancton de la baie de Tunis révèlent une composition taxonomique riche de 220 espèces et dominée au point de vue numérique par un microzooplancton à Tintinnides. La biomasse totale moyenne de près de 222,78 mg P.S. / m^3 caractérise un important macrozooplancton.

Mots clés : Zooplancton / Biomasse / Eaux côtières / Méditerranée Occidentale

Introduction

En Méditerranée, les études systématiques et numériques sur le zooplancton sont très nombreuses. Au niveau du littoral tunisien charnière entre le bassin occidental et oriental de la Méditerranée, le compartiment zooplanctonique a quant à lui été peu étudié. Avant les travaux de Daly Yahia [1, 2] seuls les travaux qualitatifs de Rose et Vaissière [3] sur les Copépodes, de Séguin [4] sur le zooplancton des côtes nord tunisiennes et ceux de Ktari-Chakroun [5, 6] sur les Cladocères et l'Ichtyoplancton du golfe de Tunis existent actuellement sur cette région de la Tunisie. Des groupes zoologiques ayant un rôle primordial dans la chaîne alimentaire marine comme les Tintinnides, les Copépodes, les Appendiculaires et les Méduses, n'ont jamais été étudié sur notre littoral d'une manière quantitative sur un cycle annuel.

Matériel et méthodes

Des prélèvements physico-chimiques et phytoplanctoniques [7] ont été réalisés au niveau de 17 stations à travers la Baie de Tunis au cours de la période de décembre 1993 à novembre 1995 (figure 1). Les pêches zooplanctoniques n'ont, quant à elles, été effectuées qu'au niveau des 14 stations dont la profondeur était supérieure à 2 m, à l'aide d'un filet Nansen à fermeture (55μm de vide de maille) et d'un filet Hensen – egg (300μm de vide de maille). L'étude du mésozooplancton et du macrozooplancton est réalisé sous loupe binoculaire à l'aide d'une cuve de Dollfus. Le microzooplancton, a été étudié selon la méthode de sédimentation d'Utermölh [8].

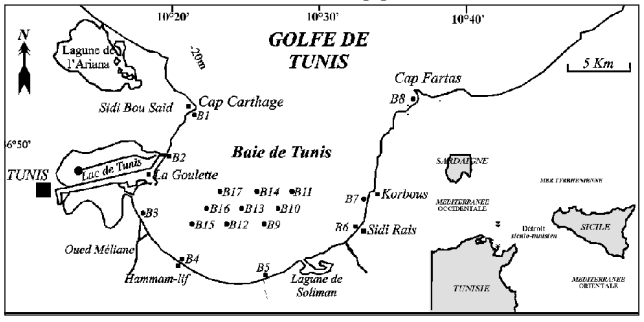

Figure 1. Situationgéographique et stations de prélèvements

La détermination de la biomasse a été réalisée en mesurant le poids sec du zooplancton séché à l'étuve à 70°C durant 24 à 48h [5] : une partie aliquote du trait de zooplancton a été fractionnée en classes de taille (55μm / 300μm ; 300μm / 500μm ; 500μm / 5000μm et > 5000μm).

Résultats et discussion

L'examen de l'ensemble des prélèvements réalisés nous a permis de caractériser faunistiquement la baie de Tunis en recensant 220 espèces zooplanctoniques. Parmi les groupes zooplanctoniques étudiés, ce sont les Tintinnides, les Copépodes et les Méduses qui présentent la plus importante richesse spécifique avec respectivement 62, 52 et 21 espèces. Les Rotifères (11 espèces), les Siphonophores (9), les Mysidacés (7), les Appendiculaires (7), les Foraminifères (6), les Chaetognathes (6), les Mollusques Pélagiques (6) et les Cladocères (6) présentent une richesse spécifique de moindre importance, tandis que des groupes comme les Ostracodes (5 espèces), les Amphipodes (5), les Radiolaires (3), les Isopodes (3), les Dolioles (3), les Annélides Polychètes Pélagiques (3), les Cumacés (2), les Acanthaires (1) les Héliozoaires (1) et les Salpes (1) sont mal représentés dans la Baie de Tunis. Du point de vue quantitatif, les fluctuations numériques du zooplancton ne s'accordent pas avec la biomasse totale surtout lorsque l'on considère d'une part les organismes microzooplanctoniques et d'autre part, l'apport de matière considérable qu'engendre la pénétration dans la Baie de Tunis d'espèces macrozooplanctoniques comme la Scyphoméduse *Pelagia noctiluca* et la Limnoméduse *Olindias phosphorica*. La figure 2 montre ainsi que la biomasse totale atteint des valeurs élevées en saison automnale et surtout hivernale, le poids sec total moyen atteignant 1274,56 mg P.S./m^3 en janvier 1994 avec de fortes valeurs ponctuelles au niveau des stations B9 (1640,15 mg P.S./m^3) et B15 (2084,28 mg P.S./m^3). Du point de vue numérique, le microzooplancton apparaît comme le constituant essentiel du zooplancton dans la baie de Tunis. Il représente toujours plus de 25% du zooplancton total atteignant au cours de certains mois automnaux et hivernaux plus de 80% du zooplancton. Le mésozooplancton rarement dominant en densité représente avec le macrozooplancton l'essentiel de la biomasse en poids sec.

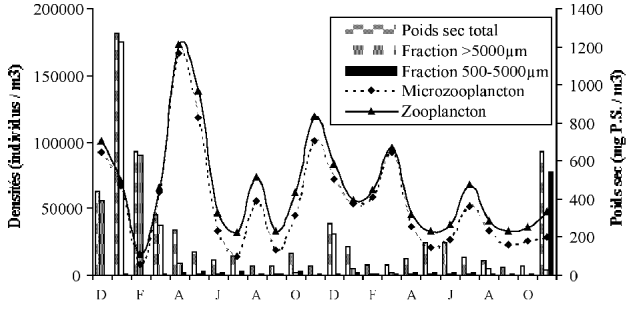

Figure 2. Variations mensuelles moyennes dela densité (individus/m^3) et de la biomasse totale (mg de P.S./m^3) du zooplancton dans la Baie de Tunis au cours du cycle de l'étude

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LES DINOFLAGELLES DE LA BAIE DE TUNIS. COMPOSITION SPECIFIQUE ET NUMERIQUE

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Résumé

Durant deux années (décembre 1993 – novembre 1995), des prélèvements d'eau collectés mensuellement, au niveau de 17 stations de la baie de Tunis, nous ont permis de dresser l'inventaire des dinoflagellés ainsi que de suivre leur évolution. Sur les 158 taxons identifiés au sein des eaux de la baie, seuls *Scrippsiella spp* et *Peridinium quinquecorne* ont joué un rôle prépondérant dans la dynamique quantitative des dinoflagellés. Par ailleurs, nous avons recensé parmi ce groupe 9 espèces susceptibles d'être nuisibles à l'homme.

Mots clés : Dinoflagellés / Systématique / Eaux côtières / Méditerranée Occidentale

Introduction

Les côtes tunisiennes, malgré leur situation géographique, transitoire entre le bassin occidental et oriental, n'ont fait l'objet jusqu'à présent que de rares études portant sur les organismes phytoplanctoniques. Ces dernières années, nous avons observés un accroissement du nombre de proliférations algales, causées par des dinoflagellés, le long des côtes tunisiennes [1]. Par ailleurs, la baie de Tunis comme de nombreux autres écosystèmes méditerranéens, subit depuis une cinquantaine d'années une forte pression anthropique, essentiellement dans sa région ouest et sud. C'est ainsi que nous présenterons dans ce travail une approche de la dynamique temporelle des dinoflagellés la baie de Tunis en mettant l'accent sur les espèces potentiellement nuisibles.

Matériel et méthodes

Des prélèvements hydrologiques mensuels, réalisés entre décembre 1993 et novembre 1995 au niveau de 17 stations de la baie de Tunis (10°17' et 11°37'de longitude Est ; 36°42' et 36°53' de latitude Nord), ont permis d'étudier 12 paramètres physico-chimiques ainsi que la structure du peuplement phytoplanctonique [2]. Les prélèvements d'eau, effectués à l'aide d'une bouteille type Ruttner de deux litres, ont été fixés au formol neutralisé (2%) et au Lugol (0,5%). L'examen microscopique a été réalisé par la méthode Utermöhl (microscope inversé Leitz) à l'aide de cuves à sédimentation de 25 ml [3].

Résultats et discussion

L'inventaire des espèces de dinoflagellés, reconnus dans le plancton de la baie de Tunis, comprend 158 taxons pour 30 genres. Les espèces du genre *Ceratium* Schrank sont de loin les plus nombreuses avec 52 taxons. D'autres genres sont représentés mais avec beaucoup moins d'importance spécifique : *Protoperidinium* Bergh (17 espèces), *Prorocentrum* Ehrenberg (11), *Oxytoxum* Stein (11), *Alexandrium* Halim (10) [4] et *Phalocrama* Jörgensen (6).

Parmi les 5000 espèces phytoplanctoniques marines, quelques 300 espèces peuvent proliférer et entraîner une décoloration de la surface de l'eau. Une quarantaine d'autres espèces ont la capacité de produire des toxines qui peuvent atteindre l'homme à travers la chaîne alimentaire [5 , 6 , 7]. Au niveau de la baie de Tunis, nous avons recensé 9 espèces de dinoflagellés susceptibles d'être toxiques : *Alexandrium minutum* Halim, A. cf. *tamarense* (Lebour) Balech, *Dinophysis* cf. *acuminata* Claparède et Lachmann, D. cf. *sacculus* Stein; *D. caudata* Saville-Kent, *D. tripos* Gourret, *Prorocentrum lima* (Ehrenberg) Dodge, *P. mexicanum* Tafall, *P. minimum* (Pavillard) Schiller.

Sur le plan quantitatif, les dinoflagellés sont faiblement représentés dans le milieu avec une densité moyenne respective de 1925 cellules/l et de 2649 cellules/l au cours de la première (décembre 1993-novembre 1994) et de la deuxième année d'étude (décembre 1994-novembre 1995). L'évolution mensuelle des dinoflagellés de la baie de Tunis a présenté un cycle annuel caractérisé par une poussée principale printanière et une efflorescence secondaire estivale (Figure 1) accompagné d'une importante hétérogénéité spatiale.

La dynamique quantitative des dinoflagellés totaux a été régie par les deux espèces de Scrippsiella Balech ex Loebich III et par Peridinium quinquecorne Abé dont la dominance relative a atteint respectivement 30,35% et 22,64%. Viennent ensuite, par ordre d'importance Gymnodinium spp Stein (9,19%), Prorocentrum micans Ehrenberg (8,75%) et P. triestinum Schiller (7,25%). Quant aux espèces susceptibles d'être nuisibles à l'homme, elles représentent de faibles densités au niveau de la baie (Tableau 1).

Cette étude, nous a permis de mettre en évidence, au niveau de la baie de Tunis, que le peuplement de dinoflagellés est régi par des taxons dont la plupart ont été incriminés, à l'échelle mondiale, lors d'apparitions d'eaux colorées, d'intoxications humaines ou de mortalités de poissons.

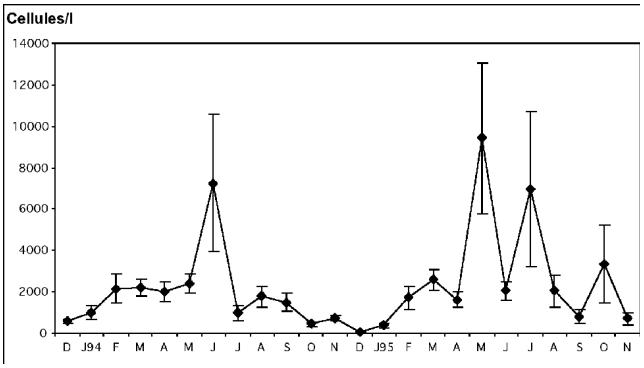

Figure 1 : Evolution mensuelle de la densité totale des dinoflagellés (Barre d'erreur = Erreur standard)

Tableau 1 : Densités moyennes des différentes espèces toxiques

	1ère année d'étude (déc. 93 - nov. 94)	2ème année d'étude (déc. 94 - nov. 95)	Densité mensuelle maximale
Alexandrium spp	79 (Cellules/l)	41 (Cellules/l)	295 (Cellules/l)
Dinophysis cf. *acuminata*	4	2	28
D. cf. *sacculus*	<1	<1	3
D. caudata	1	1	6
Prorocentrum lima	2	4	15
P. mexicanum	2	3	17
P. minimum	5	21	173

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FIRST DATA ABOUT ZOOPLANKTON IN S. STEFANO ROADSTEAD (LA MADDALENA'S ARCHIPELAGO)

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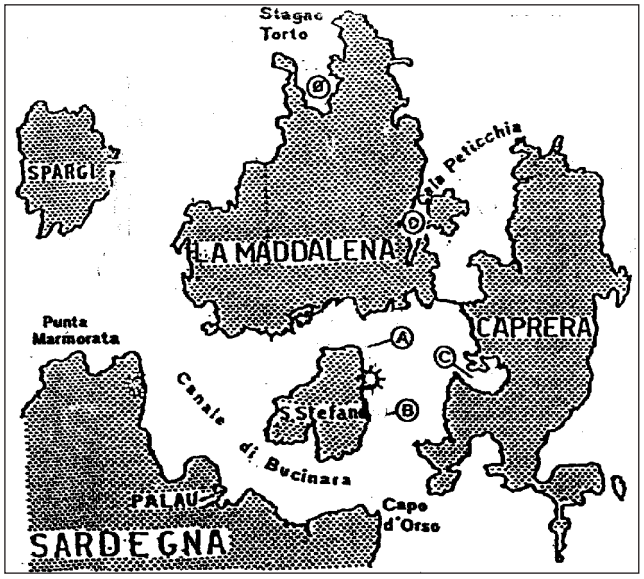
Summary
This work is related to the result archieved from the sampling of the zooplankton in La Maddalena's Archipelago; besides, it has been verified possible presences of radioactivity.

Key-words: Plankton, coastal water, radioactivity.

Since 1972, when a USA support naval base for nuclear submarines settled down in S. Stefano roadstead, many problems arose in order to protect people and environment. Monthly researches have been carried out in order to study the environing characteristic and the zooplankton in collaboration with La Maddalena Italian Navy Nucleo SDAI and the Sassari Ambient Physics Laboratory (1995-96). In this case of need 4 stations (0, A, B, C) have been set besides the radioactivity testing on the plankton patterns (1,2). (Fig.1).



In each station water samples have been draw on the surface and below as well; basic mesologic characteristics have been mesured. Also a double vertical netful has been done for gathering the zooplankton by using a 200 μm mesh net. The first one has been filtered using filters paper of cellulose acetate with porosity of 0.45 μm in order to get a spectrometric g analysis with a germanium detector in a 30000 sec analysis time.; the other one has been used for studying zoocoenosis.

No remarkable temperature change has been noticed between the surface and the seabed. The highest temperature has been registered in august with 28°, the lowest has been tested in december with 12°.The maximum oxygen concentration has been found out in june (116% saturation point); the minimum one in december (81%). The pH kept within sea water bounds with a change between 7.56 and 8.25.

The following taxa have been found:

Foraminifera: (*Textularia agglutinans* Orb., *Tretomphalus bulloides* (d'Orbs.); Radiolaria: (*Heliosoma echinaster* Haeck); Tintinnidae: (*Codonella aspera* (Fol.), *Poroecus apiculatus* (Cl.), *Favella serrata* (Mob.), *Xystonella lohmanni* Brandt; Anthomedusae: (*Eucodonium brownei* Hartlaub); Siphonophora: (*Sulculeolaria quadrivalvis* Blainville); Gastropoda: (larvae n.d.); Bivalvia: (larvae n.d.); Polychaeta: (*Sabellaria sp* (larvae), *Sabellaria alveolata* (larvae); Cladocera: (*Evadne spinifera* Mull.); Copepoda: (*Euterpina acutifrons* Claus, *Microsetella norvegica* Boeck, *Clausocalanus avenicornus* Dana, *Acarta clausi* Giesbrecht, *Centropages typicus* Kröyer, *Oithona nana* Giesbrecht); Ostracoda: (*Cypridina mediterranea* Costa); Cirripedia: (nauplius); Echinoidea: (*Echinocyamus pusillus* (O.F. Muller) (larvae); Ophiuridea: (*Ophiothrix fragilis* (Abild.); Appendicularia: (*Oikopleura dioica* Fol.); Salpida: n.d.

In station 0 has been registered the lowest number of taxa; station C is the one with the highest number. Copepoda, Cirripedia, Gastropoda, Bivalvia, Appendicularia and Foraminifera are the most recurrent. Their highest density has been registered respectively in A, B and C stations; station 0 has showed the lowest level.

Considering the spectrometric g tests about environing radioactivity (Tab. 1) registered on the plankton provided by Sassari USL office N°1 it has been remarked that radioactivity level is below the ambient average allowed registered in 1984 (3, 4).

According to the ecological data we can say that the environment is quite integral as the communities variety shows.

Tab.1 – Spectrometric g-tests on the plankton. The symbol < mean that the value noticed is lower than minimum value to reference.

Act-s (Bq/l)	Stat. A	Stat. B	Stat. C	Stat. 0
Ac-228	< 0,21762	< 0,16080	< 0,19429	< 0,21306
Be-7	< 15,794	< 12,360	< 12,903	< 16,916
Bi-214	< 0,12106	< 0,11083	< 0,10910	< 0,12905
Ce-141	< 16,632	< 16,151	< 18,140	< 19,840
Ce-144	< 0,26123	< 0,21747	< 0,28470	< 0,33434
Co-60	< 3,99883E-02	< 3,63638E-02	< 4,04547E-02	< 5,40287E-02
Cs-134	< 4,98928E-02	< 4,68360E-02	< 4,46057E-02	< 6,39316E-02
Cs-137	< 3,91346E-02	< 3,02048E-02	< 4,00206E-02	< 4,84988E-02
K-40	< 1,7899	< 1,6580	< 1,4847	< 2,1033
Mn-54	< 6,90693E-02	< 5,68262E-02	< 6,84941E-02	< 9,60961E-02
Pb-212	< 9,67370E-02	< 8,42424E-02	< 9,37124E-02	< 0,11513
Pb-214	< 8,38144E02	< 8,32805E-02	< 8,58532E-02	< 8,73801E-02
Ra-226	< 0,79838	< 0,71384	< 0,86072	< 0,91582
Ru-103	< 5,5835	< 5,1639	< 6,8782	< 7,5356
Th-232	< 22,783	< 17,980	< 20,626	< 24,593
Th-234	< 3901,7	< 3562,5	< 4200,4	< 4433,2
Tl-208	< 7,33299E-02	< 6,81128E-02	< 7,79036E-02	< 7,75862E-02
Zr-95	< 1,1085	< 1,3218	< 1,6302	< 1,7609

Acknowledgments. A special thanks to *Marisardegna* and the Nucleo SDAI for authorising the use of their crafts and also to the Sassari USL N°1 for suppling all the rateometric data needed.

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THE NATIONAL COASTAL PLAN: FIRST BIOSEDIMENTOLOGICAL RESULTS IN A TEST AREA IN THE LIGURIAN SEA (NW ITALY)

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Abstract

Within the context of the Italian Coastal Plan, bio-sedimentological aspects have been studied in a coastal area with relevant erosion problems. Sediments, *Cymodocea nodosa* meadows and *Sabellaria alveolata* reefs have been sampled and analysed, in order to study the two organisms and their interactions with shorelines evolution. The final aim is to find out possible bio-sedimentological indicators, which could be useful in the understanding of coastal dynamics and marine ecosystems, therefore giving guidelines in coastal management.

Key-words: coastal management, bio-indicators, erosion, geomorphology, shoreline evolution

Introduction

The Marine Environment Research Centre ENEA S.Teresa and the Italian Ministry of Environment are working on a 3-year project for a National Coastal Plan, with the leading idea of the sustainable use of coastal resources, in order to give guidelines on integrated coastal management.

On a local scale, a test area has been chosen in the NW Mediterranean (Eastern Ligurian Sea, Tigullio Gulf) for its relevant ecological value (being partially a Marine Protected Area), strictly close to an area greatly affected by tourism, where two marinas (Chiavari and Lavagna) have been built (Figure 1). The coasts here are scarcely nourished by natural sediment sources and have been protected with hard coastal defence structures.

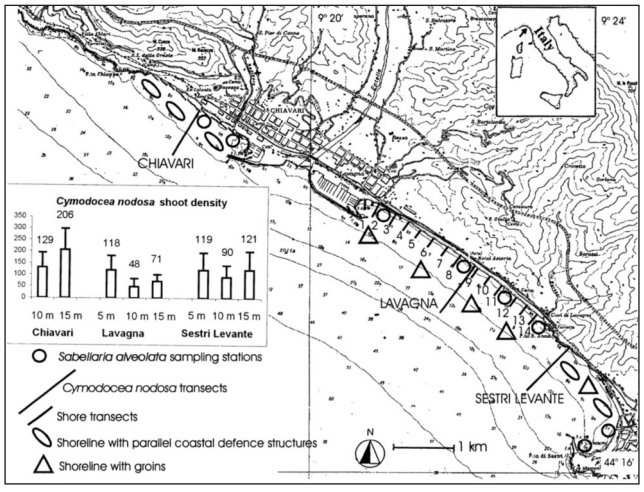

Figure 1. Map of Tigullio Gulf (Ligurian Sea, NW Italy), showing the study area, sampling stations and transects

The aim of the work is to study bio-sedimentological aspects through two organisms that together are thought to be good indicators of the health of a coastal area with high environmental values and at the same time with crucial problems of erosion (1).

Cymodocea nodosa and *Sabellaria alveolata,* respectively a seagrass and a polychete annelid, are both extremely important indexes to the status of marine coastal ecosystems. *Sabellaria alveolata* forms biogenic reefs between 2 and 7 m depth on low-standing rocks (2, 3), while *Cymodocea nodosa* mainly colonises the seafloor from 5 to 15 m depth on sand (4, 5). The organisms' responses to sediment characteristics and shoreline evolution are the basis of the present research.

Methods

The following activities and analyses were carried out within summer 2000:

➢ Sea-bottom sediment samples and phenological parameters (cover, leaf length and width, leaf area index, percentages of broken and dead leaves, coefficient A) of *Cymodocea nodosa* meadows were determined along three transects (Chiavari, Lavagna and Sestri Levante) at 5, 10 and 15 m depth;

➢ Samples of *Sabellaria alveolata* reefs and sea-bottom sediment samples below them (around 3.5 m) were studied through granulometric, mineralogical and calcymetric analyses;

➢ Geomorpho-sedimentological surveys on shorelines (14 transects) were focused in the area from Lavagna's harbour to Sestri Levante.

Results and conclusions

Data and results from shoreline surveys have pointed out how hard coastal defence structures, especially groins, have greatly changed the natural coastal dynamics. The most critical shores to the erosion phenomena have been localised (transects number 4, 5, 6) and measured (only 10-15 m long while the adjacent beaches are around 30 m long). The main causes for this situation are thought to be the seawall that keeps the railway line (running along the beaches) safe from sea storms, but induces a high wave reflection process. The area orientation, down-drift Lavagna harbour, makes it extremely opened and sensible to both SE and SW seas (6).

The critical aspect of Lavagna's area given out from shoreline evolution surveys has been confirmed by the biological results from *Cymodocea nodosa* transect. Despite the homogeneity of sediment distribution (very fine to fine sand) within *Cymodocea nodosa* meadows, the seagrasses along Lavagna transect are characterised by the lowest values of shoot density (see histograms on Figure 1) and cover. In that area, the "Coefficient A", which gives an estimation of percentages of broken leaves mainly caused by water movement, has the highest values. Together with the hard coastal defence structures, the strong hydrodynamics seems to be one of the most stressful factor acting on Lavagna area.

Sabellaria alveolata reefs are made by organically cemented sand-tubes, inhabited by the worm itself.

This polychete makes a selection among sediments with different grain sizes, generally using coarse sand with mean size between 2 and 4 mm. On the contrary, no relevant differences have been found in mineralogical compositions between the substratum and the sediment used for tube construction.

Sabellaria alveolata has not been found on the western side of the area (Chiavari), where few coastal defence structures are positioned parallel to the shore, making the seawater stagnant behind them even with a rough sea. Largest reefs are built in areas subjected to strong hydrodynamics, suggesting that *Sabellaria alveolata* may take advantage from the highest re-suspension of sediments.

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COMPOSITION ET STRUCTURE DES COMMUNAUTÉS PHYTOPLANCTONIQUES DE LA LAGUNE DE NADOR (MAROC)

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Résumé

Les prélèvements bimensuels du phytoplancton ont été effectués au niveau de huit stations durant la période 1996/97. Le nombre d'espèces s'élève à 267 dans l'ensemble de la lagune, avec une répartition spatiale hétérogène, en grande partie reliée aux différents paramètres physico-chimiques et hydrologiques du milieu. Ces paramètres sont à la base d'une mixture d'espèces franchement marines et d'espèces inféodées aux milieux saumâtres.

Mots clefs : Composition, Structure, Phytoplancton, Lagune de Nador, Maroc.

La lagune de Nador a une grande importance sur le plan socio-économique (aquaculture et pêche) et sur le plan écologique en abritant une flore et une faune complexes et diversifiées. Le bassin lagunaire est fortement perturbé par les activités anthropiques et par la fermeture de la passe. Devant cette situation, de nombreux travaux ont été entrepris pour comprendre l'organisation, le fonctionnement et l'évolution de la lagune (1, 2, 3, 4). La présente étude a pour objectif l'identification des peuplements phytoplanctoniques ainsi que leur structure spatio-temporelle. La lagune, située sur le littoral nord-est marocain entre le cap des Trois Fourches et le Cap de l'Eau (2°45'N- 2°55'W ; 35°10'N),a une superficie de 115 km^2 (fig. 1). Elle est accidentée sur sa bordure occidentale par le promontoire d'Atalaâyoune qui la divise en deux sous-ensembles. La profondeur augmente rapidement à partir des rives pour se stabiliser dans la partie centrale entre 6 et 7 m. La lagune communique avec la Méditerranée par la passe Boukhana. A partir de 1987, un colmatage sédimentaire progressif a réduit sérieusement les échanges entre la lagune et la mer et a abouti à une fermeture en 1993. Cette situation a engendré des conséquences néfastes sur la lagune tant biologiques, hydro-chimiques que sédimentaires.

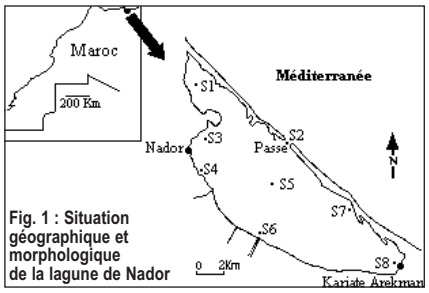

Fig. 1 : Situation géographique et morphologique de la lagune de Nador

Matériel et méthodes

Le choix a porté sur 8 stations (Fig. 1) réparties sur l'ensemble de la lagune. L'échantillonnage a été effectué par un filet à plancton de type standard traîné horizontalement pendant deux minutes. L'échantillon recueilli au niveau du collecteur est fixé au formol (5 %) neutralisé.

Résultats

La lagune de Nador présente une richesse taxonomique composée de plus de 260 espèces appartenant essentiellement aux Dinoflagellés et aux Diatomées (5). Cette richesse oscille entre 3 et 85 espèces selon les stations et les périodes d'échantillonnage. Le nombre d'espèces des Diatomées (fig. 2) est toujours supérieur à celui des Dinoflagellés au niveau de toutes les stations. L'ensemble du peuplement est caractéristique des bassins paraliques légèrement confinés. Ceci est justifié par la rareté des Cyanophycées planctoniques (6). Cependant, la présence des espèces benthiques et des espèces pélagiques témoigne d'un brassage de la colonne d'eau avec remise en suspension à partir du fond (7). La répartition spatiale des espèces représente une certaine zonation. Les Dinoflagellés (*Ceratium furca, Ceratium fusus, Prorocentrum micans, Gymnodinium splendens* et *Protoperidinium oblongum*) sont présents dans l'ensemble de la lagune. Les Diatomées centriques (*Chaetoceros sp, Rhizosolenia sp, Hemiaulus haukii, leptocylindrus danicus* et *Guinardia flaxida*) se développent essentiellement dans la partie centrale, la zone de la passe et la zone d'Atalaâyoune. La richesse spécifique (Fig. 3) diminue nettement de la passe vers les zones périphériques, surtout en direction de l'extrémité Sud-Est et la rive continentale. Cette diminution est plus brutale et plus prononcée dans le bassin Sud (de 217 à 72 espèces) que dans le bassin Nord (de 217 à 166 espèces). On remarque également que la diminution du nombre d'espèces au niveau de la zone A (Fig. 3) suit rigoureusement le trajet des courants à partir de la passe, c'est-à-dire le gradient de confinement. La même constatation a été faite chez la macrofaune benthique (1). Le peuplement phyto-planctonique présente une variation temporelle de la richesse spécifique qui se caractérise par la dominance des Dinoflagellés durant la période novembre-juin. Cette configuration du peuplement s'inverse en été avec dominance des Diatomées.

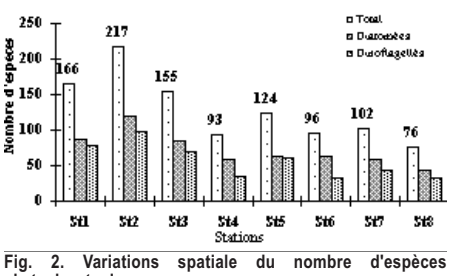

Fig. 2. Variations spatiale du nombre d'espèces phytoplanctoniques

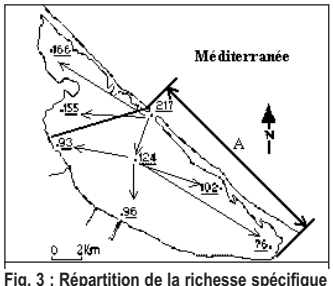

Fig. 3 : Répartition de la richesse spécifique au niveau de la lagune de Nador

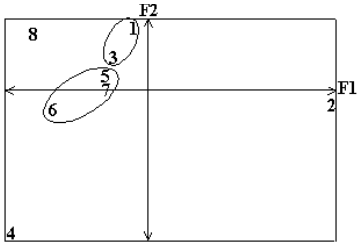

Fig.4. carte de dispersion constitué par le plan factoriel F1xF2

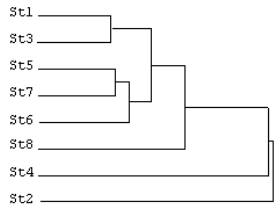

Fig. 5. Dendogramme regroupant les stations en fonction de leurs affinités.

L'analyse de la carte de dispersion des espèces phytoplanctoniques (Fig. 4) dans les stations étudiées, selon le plan factoriel formé par les axes F1 et F2 permet de dégager les constatations suivantes :* L'axe F1 (26.38 %) permet de distinguer deux types de milieux selon un gradient de continentalité : le milieu lagunaire et le milieu marin.* L'axe F2 (16.88 %) trace un gradient net de la biodiversité dans l'ordre suivant des stations: 4, 6, 7, 5, 3 et 1.

Le dendogramme relatif aux stations (Fig. 5) montre cinq types de milieux :

Groupe I: regroupe deux stations (S1 et S3) qui se caractérisent par des espèces des milieux côtiers notamment *Dokinia lata, Hanzschia amphioxys*, etc.

Groupe II: regroupe trois stations (S5, S6 et S7) qui se caractérisent par des espèces des milieux côtiers et estuairiens telles que *Scenedesmus falcatus, S. rastro-spinosus, Biddulphia aurita,, Melosira nummuloides, Alexandrium ostenfeldeii, Ceratium hexacantum, C. longirostrum, Protoperidinium tuba...* etc.

Groupe III: constitué par une seule station (S8) qui se distingue par sa faible richesse spécifique et par l'absence des efflorescences micro-algales.

Groupe IV: constitué par une seule station (S4) qui se caractérise par *Nitzschia claussii, Trigonium sp2, Gonyaulax sp1* et *Protoperidinium quinquicorne*.

Groupe V: constitué par une seule station (S2) qui se caractérise par des Diatomées Centriques et des Dinoflagellés dont la présence est sporadique telles que *Bacteriastrum elangatum, Bellerochea malleus, Biddulphia pulchella*, etc.

Conclusion et discussions

En général, le peuplement phytoplancto-nique de la lagune de Nador se caractérise par l'absence des espèces typiquement et exclusivement saumâtres, tandis que dominent les taxons qui sont capables de supporter les variations considérables des facteurs ambiants. La variation spatiale de la richesse spécifique s'établit selon un gradient décroissant de la passe vers la périphérie de la lagune, c'est-à-dire en fonction du degré de confinement. En effet, plus on s'éloigne de la passe, le nombre d'espèces ainsi que la production phytoplanctonique diminuent. Cette diminution s'explique par la frappe paralique qui affecte les espèces thalassiques brutalement importées dans le bassin lagunaire à marée haute.

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PARTICULARITÉ ÉCOLOGIQUE ET NIVEAU DE PRODUCTION D'UNE LAGUNE TUNISIENNE : LE LAC ICHKEUL

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Résumé

Le lac Ichkeul fait partie d'un Parc National situé entre une chaîne de montagne et la méditerranée. Il est ainsi alimenté en eau douce en période pluvieuse alors qu'en été, il reçoit les eaux marines. Cette alternance saisonnière le soumet à une succession de séquences écologiques antagonistes : phase oligohaline et phase eury à hyperhaline. Elle lui confère ainsi une originalité écologique. Le lac est fréquenté par une avifaune importante et une ichthyofaune diversifiée d'origine marine et potamique. Cependant, la production annuelle ichthyque (1987-1998) accuse une baisse qui pourrait être attribuée à l'action des facteurs saisonniers du milieu, essentiellement par les aménagements hydrauliques : les barrages édifiés sur les oueds en amont et l'écluse sur l'oued Tinja en aval, et par la surexploitation des ressources.

Mots clés : Ecosystem, Lagoon, Fisheries, Eastern Mediterranean

Le lac Ichkeul, lagune la plus septentrionale de la Tunisie, couvre en moyenne 8500ha. Ce lac fait partie du Parc National de l'Ichkeul. Cet écosystème couvre une superficie de 12600ha. Il est situé entre 37°10'N et 9°40'E. En fait, la partie sud du lac, entourée par des marais et d'un jebel, reçoit dans sa partie amont les eaux douces de six oueds. Le lac Ichkeul communique avec le lac de Bizerte par l'intermédiaire d'un canal sinueux, l'oued Tinja. Il est ainsi classé dans la catégorie des lagunes de deuxième ligne (Fig.1).

Fig.1- Localisation du lac Ichkeul (— oued, ▬ ▬ ▬ marais) échelle : 1/200000

Les particularités les plus importantes de cet écosystème sont i : apport en eau douce par les oueds, ii : exploitation halieutique au niveau du lac, iii : présence d'une écluse à la partie amont de l'oued Tinja, vi : milieu recherché par le peuplement d'oiseaux aquatiques phytophages. Cette situation justifie son classement au niveau du Patrimoine Mondial de la Nature. Les douze dernières années ont été marquées par trois périodes de sécheresse. La position duLac Ichkeul aux confins de deux aires continentales et marines le soumet à une succession de séquences écologiques antagonistes se décomposant en phase "lac-oued" oligohaline en saison pluvieuse et phase "lagune" euryhaline en saison sèche. Ce qui se traduit par des écarts de température (5-32°C), de salinité (5-45g/l), de teneurs élevés en oxygène (3-10mg/l) et de variations importantes de sels nutritifs (Nitrates : 1-2,44mg/l, Phosphate total : 0.008- 9.67mg/l). Ces facteurs limitants ainsi que la faible profondeur du lac (2m) restreignent le peuplement floristique et faunistique aux espèces les plus tolérantes de l'étage infralittoral supérieur (1).

Flore. Le phytoplancton est représenté par des Diatomées centriques et de chlorophycées. Le Phytobenthos est représenté par *Pomatogeton pectinatus* et de Zoostères.Zoobenthos: les Bivalves (*Ceratoderma glaucum et Arba tenuis*) et les Polychètes(*Nereis diversicolor*) sont les plus dominants.

Faune ornithologique. L'herbier de Pomatogeton fait du lac, en saison pluvieuse, un refuge d'hivernage pour un grand nombre d'oiseaux aquatiques migrateurs phytophages (évalué à 187732 individus) appartenant à 42 espèces (2). Les espèces les mieux représentées sont le Canard siffleur(*Anas penelope*), le moulin (*Aythyra ferina*), la foulque macroule (*Fulica atra*) et l'oie cendrée (*Anser anser*).

Faune ichthyque. 22 familles ichthyques ont été signalées dans le lac Ichkeul. Elles sont d'origine marine et continentale; on peut les classer en trois groupes : les premiers migrateurs marins sont fortement eurythermes et euryhalines, appartenant essentiellement aux familles des Mugilidés (*Mugil cephalus* et *Liza ramada*), des Anguillidés, des Clupeidés et des Moronidés. Le deuxième groupe est caractérisé par des espèces d'eau douce (*Barbus callensis, Gambusia affinis* et *Pseudophoxinus callinsis*); le troisième groupe est représentés par des espèces sédentaires saumâtres *(Atherina boyeri, Hyporamphus picari, Belone belone*). Malgré les contraintes qui pèsent sur l'écosystème de l'Ichkeul, les poissons semblent évoluer dans un espace productif. En effet, la condition des espèces marines et potamiques observées dans le lac Ichkeul et ailleurs le confirme (tableau 1).

Tableau 1 – Comparaison du poids des poissons dans le lac Ichkeul et les autres milieux aquatiques

Espece	Taille totale (cm)	Poids (g) dans le lac	Poids (g) dans d'autres milieux
Dicentrarchus labrax	30	604	486 (golfe de Tunis) (3)
Solea aegyptiaca	20	80	65.5 (côte Sud de Tunisie) (4)
Barbus callensis	20	99	77 (oued Sejnane) (5)
Mugil cephalus	30	403	387 (golfe de Tunis) (6)
Liza ramada	28	256	233 (golfe de Tunis) (6)

Au niveau de cet écosystème, l'exploitation halieutique est assurée par l'utilisation de trois types d'engins : les bordigues, installées en travers de l'oued Tinja, permettent la capture des Mugilidés; les capétchades, installées dans divers points du lac, sont destinées à la capture des anguilles. Les filets trémails sont utilisés à l'intérieur du lac. Le suivi de la production sur une période de douze ans (1987-1990) montre que les moyennes calculées toutes les quatre ans (tableau 2) au niveau de la bordigue et à l'intérieur du lac ont subi une baisse de 22% durant les années 1991-1994 par rapport à la période 1987-1990. Cette situation s'est maintenue à un niveau moyen de 94 tonnes/an. Par contre, la production de l'anguille n'a cessé de diminuer au cours de cette même période; de 1991 à 1994, la production moyenne annuelle a baissé de 40,85% par rapport à la période précédente (1987-1990). De même pour la période 1995-1998, la baisse de la production moyenne annuelle a atteint 63,8% par rapport à celle 1991-1994. La tendance à la baisse de la moyenne de la production totale (32% et 28.7%) pourrait être expliquée par des changements environnementaux au niveau de l'écosystème, dus aussi bien aux variations climatiques qu'aux actions anthropologiques et par la surexploitation de l'anguille ainsi que les faibles recrutements ces dernières années.

Tableau 1 – Comparaison du poids des poissons dans le lac Ichkeul et les autres milieux aquatiques

Année	Production annuelle Poissons Par an et moyenne par 4 ans (Bordigue)		Filet	Production totale poisson Par an et moyenne par 4 ans		Production annuelle anguille par an et moyenne par 4 ans capétchades)		Production moyenne totale Par an et moyenne par 4 ans	
1987	68		52	120		72		192	
1988	95	95	33	128	121.75	91	128.5	219	250.8
1989	126		23	146		185		334	
1990	91		2	93		165		258	
1991	94		2	96		52		147	
1992	71	86.75	1	72	95	86	76	158	170.8
1993	76		0.5	76.5		75		151.5	
1994	106		29	135		91		226	
1995	55		60	115		25		140	
1996	35	59.5	53	88	94	24	27.5	112	121.75
1997	64		8	72		36		108	
1998	84		18	102		25		127	

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MONITORING AQUATIC PHANEROGAM BEDS IN VARIOUS CORSICAN COASTAL LAGOONS

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Abstract
A monitoring system was set up in three Corsican lagoons, using phanerogams as a biological indicator of environmental quality. The species observed were *Ruppia sp., Zostera noltii Cymodocea nodosa*. The observations would tend to confirm the extensive temporal variability of macrophyte assemblages in term of repartition, biomass or density.

Key words : Lagoons, Monitoring, Phanerogams, Biomass, Density

Introduction

Coastal lagoons occupy 13% of the coastal area worldwide, and are often impacted by natural and anthropogenic influences (1). The Corsican coast possesses over fifty lagoons, which cover an area of close to 3,000 hectares. Aquatic phanerogams are major components of these lagoonal ecosystems with respect to their biomass and the role they play in these ecosystems. In light of this, a monitoring system was set up in three Corsican lagoons, using phanerogams as a biological indicator of environmental quality. The aim of this study was to monitor those parameters classically used to assess the overall health of these meadows, namely biomass, density, the organic matter content of the sediment and the mercury concentration in the shoots.

Materials and methods

Three sites were selected. These are, going from north to south, Biguglia lagoon, Urbino lagoon and Santa Guilia lagoon (Corsica, France). These three lagoons exhibit notable differences in typology, species diversity and levels of anthropogenic pressures (Table 1). Permanent monitoring structures were put in place in July 1997 to allow the evolution of the different seagrass beds to be followed. These structures consisted of a set of buoys and a transect for Biguglia lagoon, two transects for Urbino lagoon and one transect for Santa Giulia (2).

The overall condition of seagrass beds was seasonally evaluated at each station from January 1998 to July 1999. The samples were obtained using a cylindrical corer measuring 15 cm in diameter and 50 cm in height. Five replicates were taken for each of the parameters measured and for each species. The parameters examined were : (i) the density, (ii) the biomass of above-ground and below-ground tissues, (iii) the organic matter content of the sediment and (iv) the mercury concentration in the shoots (3).

Results and discussion

The *Ruppia sp* seagrass beds are found on sediments rich in organic matter (mean : 1.6 to 4.6 % DW). Their distribution was found to be highly variable from one season to the next in Santa Guila and Biguglia. In this last lagoon, for example, these formations almost completely disappeared between April and October 1998, followed by a recolonisation of the site beginning in April 1999. This marked regression would appear to be linked to the proliferation of macrophyted (Ulvophyceae), the decomposition of which lead to problems of anoxia that are detrimental to phanerogams (4). The density of *Ruppia sp* varied between 3,316 shoots/m^2 and 16,401 shoots/m^2. In Santa Giulia lagoon, there occurred a significant decrease in this parameter between July 1998 and Jule 1999. The total biomass of the *Ruppia sp*. seagrass beds in these two lagoons (35.2 to 391.13g DW/m^2) seems rather low compared with the literature values (5). Mercury concentrations were in the order of 125.0 ng.g^{-1} DW (mean for both lagoons). This value is identical to that recorded in the Berre lagoon, a site that is generally considered to be highly polluted (6). This would seem to imply that this species has a high capacity for mercury accumulation.

The *Zostera noltii* seagrass beds are relatively scarce. This is true in the lagoons of both Biguglia and Urbino where they are mainly located at shallow depths and in close proximity to the lagoon openings to the sea. Over the entire study period, a significant regression of the *Zostera noltii* seagrass bed lower depth limit was observed (a regression of 7 m from its initial position) in Biguglia lagoon, whereas these formations almost completely disappeared in Urbino lagoon. The parameters examined confirm a drop in *Zostera noltii* seagrass bed vitality, and this in particular in terms of (i) the above-ground biomass (range of values from 11 to 88 g DW.m^{-2}), which is fairly low (7) (ii) the shoot density, which decreased at both sites from 1998 to 1999, and this regardless of season (*e.g.* mean in April for Urbino: 13,186 ind/m^2 in 1998, 2,524 ind/m^2 in 1999). Mercury contamination levels were rather low for this species (mean : 74.9 ng.g^{-1} DW) and the values recorded were comparable for the two lagoons examined. *Cymodocea nodosa* seagrass beds are only found in Urbino lagoon where they exhibit a substantial bottom cover (8). Their distribution within this lagoon was stable throughout the monitoring. Seasonal variations in biomass and density were limited, which is in agreement with what is known of the biology of this species (9). Values for the latter parameter were higher than what has been reported in the literature (7, 9). Mercury contamination levels were low (mean of 73.2 ng.g^{-1} DW) and are comparable to those recorded for relatively unpolluted sites (10).

The above observations would tend to confirm the extensive temporal variability of macrophyte assemblages within coastal lagoons of the Mediterranean, in particular those which are characterised by shallow waters and a watershed that supports a variety of human activities, such as is seen for Biguglia lagoon. The long term monitoring of both the different parameters and permanent monitoring structures should provide a better understanding of the evolution of these lagoons.

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Table 1: Main characteristics of the sites examined.

Lagoon	Max. Depth	Area (ha)	Salinity	Species	Potential anthropogenic pressures
Biguglia	1.8 m	1500	4 - 26 ‰	*Ruppia sp.* *Zostera noltii*	Urban and agricultural effluent
Urbino	9.2 m	760	26-44 ‰	*Cymodocea nodosa* *Zostera noltii*	Aquaculture and agricultural activities
Santa-Giulia	1.5 m	26	5-18 ‰	*Ruppia sp.*	Tourism

INDUCTION OF NOVEL RE-SEGREGATION AND SELECTION PROCESSES BY ANTHROPOGENIC FACTORS ON LITTORAL MARINE MOLLUSCS

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Abstract

Various in vivo and in vitro methods, contact microscopy and fluorescent markers, were used by us to compare several populations of molluscs from polluted and reference sites along the Israeli littoral in the Mediterranean Sea and the Gulf of Aqaba (Red Sea). The parameters compared included multixenobiotic and antianionic defense systems, micronucleation, membrane permeability and cholinesterase activity. In all species studied the samples from the polluted sites differed markedly from these of the reference sites in all the investigated parameters. Based on the data we hypothesize the occurrence of a special type of stress-induced selection in which specific genotypes proved more fit under stress.

Key words: Anthropogenic stressors, marine molluscs, selection

Already in 1913, an environmental publication of the Smithsonian Institution noted that "life is the reaction of the living substance to the ceaseless play of the environment". Man-made environmental factors are especially prominent in the near-shore habitats of enclosed seas, exemplified by the Mediterranean Sea, the Gulf of Aqaba and similar basins. These negative influences have become especially disturbing during the last 50 years, as thousands of biologically active substances find their way into the littoral, causing a decline in species richness and inducing pathological alterations in the surviving taxa (1,2). Consequently, assemblages of genotypes were confronted with new selection regimes. As a result, new fitting mechanisms have become activated, showing features of successive selection, especially changes in polymorphism (3). Today this constitutes the very essence of response to environmental stress, in which genotypes of specific phenotypic qualities either vanish or must recombine their biological qualities to form novel genotypes suited to the demands of the habitat. One of the first such described adaptive forms was the "industrial race" of butterflies, whose melanistic pattern blended into the darkened tree-trunks. Nevo and Laevi (3, 4) described such developments in some Mediterranean molluscs. During the last five years we have studied a group of littoral molluscs from both clean and polluted sites, recognized by us as good indicators of environmental health (5, 6). These included two species of patellid gastropods, *Patella caerulea* (Mediterranean Sea) and *Cellana rota* (Red Sea), and three species of bivalves, *Pteria aegyptia* (Red Sea), *Brachidontes pharaonis* and *Donax trunculus* (Mediterranean Sea). Using in vitro and in vivo fluorescent and fluorimetric methods as described by Bresler *et al*. (5), we compared in these taxa the state of defense systems, such as multixenobiotic resistance transporters (MXRtr) and the system of active transport of organic anions (SATOA), the permeability (PERM) of the external epithelia, the levels of micronucleation (MNT), and other parameters. The results showed that the populations from polluted sites differed significantly ($p<0.05$, t-test for comparisons of means) from those from the clean sites (Table 1); correlation procedures also corroborated these results. Figure 1 compares samples of *Donax trunculus* from sandy shores of the Israeli Mediterranean. A convergent picture is shown by the Red Sea patellid *Cellana rota* and the Mediterranean *Patella caerulea* (Fig. 2). In both basins, the populations of the two taxa from polluted and clean sites are definitely separated. Moreover, in each site samples of the two taxa are closer to each other than to their con-specifics in other sites. It would be safe to assume that the examined features are, at least partly, genetically controlled, reflecting changes in genotype frequencies, probably due to action of limited, local selection. The results of such selective processes will depend primarily on three major factors: the strength and duration of the stressors, and the ability of the populations to adapt. An additional and important factor for stabilization of the novel phenotypes depends on the transport of their propagules. The shorter living these stages will be, the more rapidly the locally produced genotypes become fixed.

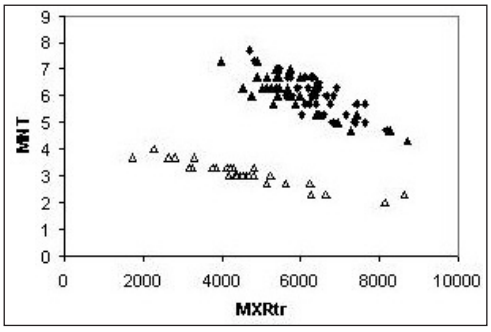

Figure 1. MNT and MXRtr values (in arbitrary units) of ninety specimens of *D. trunculus* from three sites in the Mediterranean (black marks = polluted).

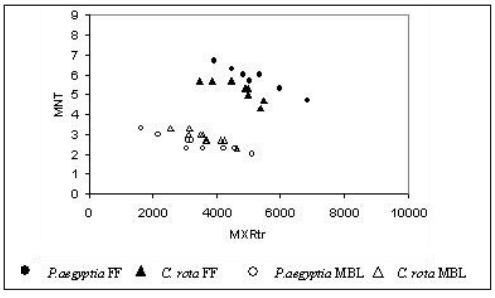

Figure 2. MNT and MXRtr values (in arbitrary units) of *P. aegyptia* and of *C. rota* from the Red-Sea (black marks = polluted). MBL = Marine Biological Laboratory (reference site); FF= fish farming cages (polluted site).

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Table 1. Average ± standard deviation values of defense systems activity in some of the studied molluscs sampled from polluted and reference sites (arbitrary units).

Species	SITE	MXRtr	MNT	SATOA	PERM
Brachidontes pharaoni	Reference	4112.20 ± 988.13	2.43 ± 0.33	265.20 ± 34.11	4.34 ± 0.28
	Polluted	7433.40 ± 790.75	5.50 ± 0.60	379.20 ± 42.15	7.96 ± 0.56
Donax trunculus	Reference	4398.70 ± 659.22	3.12 ± 0.43	303.15 ± 47.58	3.55 ± 0.25
	Polluted	6328.45 ± 1735.17	6.32 ± 0.76	344.00 ± 36.09	6.00 ± 0.21
Patella caerulea	Reference	5046.90 ± 995.45	2.66 ± 0.31	294.00 ± 57.45	4.05 ± 0.21
	Polluted	7631.00 ± 522.99	5.81 ± 0.66	397.80 ± 17.92	7.40 ± 0.75

BIOLOGICAL INDICATORS OF ENVIRONMENTAL STRESS IN POPULATIONS OF *ZOSTERISESSOR OPHIOCEPHALUS* (TELEOSTEI, GOBIIDAE) IN THE VENICE LAGOON

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Abstract

EROD activities and fluctuating asymmetry were measured in grass goby samples collected in the Venice lagoon in order to evaluate the presence of environmental stress. Results evidenced significant differences across sampled sites. Lago Teneri showed the highest EROD activities, due to higher environmental contamination level in this site, while Chioggia presented the lowest level of fluctuating asymmetry, probably due to more stable environmental conditions in this area. These results show the needs of a multiple bioindicators approach to correctly evaluate environmental stress conditions.

Keywords: bio-indicators, lagoons, teleostei

Living organisms respond to environmental stressors by continuously challenging their homeostatic mechanisms. Stress response can be evaluated at different levels of biological organisation (from biochemical and physiological to ecological and population level), to obtain an integrative information (1). In this study the grass goby *Zosterisessor ophiocephalus* (Teleostei, Gobiidae) living in the venetian lagoon is used as "sentinel" species of lagoonal conditions. The grass goby is a territorial, cavity nester species, strictly associated to the bottom sediments, and is widely distributed in the lagoon. Thus it may represent a suitable biological indicator of stress, especially as regards the sediments contamination. Fish samples were monthly collected during March and April 2000 (the core of reproductive season) in 4 stations (Chioggia, Ca' Zane, Lago Teneri and Lido) of the Venice lagoon, which were known to differ in their environmental conditions (different hydrodynamic features, confinement degree and sediment contamination). The stress responses were measured at the biochemical level as the hepatic activity of ethoxiresorufin-O-deethylase (EROD), since this enzyme is known to be induced by the organic pollution due especially to poli-chlorinated byphenils (PCBs) and other organic contaminants, like pesticides (2, 3). At the morphological level the stress response was evaluated as degree of fluctuating asymmetry (FA), that is an indicator of developmental instability, which appears to be enhanced by extreme conditions, pollution and declines in habitat quality (4). EROD activities were evaluated in 10 females and 10 males from each site in April and comparisons across sites were done by applying a variance analysis test. Asymmetry of six bilateral morphological traits (number of pectoral fin rays, maximal length of pectoral fin rays, preorbital length, postorbital length, testes weight and ovaries weight) was measured in March samples (187 males and 89 females) and tested for fluctuating asymmetry. The "total individual FA" (which resumes the asymmetrical conditions of the different bilateral traits by means the sum of their asymmetry data within each specimen) was then evaluated and its variance was compared by using the Levene's test.

Grass goby males showed EROD activities always higher than females, and the highest levels of induction were recorded in the Lago Teneri site (fig. 1a). No differences across sites were found in the females. This result supports the hypothesis of the inhibitory effect of circulating reproductive hormones in females (estradiol) on EROD induction (5, 6). Higher EROD activities identify Lago Teneri as the site with the highest levels of contamination of PCB and organo-alogenated compounds, as confirmed by data about sediment pollution (7). As regards the morphological level, four bilateral traits only (maximal length of pectoral fin rays, preorbital length, postobital length and ovaries weight) showed FA. The degree of FA did not differ between sexes and in the comparison between sites the specimens sampled in Chioggia showed a significant lower level of total individual FA (fig. 1b). The higher developmental stability in Chioggia together with the lower levels of EROD activity could suggest that this area represents a more stable environment for the species. So these results show that a multiple bioindicator approach, integrating the different stress responses, is necessary in order to adequately evaluate environmental stress within a medium-large spatial scale.

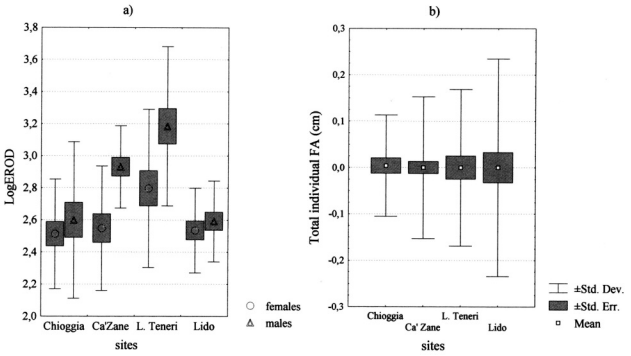

Fig. 1 a) EROD activities (F=females, M=males) and b) total individual fluctuating asymmetry (FA) in fish samples from the 4 sites (mean ± SD).

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A PROPOSAL FOR MEASURING EFFECTIVENESS IN MARINE PROTECTED AREAS

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Abstract

A large literature deals with Marine Protected Areas and their potential as conservation and management tools. However, field investigations of subtidal marine reserves are generally confounded by intrinsic ecological differences between sites investigated inside and outside reserves, by a lack of site and reserve replication, or by the absence of information about the natural variability of the biota before reserve establishment. In the Mediterranean Sea, the effectiveness of MPAs has been rarely demonstrated. Since an MPA can be considered as a zone subjected to human impact, presumably a positive one, the use of experimental procedures generally utilised for detecting environmental impacts is discussed.

Key words: Marine Parks, Rocky shores, Experimental design, Monitoring, Mediterranean Sea

To date, about 40 MPAs have been established in the Mediterranean, and there is a general interest in establishing networks of MPAs (1, 2). This spatially explicit approach to managing human impacts has ecological and socio-economic potential, but there is still little quantitative understanding of the benefits it may provide. The limited knowledge of the effects of protection is mainly linked to 1- haphazard siting and design of MPAs based on opportunity more than biological criteria and 2- conflicting objectives (*e.g.* ecosystem conservation, fisheries enhancement, ecotourism). The difficulties of measuring reserve effectiveness should be overcome by the use of appropriate sampling designs, distinguishing between the influences of management and the intrinsic natural variability of ecological systems. Comparing protected with unprotected systems should provide a better understanding of ecosystem-wide effects of human activities in coastal marine environments, above and beyond the natural variation that likely exists among different systems. In the last years, few papers have been published in the Mediterranean on the spatio-temporal variability of marine assemblages (3, 4, 5). The results show a consistent variability at all the spatial and temporal scales for all the rocky assemblages considered, either the intertidal and subtidal benthos, and the littoral fish assemblages.

Considering the protection as a positive impact (6), BACI (Before and After Control Impact) sampling designs (7) can be used, comparing one or more protected areas with multiple control sites, before and after the MPA institution. In most cases, no data are available before MPAs establishment, and the original BACI design can be modified and the protected and unprotected areas compared after the institution of the MPA (ACI, After Control Impact - 8). It is worth considering adopting:

- hierarchical sampling designs, measuring spatial variability at various scales;
- proper sampling frequencies to detect variability at different temporal scales (9). The best solution is to randomly choose several sampling times (the same for all locations) for each season. This stresses that the observed trends are not due to short-term fluctuations;
- replicate controls, chosen randomly from a set of similar locations unaffected by protection (10, 11);
- long enough study durations to allow separation between short-term variability and long-term trends;
- the choice of the most appropriate analytical tools. Some environmental impact studies have benefited from a combination of univariate and multivariate approaches (11, 12), although the most appropriate variables for the analyses are largely determined by the specific predictions about reserve effects, which in turn are determined by reserve objectives. The use of different analyses allows detecting effects on different components of the assemblage (13). These two approaches can complement each other, although there may be differences in the optimal allocation of sampling units required by the different designs.

Besides this source of natural variability, Mediterranean MPAs vary widely in their general features. The only common feature is the siting in shallow rocky areas. Thus, shallow subtidal benthic assemblages on hard substrate can be the ideal target for studying and monitoring MPAs. Shallow marine assemblages (between 5 and 10 metres depth) can be considered as good indicators of environmental changes because species living at shallow depths are particularly exposed to impacts from coastal activities and thus tend to exhibit stronger responses to human pressure than assemblages from deeper marine environments. Moreover, sessile organisms can be easily monitored and manipulated. Photographic methods are objective and can be analysed by many researchers (also by non-specialists).

At present, the lack of detailed and scientifically defensible knowledge regarding the effects of reserves makes the measure of their effectiveness very difficult, and predictions about the expected effects uncertain. Mediterranean MPAs greatly vary in their physical and biological characteristics as well as in the socio-economic context influencing their design and management, making it unlikely that a single study design will be applicable to all scenarios. However, it is possible to identify the logical structure that should guide the design and interpretation of monitoring studies:

- reserve goals have to be explicitly defined to develop specific predictions about the expected effects;
- sampling should quantify variation in populations and assemblages and tease apart natural variability from that caused by protection. To this end, studies should include multiple control locations, describe long-term trends, and include descriptions of the system before reserve establishment. Studying hard bottom benthic assemblages in MPAs and adjacent unprotected areas with similar characteristics may represent a rapid, cost-effective, and widely applicable mean of evaluating protection effects. This is a unique opportunity to investigate natural variability in marine ecosystems over broad spatial scales, potentially encompassing the whole Mediterranean basin if monitoring networks are established.

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ÉCOSYSTÈMES D'ESTUAIRE SUR SUBSTRAT COHÉRENT DANS LA LAGUNE DE GRADO-MARANO (ADRIATIQUE DU NORD)

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Résumé
Localisés sur le peu de substrats cohérents – la plupart artificiels – de la lagune nord-adriatique de Grado-Marano, les bio-indicateurs étudiés permettent d'y identifier différents écosystèmes conditionnés par l'apport d'estuaires qui revêtent ici une bien plus grande importance que dans la lagune de Venise.

Mot clés: Adriatic sea, bio-indicators, estuaries, lagoons, river input

Introduction

L'étude d'une grande lagune de l'Adriatique du Nord suggère un bref aperçu comparatif avec la plus grande lagune du secteur, celle de Venise, qui est plus étendue et profonde, plus fréquentée par les trafics et directement influencée par l'homme au cours de l'histoire. Les origines géologiques des deux systèmes lagunaires sont différentes (1). Aujourd'hui, ils s'opposent dans leur relations hydrographiques avec la mer et les continents. Venise, séparée de la mer par de longues et robustes jetées, ne reçoit presque plus d'affluents et montre localement des physionomies presque portuaires (2); Grado-Marano, aux faibles et bas lidos traversés de plusieurs cours d'eau venant des Alpes Orientales, entourée par un territoire à vocation agricole, est plus "naturelle" et soumise à un différent régime thermohalin (3).

À sa nature estuarienne la lagune de Grado-Marano doit une pauvreté d'organismes euryhalins et la présence de composantes douées d'une plus large et élastique euryhalinité.

Matériels et méthodes

Nos recherches, en cours depuis 1997, ont d'abord choisi une vingtaine de stations, étudiées en trois différentes périodes, à fin de couvrir toute la surface lagunaire et de révéler des situations écologiquement variées. On a ensuite approfondi l'étude des trois principaux estuaires qui débouchent dans la lagune: Stella à l'ouest, confluent Corno-Aussa au centre, Natissa à l'est (Fig. 1). Sont actuellement en cours d'échantillonnage des séries particulièrement représentatives des zones écologiques identifiées, ainsi que le cours détaillé du Natissa.

Les échantillons analysés sont prélevés au dessous de la limite inférieure de basse mer de vive eau, sur les balises en bois (les *bricole*) qui signalent les canaux navigables. Il s'agit principalement des représentants du benthos invertébré sessile et des communautés de péracarides, principales composantes du benthos à mobilité réduite. La carte (fig. 1) synthétise les résultats obtenus par une *cluster analysis* basée sur l'indice de similarité de Kulczynski (4).

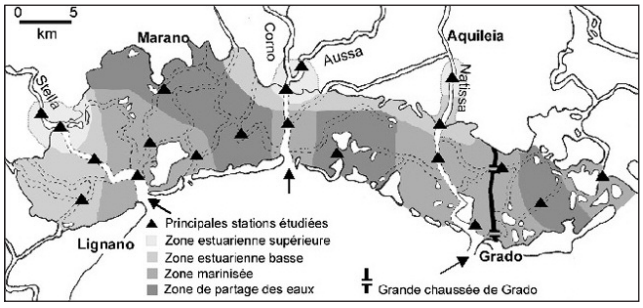

Fig. 1 – Zonation écologique du benthos dans la lagune de Grado-Marano.

Résultats et discussion

Le total des espèces identifiées comprend 43 taxa de benthos sessile et 48 espèces de péracarides. L'analyse des dendrogrammes sépare facilement deux grands groupes de stations: les plus influencées par les apports d'eau douce et celles qui, au contraire, sont plus influencées par la mer. A l'intérieur de ces nettes partitions de plus détaillées situations écosystémiques sont reconnaissables. La partie plus interne de la lagune comprend un secteur plus précisément d'estuaire (zone 1 de notre carte) situé dans un milieu encore continental, que caractérisent des variations de salinité typiques des environnements hypohalins (0 à 15 S‰) et un second secteur (zone 2), pleinement lagunaire. Ce dernier, moins sélectif vis-à-vis des espèces génériquement regardées comme euryèces, présente des valeurs de salinité des eaux, bien que toujours variables, sensiblement plus élevées (10 à 25 S‰). Dans la bande lagunaire plus près de la mer, ce n'est pas la salinité – qui diffère peu des valeurs marines - qui joue le rôle principal de facteur limitant: c'est surtout l'hydrodynamisme, fait bien connu en lagune de Venise (5). Au contact des sous-bassins contigus (zone 3, de partage des eaux) le flux de marée, passant par les différents ports lagunaires, annule son énergie cinétique en déterminant des milieux à échanges hydriques limités, où la sédimentation est forte, l'oxygénation réduite, la stagnation accentuée. Les flots de marée déterminent par contre de bons échanges dans la zone 4, où s'installent des peuplements systématiquement peu différenciés par rapport à la côte attenante de la mer.

Conclusions

Il est donc manifeste qu'à Grado-Marano la physionomie d'estuaire – qui à Venise ne se retrouve que dans la partie la plus septentrionale, où se jette dans la lagune le petit fleuve Dese (6) - intéresse toute l'étendue lagunaire. Toutefois la présence de plusieurs embouchures et la conséquente constitution de plusieurs zone de partage des eaux provoque la formation de milieux d'estuaire écologiquement séparés, surtout dans les traits plus spécifiquement hypohalins. On y trouve certes des bio indicateurs communs à l'estuaire vénitien du Dese, tels le connu serpulien d'eau saumâtre *Ficopomatus enigmaticus* (Fauvel); l'hydrozoaire *Cordylophora caspia* (Pallas) et le tanaidacé *Heterotanais oerstedi* (Krøyer). Grado-Marano n'est par contre pas peuplé par l'isopode *Sphaeroma hookeri* (Leach) considéré comme un élément typique des peuplements d'estuaire, effectivement bien représenté à Venise. Il ne manque d'ailleurs pas des différenciations entre le cours des estuaires intra lagunaires: ainsi l'isopode *Jaera italica* (Kessel.) (qui manque au Dese vénitien) abondant dans la zone 1 du Natissa qui coule d'Aquileia vers Grado, ne se retrouve pas dans le Stella, qui se dirige vers Lignano.

Surtout sur les grèves des alentours de Grado on a constaté la présence (7) du gastropode intertidal vivipare *Littorina saxatilis* (Olivi) répandu en lagune de Venise, considéré comme une probable relique d'époques à climat plus frais et humide que l'actuel, qui trouve dans un régime de marée exceptionnel en Méditerranée, un facteur de survie (8).

La poursuite de nos recherches est destinée à approfondir l'étude de ces analogies et différences de bioindicateurs qui émergent, non seulement entre les deux grandes lagunes de l'Adriatique septentrional, mais à l'intérieur même de la zonation écologique intra lagunaire de Grado-Marano.

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PRELIMINARY DATA ON BENTHIC ENVIRONMENT MODIFICATIONS FOLLOWING THE *CAULERPA TAXIFOLIA* (VAHL) C. AGARDH, SPREAD ALONG THE STRAITS OF MESSINA SICILIAN COASTS (MEDITERRANEAN SEA)

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Abstract

Investigations carried out in the Straits of Messina since 1980 showed as *Caulerpa taxifolia* meadows replaced the originary soft bottom biocoenosis , from 4 to 35m of depth. Hard bottoms were also covered, and *Cymodocea nodosa* formations partially replaced. At the contrary, Posidonia oceanica formations do not appear substantially damaged. Although preliminary data indicated a diversity increasing on some investigated soft-bottom communities, a reduction of diversity is probable along the middle period, due to the increasing sameness of the benthic landscape.

Key-Words: Algae, Straits of Messina, Mediterranean Sea,

Introduction

The Straits of Messina was the first southwestern locality where *Caulerpa taxifolia* (Vahl) C. Agardh has been found after its spread along the northern-western Mediterranean coasts (1). Since the first report, great expanses of sea bottoms have been covered along the Sicilian coasts, while a small number of smaller colonies have been identified along Calabrian coasts. Data concerning structure and distribution of benthic communities in the Messina Straits have been collected by our Department since 1980. This allowed to trace the most relevant chenges observed in the benthic environment following the settlement of *C. taxifolia* prairies.

Materials and Methods

Data employed for the present study were collected during various programs of research regarding the Sicilian side of the Straits of Messina. The most important of these was an investigation carried out in collaboration with the National Research Council (CNR, Messina) (2), and a further one commissioned by the Regional Administration in 1995 (unpublished data). During these investigations, more than 250 grab and dredge samples were collected from 5m to 150m depth, and almost 30 hours of ROV recognitions were recorded along about 25 Km of sea bottoms. Investigations extend up to the present day, mainly through grab samplings and scuba diving surveys, along 10 Km of the coast line .

Results and discussion

The most recent surveys, carried out up to November 2000, have shown how the *Caulerpa taxifolia* prairies extend almost continuously for at least 6 km of bottom, along the Straits of Messina Sicilian coasts; this is in accordance with recent investigations (3). The bathymetric range went from about 3m to 35m depth, although prairie upper limits can reach intertidal depths and have also been observed along the channel communicating with the Ganzirri brackish pool. Furthermore, some small *Caulerpa* patches were recorded from 40 to 65m depth, along both the Sicilian and Calabrian sides. Although *C. taxifolia* was able to colonize any hard or soft bottom type, prairies show some interruptions facing the largest currents. Probably, the high and irregular sediment inputs and soft bottoms made unstable by strong slopes, do not permit easy colonization. The entire area affected by the *Caulerpa* spread has been seen in the past in four main biocoenosis types (2;4). In fact, infralittoral soft bottoms were mainly occupied by the coarse sand and fine gravel under bottom current biocoenoses (SGCF of Pérès and Picard) (5), this being due to the very high hydrodynamic levels characterizing the Straits of Messina (6). Despite this, soft bottoms did not appear monotonous, because of the great variety of local conditions, also by hard bottoms and *Posidonia* meadows patch distribution.

In particular, various *facies* of the SGCF were identified on bottoms characterized by free-living and encrusted calcareous algae, in the "intermattes" channels and, similar to other south-Tyrrhenian localities (7), related to the hard bottom kelp communities. Furthermore, small tracts of bottom, close to the coast line, showed benthic communities identified as fine well sorted sand biocoenoses (SFBC of Pérès and Picard) (5). With regard to the hard bottom biocoenosis, great levels of complexity are known to exist for photophylous algae infralittoral communities (AP of Pérès and Picard) (5), as well as those described by Giaccone and Rizzi Longo (8), and Fredj and Giaccone (9). The most original of such algae associations, especially characterized by the *Saccorhiza polyschides* and *Phyllaria reniformis* kelps, as well as the Atlantic brown alga *Cystoseira tamariscifolia*, are at to day strongly damaged,.

Various causes could be hypothesized regarding this, also considering the fact that Cystoseira communities are well known to be in decline all over the Mediterranean. However, it must be remembered that as *S. polyschides* gametophyte development is closely dependent on *Mesophyllum lichenoides* coralline algae (10), a dense *Caulerpa* canopy could pose a strong threat of disturbance. As far as seagrass meadows are concerned, the living *Posidonia* formations do not appear damaged, although *Caulerpa* prairies cover soft bottoms around the mattes as well as the bottom of channels. Only some subfossil "mattes," from 15 to 20m depth, were covered by *Caulerpa*. On the contrary, a reduction in the expanse of *Cymodocea nodosa* was observed in several localities.

Although the clear variations on sea bottom landscapes would suggest possible strong modifications on benthic community composition, quantitative data are not available in literature. Preliminary data, regarding some soft bottom communities in the Straits of Messina, seem to indicate an increasing diversity in respect to the past (Giacobbe, work in progress). However, even if this fact should be confirmed shortly, it would not necessarily imply a real increase in biodiversity, in that, as *C. taxifolia* is in a phase of active expansion it is clear that the co-related community is still far from being stabilized.

Conclusion

Investigations carried out in the Straits of Messina after *C. taxifolia* spread have indicated that where once existed various types of biocoenoses, now there is an uniform prairie of *C. taxifolia*, with a probably β diversity decreasing. In fact, *Caulerpa* covers indifferently both the hard substrata and the soft ones, fortunately with the exception of the *Posidonia* formations with which it would seem to have integrated, and in part, shared, the habitat. With regard to this, a new research programme proposes to learn how the composition and structure of the community of the soft bottoms would change, following the stabilization of the substratum, and what effects immobilization of large quantities of organic substances, by *Caulerpa* would have on the eco-system and marine and fishing resources.

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ETAT DE REFERENCE DE LA MACROFAUNE BENTHIQUE DU PORT DE DJENDJEN (ALGERIE ORIENTALE)

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Résumé
L'organisation du macrozoobenthos du port de Djendjen offre la possibilité d'établir l'image de référence d'un peuplement portuaire à l'abri des altérations classiques propres à ces milieux. L'activité réduite, son caractère récent, sa position centrale dans le golfe de Jijel, son faible confinement et l'absence de rejets à l'intérieur du port ont favorisé l'installation d'une macrofaune riche, diversifiée, dense et fortement équilibrée. Le port de Djendjen présente les caractéristiques d'un milieu en transition entre un état original à structure faunistique bien structurée et un début de déstructuration liée à certaines espèces telles que *Heteromastus filiformis*, *Lumbrineris latreilli* ou *Corbula gibba*.

Mots clés : Bio-indicateurs, Pollution, Zoobenthos, Western Mediterranean

Introduction

L'étude du port de Djendjen constitue une partie de la phase IV du programme "Bio-surveillance et Bio-indicateurs en milieux perturbés algérien". L'image fournie par la macrofaune benthique dans cette étude constitue l'état zéro pour l'évaluation d'éventuels dommages qu'occasionnera l'essor prévu de ce port.

Matériel et méthodes

36 stations (4-19 m) sont prospectées selon un quadrillage systématique, dont 3 stations de références situées à l'extérieur du port. L'échantillonnage de 0.25 m^2 de substrat (benne Van Veen) est réalisé à bords du N/O *M.S. Benyahia* entre le 30/06 et le 02/07/1997. La macrofaune a subi un traitement classique. Des descripteurs numériques classiques sont utilisés pour la caractérisation des entités faunistiques. l'indice de diversité spécifique de Shannon et Weaver H (1) et à l'équitabilité E (2) sont utilisés pour l'étude de l'équilibre numérique. L'ACP est entreprise à la recherche des unités faunistiques.

Résultats

259 espèces (82 familles et 160 genres) sont récoltées sur les fonds meubles prospectés. Les Polychètes (48.26 %), les Crustacés (29.73 %) et les Mollusques (11.58 %) conditionnent la structure systématique. La décomposition de celle-ci révèle l'importance des Ariciidae, des Cirratulidae, des Capitellidae, des Spionidae et des Maldanidae qui fournissent 67.61 % des Sédentaires et 36.1 % des Polychètes. Une biomasse moyenne de 3.166 g.pslc/m^2 ± 2.087 est mesurée pour une densité moyenne de 1151.9 ind./m^2 ± 947.1. L'équitabilité (017-097) et l'indice de Shannon (1.21-5.87) traduisent un état d'équilibre numérique avancé. Les espèces pivots sont caractéristiques des zones de déséquilibre. On retrouve *Lumbrineris latreilli, Heteromastus filiformis, Nuculana pella, Tellina pulchella*. Néanmoins, *Abra alba* et *Audouinia tentaculata*, espèces opportunistes, occupent une place appréciable au sein de cette macrofaune. Ces espèces sont classées préférentielles alors que *Capitella capitata*, opportuniste d'ordre 1, figure à la limite des espèces préférentielles-espèces accompagnatrices. Les sabulicoles (22 %) et les indicatrices de perturbation (21%) conditionnent la structure de la macrofaune sur le plan biocénotique alors que sur le plan trophique cette structuration est assurée par les déposivores de surface (28.26 %), voire les suspensivores. L'analyse en composantes principales dégage quatre groupes faunistiques (fig.1):

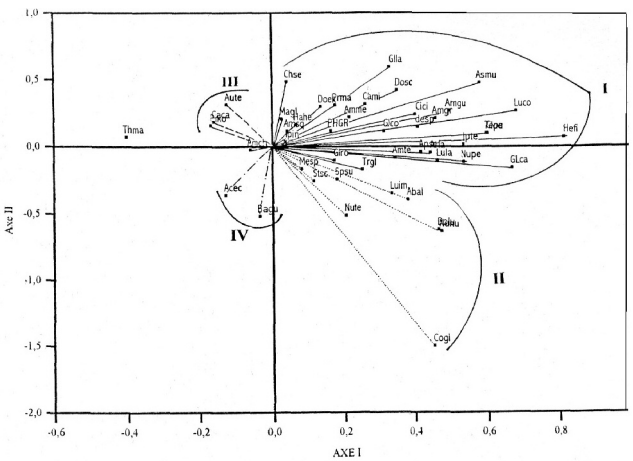

Fig.1: Analyse en composantes principales sur les plans des axes factoriels I et II

Groupe I : composé de 26 espèces à fortes disparités numériques. Les plus importantes sont *Chaetozone setosa, Amphipholis squamata, Iphinoë tenella, Phascolosoma granulatum, Capitomastus minimus, Bodotria scorpioïdes, Glycera lapidum, G. convoluta, G. capitata, Apseudes spinosus, Tellina pulchella, Lumbrineris coccinea, L. latreilli, Heteromastus filiformis*. Ce groupe, fortement diversifié, est à grande hétérogénéité quantitative. En outre, l'essentiel des groupes systématiques, écologiques et trophiques identifiés sur les fonds meubles du port de Djendjen y sont représentés. Cette situation suggère un caractère transitoire de cette macrofaune.
Groupe II : 9 espèces à très forte variabilité numérique spatiale composent ce groupe. Cette variabilité est clairement exprimée par les niveaux d'abondance d' *Abra alba, Corbula gibba, Dosinia lupinus, Nucula tenuis, N. nucleus, Spisula subtruncata, Sternaspis sucutata, Mediomastus sp*. et *Lumbrineris impatiens*. La tendance au sein de ce groupe est aux Bivalves et aux déposivores de surface. On y enregistre la cohabitation entre espèces de milieux enrichis en matières organiques (*Corbula gibba, Abra alba* et *Mediomastus sp*.) qui sont connues pour leurs larges potentialités écologiques et les espèces caractéristiques de zones subnormales (*Dosinia lupinus, Lumbrineris impatiens*). Ce serait aussi le groupe des sabulicoles. A l'interface des groupes I et II, s'individualisent six espèces (*Ophiura texturata, Nuculana pella, Lumbrineris latreilli, Glycera capitata, G. rouxii* et *Trichobranchus glacialis*).
Ce cortège serait un groupe de transition entre les éléments très hétérogènes du groupe I et ceux présentant une tendance aux espèces de zones de déséquilibre du groupe II.
Groupe III : Groupe des vasicoles indicatrices de pollution avec quatre Polychètes : *Audouinia tentaculata, Tharyx marioni, Capitella capitata* type 2 et *Pectinaria koreni* associées à l'Echinoderme *Amphiura chiajei*; espèces signalées parmi les espèces clés en milieux perturbés (3, 4).
Groupe IV : limité au Cardidae *Acanthocardia echinata* et à l'Amphipode *Bathyporea guillamsoniana*.

Les deux premiers axes réunissent les espèces des groupes I et II au pôle positif, avec une forte contribution d'*H. filiformis* à l'axe I, Capitellidae vasicole indicateur d'instabilité perturbation. Le groupe I correspondrait à un peuplement à diversité modérée qui aurait pu s'installer après un état de stress du milieu et dans lequel subsisterait ces espèces. *H. filiformis* espèce caractéristique des ports algériens (4, 5) est présente au port de Djendjen avec le plus fort indice biologique et la seconde fréquence après *Lumbrineris latreilli*. Ce serait une espèce pivot autour de laquelle s'est organisée la macrofaune.

Discussion

Le macrozoobenthos du port de Djendjen présente toutes les caractéristiques d'une faune de transition. On assiste au niveau de ce port à la mise en place d'une macrofaune de zones de déséquilibre ou subnormale avec le chevauchement entre entités caractéristiques d'une part de milieux perturbés sur fonds de vases enrichis en matières organiques et celles habituellement rencontrées sur des fonds de sables. Le lessivage continu des sédiments de surface, du fait de la position centrale du port dans le golfe qui l'expose aux courants convergents, expliquerait dans une large partie l'instabilité sédimentaire qui y règne. Celle-ci aurait pour conséquence directe l'absence d'un schéma classique de distribution des espèces dans les milieux portuaires confinés et perturbés par excellence.

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MACROZOOBENTHOS D'UN MILIEU PORTUAIRE PERTURBE : LE PORT DE JIJEL (EST ALGERIEN)

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Résumé
L'analyse de la macrofaune benthique du port de Jijel (Est algérien) est entreprise dans le but d'identifier les grandes lignes de sa structuration en relation avec les conditions de confinement particulièrement prononcées dans ce port. Ce port, se révèle, à l'image des principaux ports d'Algérie, fortement pollué et abritant une macrofaune pauvre, oligospécifique par endroits, très dense, déstructurée et en déséquilibre numérique, s'ajoute à cela la monotonie, zoologique, biocénotique et trophique.

Mots clés : Bio-indicateurs, Pollution, Zoobenthos, Western Mediterranean

Introduction

Le macrozoobenthos du port de Jijel est très mal connu, seule une étude ponctuelle (juillet 1986) portant sur une surface de 4 m_ a été réalisée par Bakalem (Comm. pers.). Une prospection dans le cadre du programme "Bio-surveillance et Bio-indicateurs des milieux perturbés d'Algérie" est entreprise en juin 1997 pour l'estimation du dommage global occasionné à ce compartiment à travers les peuplements macrozoobenthiques qui se sont révélés encore une fois d'excellents bio-indices structuraux (1, 2, 3, 4).

Matériels et méthodes

Pour ce faire, 10 stations (3-15 m) sont prospectées en juillet 1998 à bords du N/O *M.S. Benyahia*. Un traitement classique est réalisé à bord (tamisage, conservation) et au laboratoire (tri, identification, pesé...). Pour la caractérisation de la macrofaune, il est fait appel à des descripteurs numériques (abondance, densité, dominance, indice biologique, fréquence) et à l'indice de Shannon et Weaver (H), l'indice d'équitabilité (E). Une analyse multivariée (ACP) est tentée afin de dégager les grandes tendances de cette organisation macrozoobenthique.

Résultats

Les eaux de fond du port de Jijel présentent une forte homogénéité thermique et haline, soit des marges de fluctuation très faibles (0.75 °C et 0.63 psu). La température et la salinité moyennes sont toutefois conformes à celles des milieux portuaires d'Algérie au début-été (25.26 °C ± 0.28 et 34.79 psu ± 0.26). Du point de vue oxygénation, le port de Jijel ne semble paradoxalement pas diminué (6.78 mg/l ± 1.24).

109 espèces réparties entre 47 familles et 91 genres sont inventoriées. Cette richesse est essentiellement constituée de Polychètes (46 espèces, 42.2 %), de Crustacés (26 espèces) et de Mollusques (21 espèces). Ces trois groupes fournissent 85.32 % de la richesse totale. Les Echinodermes, les Oligochètes, les Enteropneustes, les Nemertes, les Sipunculidiens interviennent accessoirement dans la régulation qualitative de la structure macrozoobenthique. Les Cirratulidae *Audouinia tentaculata* et *Chaetozone setosa*, les Capitellidae *Heteromastus filiformis* et *Capitella capitata*, le Corbulidae *Corbula gibba*, le Scrobiculariadae *Abra alba* et le Nereidae *Nereis caudata*, toutes des espèces tolérant de fortes charges polluantes notamment organiques, contribuent fortement tant du point de vue numérique que pondéral à structurer la macrofaune du port. Ce sont pour la majorité des espèces de vases enrichies en matières organiques. La structure trophique présente une tendance à la monotonie, avec une prépondérance des déposivores de surface (DS). Cette prépondérance des DS est moins prononcée quantitativement, avec des contributions moyennes respectives de 30.28, 29.28 et 26.58 % pour les DS, les SDS (suspensivores-déposivores de surface) et les S (suspensivores). La projection des vecteurs espèces sur les deux premiers axes factoriels (ACP), cumulant près de 43 % de la variance totale, dégage quatre entités faunistiques (Fig.1).

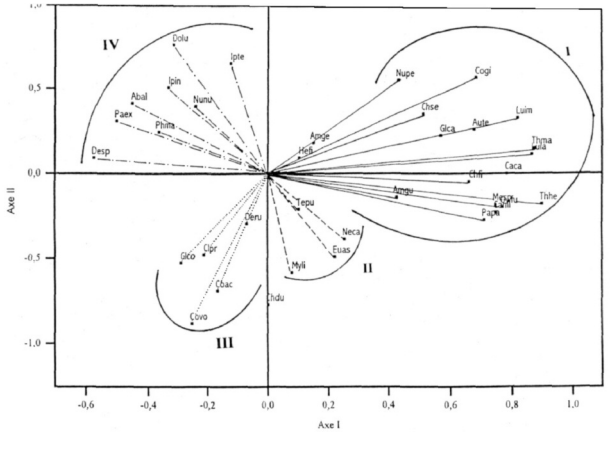

Fig.1: Analyse en composantes principales sur les plans des axes factoriels I et II.

Groupe I : Il regroupe 17 espèces : *Capitella capitata* type 1, *Chaetozone setosa, Corbula gibba, Nuculana pella, Heteromastus filiformis, Tharyx marioni, T. heterochaeta, Lumbrineris latreilli, L. impatiens, Audouinia tentaculata, Glycera capitata, Paraonis paucibranchiata, Ampharete grubei, Capitomastus minimus, Amphicteis gunneri, Owenia fusiformis* et *Chone filicaudata*. Une très forte tendance aux vasicoles indicatrices de perturbation (Ipert.) et aux déposivores de surface et les déposivores de sub-surface (DSS) se dessine au sein du groupe I. Ce sont pour la majorité des espèces caractéristiques des milieux portuaires algérien en période estivale (4, 5, 6).
Groupe II : Il se compose de 5 espèces à tendance sabulicoles : *Tellina pulchella, Nereis caudata, Eusyllis assimilis, Mystides limbata et Chone duneri*.
Groupe III : *Clymene praetermissa, Glycera convoluta, Corophium acherusicum* et *C volutator* composent le groupe III.
Groupe IV : Ce groupe comprend *Dosinia lupinus, Iphinoë tenella, I. inermis, Nucula nucleus, Abra alba, Parvicardium exiguum, Phtisica marina* et *Dexamine spinosa*. Aucune tendance précise ne se dessine au sein de ce groupe, si ce n'est celle aux Amphipodes et aux Bivalves.

Evolution de la macrofaune entre juillet 1986 et juin 1997

L'évolution de cette macrofaune depuis les travaux de Bakalem (comm. pers.) révèle une très forte stabilité entre les deux situations. Les groupes systématiques, biocénotiques et trophiques structurants sont, à quelques nuances près, les mêmes. Cette stabilité est surtout perceptible dans la contribution des espèces indicatrices de perturbation du milieu. Bakalem signale en 1986 quatre espèces principales: *Pseudoleiocapitella fauveli, Lumbrineris gracilis, Chaetozone setosa* et *Corbula gibba* pour la zone avant port et *Lumbrineris gracilis, Tharyx marioni, Chaetozone setosa* et *Corbula gibba* pour les fonds de darse. Sur l'ensemble des fonds prospectés en 1997, deux de ces espèces (*Chaetozone setosa* et *Corbula gibba*) figurent parmi les espèces préférentielles. La structure trophique montre une inversion, d'une prépondérance S-DS en 1986 , elle passe à une importance des DS-SDS en 1997. Les autres éléments de cette évolution sont l'augmentation conséquente de la densité (de 523-885 ind./m^2 en 1986 à 524-9192 ind./m^2 en 1997), voire de la biomasse moyenne alors que les équilibres numériques entre espèces sont restés globalement dans les mêmes proportions. En effet, les indices H et E fluctuaient entre 3.3-3.5 et 0.71-0.8 en 1986, alors qu'en 1997, ils se situent dans les intervalles respectifs de 1.3-4.05 et 0.27-0.81.

Discussion

La macrofaune du port de Jijel présente l'image type d'un peuplement portuaire, confiné, fortement perturbé et dominée par les indicatrices de pollution. La distribution topographique des espèces sur les fonds meubles prospectés au port de Jijel rappelle le modèle en mosaïque, mis en évidence au port d'Oran en situation estivale (4). Ce type de schéma traduit une distribution des peuplements en l'absence d'un axe d'écoulement privilégié de la pollution, avec plutôt un chevauchement de peuplements lié à plusieurs sources de pollution (4, 5).

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DOES TROPICAL ALGA *CAULERPA TAXIFOLIA* (VAHL) C. AGARDH INFLUENCE THE MACROZOOBENTHOS COMPOSITION ?

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Abstract

Relationship between macrozoobenthos species in the autochthonous vegetation settlements and in the settlements infested and prevailed by tropical alga *Caulerpa taxifolia*, have been observed in the summer of 1998 (Starigrad Bay, Hvar Island, Adriatic Sea). Preliminary results indicate that the number of macrozoobenthic species is higher in the samples of autochthonous vegetation with *C. taxifolia* than in the samples without it, which is not in accordance with data from the researches in the Mediterranean, where the negative influence of *C. taxifolia* to biological diversity was recorded. In order to give precise answers to the question in the title, the research has been carried on.

Key-words: macrozoobenthos, Caulerpa taxifolia, Adriatic Sea

Introduction

The tropical alga *C. taxifolia* was observed for the first time in the Adriatic Sea in Starigrad Bay in the summer of 1994. The alga was found at depths between 0.5 and 20 m, on the hard bottom with photophilic and sciaphilic biocoenoses and on the sandy and muddy bottoms with seagrass beds of *Posidonia oceanica, Cymodocea nodosa* and *Zostera noltii* (1, 2). The influence of *C. taxifolia* on the composition of the Adriatic macrozoobenthos hasn't been researched so far. There are only data about the influence of this alga on the composition of epibionthic meiofauna in the North Adriatic (3). Its impact on ecological events (4), on invertebrate composition (5), epiphytic fauna and fish (6) and particularly on the behavior of the sea-urchin *Paracentrotus lividus* (7, 8, 9) has been researched in the Mediterranean. In this paper the preliminary data upon macrozoobenthos composition in the settlements of autochthonous vegetation and settlements attacked by *C. taxifolia* and the settlements of *C. taxifolia* have been given.

Material and methods

The investigations were performed by SCUBA diving in Starigrad area between 2 and 8,8 m depth in the summer of 1998. The material was collected from surface of 1/4 m^2, in the settlements of autochthonous vegetation and in the settlements where *C. taxifolia* spreads. The samples were collected: at 2 m depth on the hard bottom in shadow part of inclined (600) rock where *C. taxifolia* hasn't been introduced yet and the part where it has completely covered the rock; at 5 m depth in the settlement of *Cystoseira adriatica* and in the mixed one with *C. taxifolia* (approx. 50%); at 3 m depth on muddy-sandy bottom where the settlement is composed of *Cymodocea nodosa* and the mixed one; at 6,6 and 8,8 m depth on sandy-muddy bottom in the settlement of *C. nodosa* and the mixed one. All specimens of the dominant groups of macrozoobenthos living in each sample were sorted, identified and counted.

Results and discussion

The results of the preliminary research indicate that in the sample taken at 2 m depth on inclined rock (sciaphilic) in the settlement of *C. taxifolia* there were more macrozoobenthic species (34 species) than in the settlement of sciaphilic algae (17 species); superior in number are sponges and molluscs. The number of species at 5 m depth in mixed settlement of *C. adriatica* and *C. taxifolia* is higher (16 species) than in *C. adriatica* settlement (14 species); the number of molluscs was the same in both samples (7 species); the sponges (3 species) were found only in *C. adriatica* settlement, while echinodermata (2 species) were found only in the mixed sample (Fig. 1).

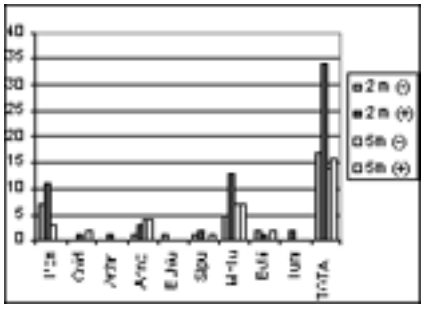

Fig.1. Number of macrozoobenthic species in samples without (-) and with *C. taxifolia* (+).

On muddy-sandy bottom (3 m depth) in the sample of *C. nodosa* we have recorded more species (10 species) than in the mixed sample (6 species). In both samples the most numerous are molluscs. On sandy-muddy bottom (6,6 m depth) in the sample of *C. nodosa* there haven't been recorded any macrozoobenthic species, while in the mixed settlements 5 species were recorded. At 8,8 m depth in *C. nodosa* settlement 11 species were observed and 13 species in mixed one. In the mixed settlement there were defined the single species of cnidarians and crustaceans and 3 species of echinoderms which weren't recorded in the settlements without *C. taxifolia*. However, the number of molluscs is higher in *C. nodosa* settlement (9 species) than in the mixed one (7 species) (Fig. 2).

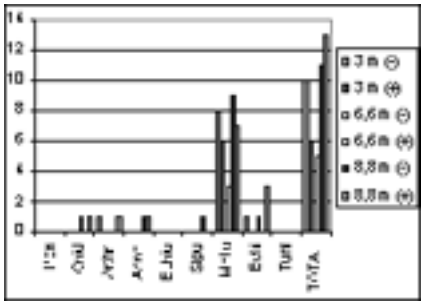

Fig. 2. Number of macrozoobenthic species in settlements without (-) and with *C. taxifolia* (+).

Analysing the results of the preliminary research the question was raised : Does the tropical alga *C. taxifolia* influence the macrozoobenthos composition and to what extent? The final answer should be found in more complex researches that are in the course.

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FISH VISUAL CENSUS IN SHALLOW MEADOWS OF MEDITERRANEAN SMALL-SIZED SEAGRASSES

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Abstract

The abundance of six nectobenthic fish was estimated by visual censuses along transects of different length (*i.e.*, 5x2, 10x2 and 25x2 m) in shallow seagrass beds of *Cymodocea nodosa* and *Zostera noltii*. Four species (*Symphodus ocellatus, Diplodus annularis, Sarpa salpa, Sparus aurata*) were underestimated using the shortest transects, while *Symphodus cinereus* and *Mullus surmuletus* were unaffected by transect length. The precision of the estimates tends to decrease with the transect length. Transects of 25x2 m permit to optimise sampling effort and precision, but those of 10x2 m may represent an acceptable compromise.

Key words: Fish visual census; Cymodocea nodosa; Zostera noltii; Sardinia Island.

Introduction

In the Mediterranean Sea, underwater visual censuses have been used to study fish assemblages in vegetated habitats (algae and the seagrass *Posidonia oceanica*), rocky substrates and bare sands (1; 2). The specific technique (*e.g.*, strip transect) and the sampling area employed usually depend on the habitat, the environmental conditions and the aim of the research (3). Recently, an increasing attention was paid to fish assemblages of small-sized seagrasses (*Cymodocea nodosa* and *Zostera noltii*), which mainly colonise sheltered embayments and coastal lagoons (4). In such systems, Guidetti & Bussotti (4) studied the seasonal dynamics of the fish fauna and recorded juveniles of several species, stressing the potentially important role that such habitats could exert compared to the little information so far available.

In this note, fish abundance estimates obtained using transects of different length in shallow mixed meadows of *C. nodosa* and *Z. noltii* are compared to optimise sampling effort and precision.

Materials and methods

The study was carried out in August 2000 in the Gulf of Olbia (NE Sardinia, Italy, 40°55.5' N, 09°34.4' E), where *Cymodocea nodosa* and *Zostera noltii* form widespread beds in shallow areas. Visual censuses were made along random transects of 5x2 m, 10x2 m and 25x2 m. Transect width was maintained equal to 2 m, as this measure is considered the most suitable for visual census in Mediterranean seagrass systems (1; 2; 4). Twenty replicates per transect type were done considering six common nectobenthic fish in this habitat: *Symphodus cinereus, Symphodus ocellatus, Mullus surmuletus, Diplodus annularis, Sarpa salpa* and *Sparus aurata*. Fish density (no. ind. 100 m^{-2}) was estimated by counting each specimen to a max of 10 fish, whereas abundance classes (see 3) were used for schools. Differences in mean fish abundance obtained along transects of different length were tested by analysis of variance. SNK test was employed for post-hoc comparisons. The Standard Error (Standard Deviation/÷n) was then used to evaluate the methodological precision.

Results and discussion.

The mean fish abundances estimated using transects of different length are shown in Fig. 1. In Table 1 are summarised the results of ANOVAs for effects of 'transect length'. Mean abundances of *Symphodus cinereus* and *Mullus surmuletus* (Fig. 1a and c, Table 1) appeared to be unaffected by the type of transect used. *Sparus aurata* was never observed by using the shortest transects, while no significant differences were detected using transects 10 or 25 m long (Fig. 1d, Table 1). Average densities of *Symphodus ocellatus, Diplodus annularis* and, even more, *Sarpa salpa* (Fig. 1b, e and f) obtained along transects 5 m long were lower than those estimated along transects of 10 or 25 m (Table 1). For five species out of six (*i.e.*, *S. cinereus, S. ocellatus, D. annularis, M. surmuletus* and *S. salpa*) standard errors of means tend to decrease with the transect length. As regards S. aurata, instead, similar standard errors were obtained using transects 10 or 25 m long.

Table 1. Summary of ANOVAs for effects of transect length
*(A: 5x2 m; B: 10x2 m; C: 25x2 m) on fish abundances. P: significance level (n.s.: not significant; *: p<0.05; **: p<0.01).*

Species	F test	P	SNK test
Symphodus cinereus	0.29	n.s.	-
Symphodus ocellatus	5.46	**	A<B=C
Mullus surmuletus	1.08	n.s.	-
Diplodus annularis	3.10	*	A<B=C
Sarpa salpa	7.06	**	A<B=C
Sparus aurata	4.79	*	A<B=C

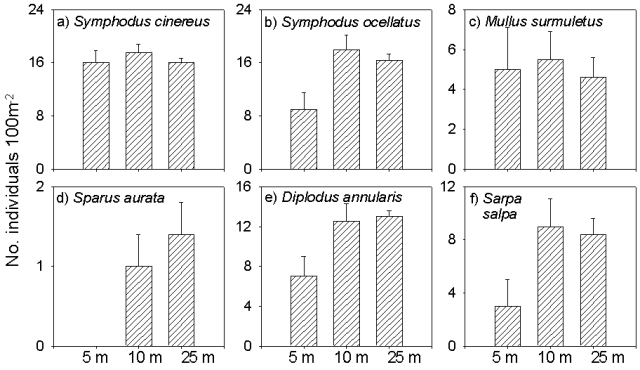

Fig. 1. Mean abundance (SE) of the six fish species estimated using transects of different length.

In a previous study on fish assemblages of *C. nodosa* and *Z. noltii* (4), larger transects (25 x 6 m) than those tested here were used. Nevertheless, the authors recommended the use of narrower transects chiefly to increase the methodological efficiency in censusing shy and cryptic species, as well as juvenile fish. The results reported here suggest that transects of 25x2 m allow to optimise sampling effort and precision. However, transects of 10x2 m could represent an acceptable compromise to limit damages to the meadows caused, for instance, by experimental manipulations involving canopy removal.

Acknowledgements

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DINOFLAGELLATE CYSTS FROM THE SEDIMENTS OF THE EUTROPHIC EASTERN HARBOUR OF ALEXANDRIA, EGYPT

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Abstract
A sediment core from the eutrophic zone of the Eastern Harbour of Alexandria is examined for organic carbon content, grain size and dinoflagellate cysts. The rate of sediment deposition is abnormally high in the sink area of downstream from the outfall, but there is an obvious seasonal trend. Cyst deposition follows a parallel trend, accelerating by the end of summer. *Pyrophacus* sp. cyst are dominant in the core. The stratification of *A. minutum* cysts confirms its observed disappearance from the plankton.

Key words: Alexandria. Dinoflagellate cysts. Eutrophication. Alexandrium minutum

The Eastern Harbour (E.H.) of Alexandria is a semicircular, semi-closed bay, about 2.4 km in its greatest width. It is surrounded by the City along its southern margin and communicates with the sea on its northern side. The bay has always been the recipient of large volumes of domestic waste water from several point sources. In 1996-1997, however, all effluents but one were closed, the same volume of waste water becoming disposed of through the remaining effluent on the south-west bay margin. Since Halim (1), recurrent heavy blooms and red tide outbreaks, caused mostly by *Alexandrium minutum* Halim, have been documented and described (2, 3, 4, 5). After its toxic outbreak in 1994 (5), *A. minutum* appears to have become gradually extinct, being replaced by several other potentially harmful species. Its disappearance has been attributed by Ismael and Halim (6) to erosional instability of the bottom sediments bearing its cysts and caused by active hydrodynamic forcing. It should be mentioned that nothing is known about sediment cysts from Egyptian waters.

Three 18 cm cores were collected from three equidistant stations along the north-south axis of the bay. They were sliced into 2 cm fractions, subjected to grain size analysis and their organic carbon content determined. The fractions retained by the 20 μm sieve was sonicated and microscopically examined.

We report here on core 1, collected immediately downstream from the outfall, from the sink area. The lower layer of the core corresponds to the year 1996-97, the year the outfall became fully functional, and the upper most layer to the sampling year, 1999.

The organic carbon (OC) content increased from 0.9% to 5.4% at the high average sedimentation rate of 6cm year^{-1}. there is a clear cut seasonal trend, the sinking rate accelerating during summer, the season of maximum sewage outflow. Winter brings an apparent reversal in the OC content, as the oxidation rate at the sediment-water interface exceeds the rate of sewage deposition. The correlation between OC content and grain size is significantly and negatively correlated.

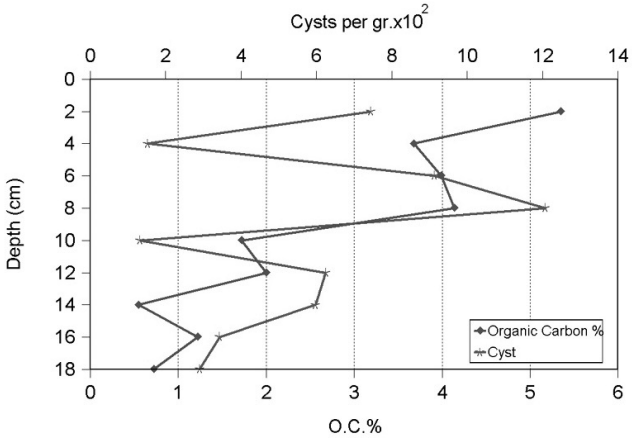

Fig. 1. Organic carbone and dinoflagellate cyste in core 1

There is a striking parallelism between the OC content and the stratification of the dinoflagellate cysts in the core. The profile of cyst abundance is also seasonally clear cut, with an increased rate of cyst deposition at the end of the summer blooming season followed by a slow down in winter. *Pyrophacus* sp. cysts contributed 44% to the total core, followed by *Lingulodinium* sp. (13%), *Scrippsiella* sp.(12.5%), undetermined cyst 1 (12%), *Alexandrium minutum* (8%), undetermined cyst 2 (7.6%) and *Protoperidinium* sp. (3%).

The stratification of *A. minutum* cysts appears to confirm the interpretation of Ismael and Halim (6). While in the layers corresponding to the years 1996-1997 and 1998, respectively, 40 to 125 and 20 to 120 cysts per gram were deposited, none were found in the layer corresponding to 1999. This distribution is in agreement with the observed disappearance of the species from the plankton.

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BENTHOS OF THE *CAULERPA TAXIFOLIA* SETTLEMENT AT MALINSKA (CROATIA, ADRIATIC SEA)

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Abstract
Diversity of macrobenthos in the *Caulerpa taxifolia* settlement at Malinska was analyzed. In general, flora and fauna are alike to those in the western Mediterranean.

Key words: zoobenthos, phytobenthos, Adriatic Sea, Caulerpa taxifolia

In the Malinska area (Krk Island, north Adriatic Sea) the invasive green alga *Caulerpa taxifolia* was firstly noted in November 1994. In 1996 the harbour settlement was eradicated (1) and this site remained deprived of alga till now. But a few Caulerpa bushes at nearby locations which were not treated gave rise to an actual extension of alga in the area of about 13 250 m2. Although tropical by its origin, *Caulerpa* has survived low winter temperatures of only 9°C and by now it is patchily distributed at the Malinska breakwater, the town beach and at the Haludovo hotel complex. The settlement cartography was elaborated by Zavodnik et al. (2).

The aim of present study was to get an insight into the mobile and sediment living benthos covered by *Caulerpa* carpet. The area was surveyed monthly from December 1997 till November 1999. Data were compiled by divers' visual census and manual collections along transects crossing the algal carpet, and by processing the sediment taken from 25 x 25 cm plots.

At sites noted above *Caulerpa* was mostly anchored by cauloids in the sandy sediment at a 6-8 m depth. Only a few fronds were attached to a large litter and pebbles which supported other seaweeds too. Sparse *Zostera noltii* and *Cymodocea nodosa* meadows also appeared at some sites. In the upper sediment layer the seagrass roots and *Caulerpa* cauloids were densely intermingled. A preliminary note on associated seaweeds was provided previously (2). Red algae *Laurencia obtusa, Polysiphonia spp., Rhytiphloea tinctoria* and *Vidalia volubilis* were common in all seasons. Brown algae were represented by *Dictyopteris polypoides, Dictyota dichotoma*, two *Halopteris* species, and others. Among green algae, *Cladophora albida, C. prolifera* and *Ulva rigida* were outstanding. On *Caulerpa* fronds 26 epiphytic species were noted.

Information on macrofauna noted by divers (i.e. visual census) and on that extracted from sediment batches was rather diverse (Fig.1). Total 114 invertebrate species were noted. Diversities of high taxa were similar to those noted in the western Mediterranean (3, 4), except of molluscs which at Malinska were more diverse. The presence index of 40% or more was established only in the following species: *Musculus costulatus, Anomia sp., Lucinella divaricata, Parvicardium ovale, Plagiocardium papillosum, Gouldia minima, Pitar rudis, Corbula gibba, Rissoa similis, Euspira nitida, Nassarius incrassatus, Eunice oerstedi, Lumbrineris fragilis, Scoloplos armiger* and *Ophiura albida*. Dominate taxocoenes of the sediment living meiofauna were Copepoda (62 %) and Nematoda (21 %) (A. Travizi, personal communication). A detailed analysis on the matter will be presented in another paper.

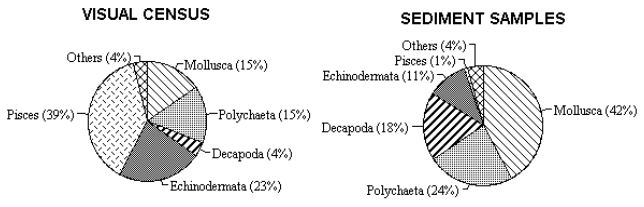

Figure 1. Species diversity of macrofauna in the *Caulerpa taxifolia* community at Malinska.

Only 12 fish species were noted at our *Caulerpa* patches. Consequently, the ichthyofauna of studied sites was poor in comparison to fish populations of compact and well distributed *Caulerpa* communities in the western Mediterranean (5, 6). Though, the stay of *Hippocampus ramulosus* on *Caulerpa* fronds, and browsing on *Caulerpa* of *Sarpa salpa* should be noted. Regrettably, biological data on the sites of research before the *Caulerpa* invasion are lacking; therefore, evaluation of eventual alterations of benthos is not possible.

Acknowledgement.
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LES POPULATIONS DU GENRE MYTILUS AU MAROC : STATUT TAXINOMIQUE ET RÉPARTITION GÉOGRAPHIQUE

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Résumé

Au Maroc, la systématique du genre Mytilus est restée confuse et incertaine en raison de l'utilisation des caractères morphométriques peu fiables. Dans le présent travail, l'utilisation des marqueurs allozymiques montre clairement la présence exclusive du taxon *Mytilus galloprovincialis* aussi bien en Méditerranée qu'en Atlantique et révèle également que sa distribution géographique s'étend jusqu'à une limite méridionale qui englobe l'ensemble des côtes du Sahara marocain. Les faibles valeurs de distance génétique obtenues reflètent un flux génique important entre les populations atlantiques et méditerranéennes et probablement aussi une mise en place récente du peuplement de *Mytilus galloprovincialis* le long des côtes marocaines.

Mots clés : Mytilus. Electrophorèse. Méditerranée. Atlantique. Systématique

La littérature qui traite de la systématique du genre Mytilus est abondante et peut être scindée en deux catégories d'après l'historique et la nature des critères utilisés. Les premiers travaux avaient pour objet d'établir une clé de détermination sur la base des caractères morphométriques de la coquille et ont montré leur limite à différencier les taxons de ce groupe notamment *M. edulis* et *M. galloprovincialis*. Les plus utilisés à cet effet sont la forme de la coquille, la forme de l'empreinte du muscle adducteur antérieur et le nombre de dents cardinales. La majorité des auteurs reconnaissent que la coquille est sujette à de fortes variations en fonction des facteurs du milieu (1, 2), ce qui rend délicat la détermination des individus sur la base de la morphométrie. Laquelle peut constituer une source d'erreur, de confusion et de controverse. En revanche, la génétique notamment grâce aux données d'électrophorèse constitue un outil performant dans la diagnose des taxons de ce groupe. Ce qui explique sa large utilisation à cet effet dans plusieurs régions du monde. Ainsi, Koehn et coll. (3) ont mis en évidence l'existence de *M. edulis* et de *M. trossulus* sur la côte pacifique de l'Amérique du Nord. En Angleterre, Skibinski et coll. (4) ont pu décrire la présence des deux taxons *M. edulis* et *M. galloprovincialis* sur les côtes britanniques. D'autres travaux plus récents ont permis de préciser le statut taxinomique des populations du genre *Mytilus* dans d'autres régions du monde notamment la présence exclusive de *M. galloprovincialis* en Méditerranée française et la présence simultanée de *M. edulis* et de *M. galloprovincialis* sur le littoral atlantique de France (5) et la présence de *M. galloprovincialis* sur les côtes atlantique et méditerranéenne de la péninsule ibérique (6). L'identification se fait toujours 1) en utilisant un échantillon témoin dont la détermination est préalablement établie d'après les travaux pionniers précédemment cités et servant de référence ; et 2) en analysant des locus dont la valeur diagnostique est déjà connue, ces locus sont MPI, ODH, EST-D, PGI et LAP.

Sur les côtes marocaines, là où les gisements naturels du genre *Mytilus* sont à la fois abondants et denses, la situation est restée confuse. Les seules informations disponibles émanent de simples observations de terrain ou de l'examen sommaire de quelques caractères morphologiques sur peu d'individus. Ces informations sont insuffisantes dans la mesure où de larges zones côtières n'ont pas été prospectées, incertaines voire même contradictoires parfois quant au statut taxinomique attribué. Dans le but de connaître le statut taxinomique des populations marocaines, onze stations ont été échantillonnées (Fig. 1). Il s'agit de Nador, Cabo Negro et Ksar-Sghir en Méditerranée, et d'Asilah, Guy-ville, Azemmour, Essaouira, Taghazout, Mirhleft, Tantan et Dakhla en Atlantique. Les échantillons prélevés (50 à 60 individus par station) ont été comparés à un échantillon témoin provenant de Sète (Méditerranée française) représentant le taxon *M. galloprovincialis* par électrophorèse des protéines enzymatiques à plusieurs locus dont ceux connus pour être totalement ou partiellement diagnostiques.

Résultats et discussion

Les résultats préliminaires obtenus notamment par l'analyse des locus diagnostiques montrent qu'au Maroc, aussi bien en Méditerranée qu'en Atlantique seul le taxon *M. galloprovincialis* existe. En effet, au niveau des deux locus hautement diagnostiques MPI et ODH, les échantillons marocains présentent les mêmes allèles que l'échantillon témoin. D'après ces mêmes résultats, la distribution géographique du genre Mytilus en Afrique du Nord s'étend jusqu'au sud de Dakhla (Sahara marocain) et se poursuit vraisemblablement sur les territoires mauritaniens. Ce qui confirme d'ailleurs les résultats de Daguin et Borsa (7) obtenus sur des échantillons de ces régions mais en utilisant le polymorphisme à un marqueur d'ADN nucléaire révélé par la PCR : le locus mac-1. Ces auteurs établissent clairement la présence de *Mytilus galloprovincialis* dans la région de Cansado en Mauritanie.

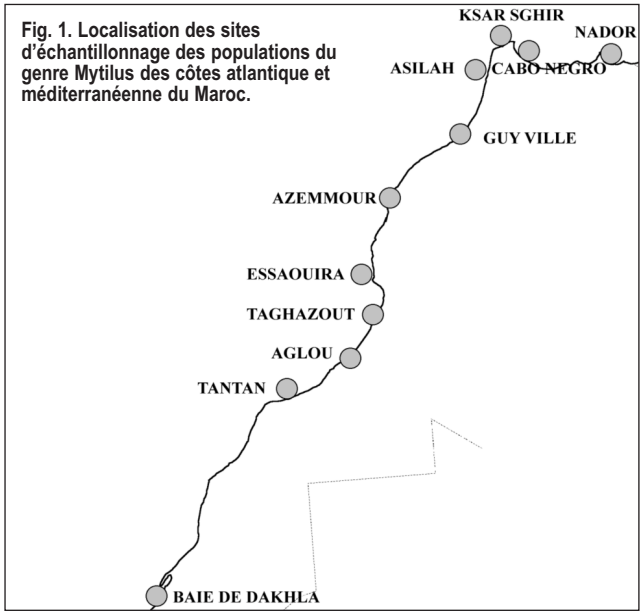

Fig. 1. Localisation des sites d'échantillonnage des populations du genre Mytilus des côtes atlantique et méditerranéenne du Maroc.

Les valeurs de distance génétique obtenues d'après l'indice de Nei (1978) entre les populations atlantiques et méditerranéennes sont dans l'ensemble faibles, traduisant un faible taux de différentiation génétique interpopulationnelle et témoignent selon toute vraisemblance d'une mise en place récente de ces peuplements (au cours du plio-quaternaire) et de l'existence d'un important niveau de flux génique homogénéisateur sous le contrôle exclusif de la phase larvaire pélagique. En effet, les déplacements larvaires peuvent être parfois de grande ampleur en particulier sous l'action des courants marins.

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RECRUITMENT AND DENSITIES OF *LORIPES LACTEUS*, A BIVALVE CONTAINING CHEMOAUTOTROPHIC SUMBIONTS, IN *A CYMODOCEA NODOSA* BED IN A COASTAL LAGOON

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Abstract

Loripes lacteus (bivalve) inhabiting a *Cymodocea nodosa* seagrass bed in a lagoon in Corsica was studied over a one year period. Bivalve densities within the sediment exhibited a high degree of heterogeneity. Recruitment was high in January, followed by a period of low level recruitment in May and a steady increase in the number of juveniles from September to December. Neither bivalve densities nor recruitment seem to correlate with water temperature, % organic matter of sediment, seagrass above- and below-ground biomass.

Key words: bivalves, symbiosis, phanerogams, lagoons

Introduction

Symbiotic chemoautotrophic bacteria occur in the tissues of a number of invertebrates where sulphide is present in their environment (1). These symbiotic bacteria provide the host with part of its nutritional requirements by chemosynthetically fixing carbon dioxide via aerobic oxidation of sulphide (2). Marine molluscs containing sulfur-oxidizing chemoautotrophic bacteria can be quite abundant in seagrass beds (3) and while large number of studies have been undertaken to characterize extreme reducing environments such as those at hydrothermal vents, very little attention has been given to characterizing lucinid habitats in littoral zones. The present work is a study of a lucinid bivalve, *Loripes lacteus*, inhabiting a *Cymodocea nodosa* seagrass bed in a lagoon in Corsica (France). The lucinid's habitat was characterized and the importance of this habitat on the lucinid population was evaluated.

Materials and Methods

Sampling was performed within the Urbino lagoon (Corsica France) from January to December 2000 by SCUBA diving, with a sediment corer of 162 cm^2 (for a sediment depth of 0-20 cm). Sediment samples were sieved on a 1 mm mesh to retrieve the clams and phanerogam tissue. We measured (i) clam size (in mm at their largest point), (ii) animal body weight (weight weight/m^2). (iii) above- and below-ground phanerogam biomass (dry weight/m^2) and (iv) organic content of sediment (% of dry weight).

Results and Discussion

Habitat characteristics: The % organic matter of the sediment was low (annual mean: 1.3%) and varied significantly throughout the year with higher values recorded in summer (Figure 1). These values are lower than most reported values for sediments containing lucinids (2 to 7%) (2, 4). Lucinid species are frequently found in seagrass sediments (3) due to the abundance of organic material. Such organic matter levels lead to an elevated activity of sulfate-reducing bacteria and the production of high levels of hydrogen sulfide (1, 5).

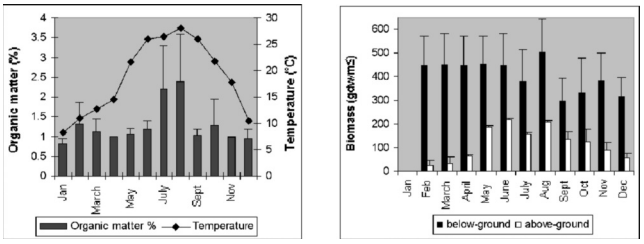

Figure 1: Left: Organic matter content of sediment and water temperature Right: Above- and below-ground biomass of *Cymodocea nodosa* seagrass bed (no biomass data for January).

Significant differences were observed in *Cymodocea nodosa* above- and below-ground biomass throughout the year (Figure 1). Above-ground biomass values were significantly greater during warm months than in colder months. Below-ground biomass values were relatively constant with a maximum in August and a minimum in September. Biomass in *Cymodocea nodosa* generally exhibits seasonal patterns with minimal leaf biomass in winter (6). Both the above- and below-ground biomass values are on the high end of the scale of literature values (6).

Bivalves : Bivalve densities varied throughout the year with periods of extreme density heterogeneity (Figure 2). There were thus no significant differences between the months. Mean *Loripes lacteus* density was 740 + 177 individuals/m^2, which is at the higher end of the scale of reported lucinid densities (3).

The 0-6 mm size class was counted to identify periods of recruitment. Juveniles were very abundant in January. An apparent low level recruitment was observed in May, followed by a steady increase in juvenile numbers from September to December. Neither bivalve densities nor recruitment seemed to correlate with the parameters measured (water temperature, % organic content of sediment, seagrass above- and below-ground biomass). Indeed, recruitment was observed during the colder months, when organic carbon content and *C. nodosa* biomass are at a minimum. A study of *Loripes lucinalis* similarly revealed that spawns did not correlate with the environmental factors often associated with spawning (temperature, chlorophyll a) (7). The high sediment carbon contents observed here in July and August may partly explain these results. Indeed, such high carbon loading generally involves a depletion in oxygen, leading to extensive sulfate reduction and the accumulation of sulfides (2). It is this dissolved sulfide that provides the energy source used to drive the bacterially-mediated carbon fixation (1) used in these types of chemoautotrophic symbioses. Thus, after a certain lag period, the high summer carbon loading would lead to the production of hydrogen sulfide. This added sulfide resource may stimulate the chemoautotrophic symbioses, with the production of energy that could be allocated to reproduction. This would of course imply that hydrogen sulfide is limiting during other periods of the year. It is clear that more work is needed to further characterize the seagrass environment before a better understanding of the role of seagrass habitat in chemoautrophic population dynamics can be reached.

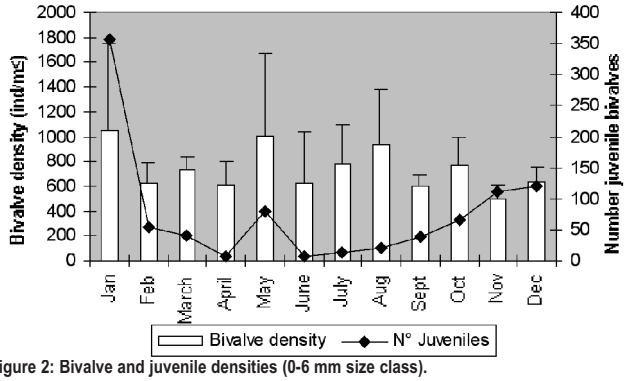

Figure 2: Bivalve and juvenile densities (0-6 mm size class).

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QUATRE ANS DE SUIVI DE LA NIDIFICATION DE LA TORTUE MARINE *CARETTA CARETTA* AUX ÎLES KURIAT (TUNISIE)

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Résumé

La tortue marine *Caretta caretta* nidifie en Tunisie principalement aux îles Kuriat et ce durant les mois de juin et juillet. Le nombre de nids, important une année sur deux, varie de 3 à 15 avec une moyenne de 9 pour les années concernées par le monitoring. Les femelles de 79,2 cm en moyenne pondent en moyenne 91,27 œufs par nid. Les taux d'éclosion et d'émergence sont respectivement de 76,3 et 74 ,41%.

Mots-clés : turtles, monitoring, conservation, islands, reproduction.

Introduction

Trois espèces de tortues marines fréquentent les eaux tunisiennes : la caouanne *Caretta caretta* est commune et s'y reproduit, la tortue luth *Dermochelys coriacea* régulièrement observée (1) et la tortue verte *Chelonia mydas* rarement signalée (2).

La nidification de *Caretta caretta* a été mise en évidence pour la première fois en 1988 sur la plage située entre Ras Dimas et Mahdia et sur la grande Kuriat (2), ensuite sur la petite Kuriat en 1993 (3) et à la Chebba en 1994, 1995 (4) et 2000 (Bradai, comm. pers.). Actuellement, les plages de la grande Kuriat représentent le site le plus important pour la nidification en Tunisie et font l'objet avec celles de la petite Kuriat d'un monitoring organisé et financé par l'Institut National des Sciences et Technologie de la Mer (INSTM), l'Agence de Protection et de l'Aménagement du Littoral (APAL) et le Centre d'Activités Régionales pour les Aires Spécialement Protégées (CAR/ASP) depuis 1997. Ces îles sont situées au sud du golfe de Hammamet à environ 18Km au large de la ville de Monastir.Dans cette note, nous présentons les résultats des quatre années du suivi de cette nidification sur ce site.

Matériel et méthodes :

Chaque année, un campement prend place sur la grande Kuriat durant les mois de l'été de juin à août. Des prospections nocturnes sont régulièrement effectuées pour guetter les femelles nidifiantes. Les femelles observées sont mesurées et marquées après la ponte. Les mensurations retenues sont la Longueur Courbe Standard de la Carapace (SCCL) et la Largeur Courbe de la Carapace (CCW). Les marques de couleur bleue utilisées portent le numéro et l'adresse du Centre des Activités Régionales pour les Aires Spécialement Protégées (CAR/ASP). Les nids déposés sont protégés du piétinement par des cages métalliques qui ont servi également pour la sensibilisation du public.

Après l'émergence des nouveau-nés, les nids sont ouverts pour déterminer :

- Le nombre total des œufs = nombre des œufs éclos + nombre des œufs non éclos ;
- Le taux de fertilité = (nombre des œufs fertiles/ nombre total des œufs)*100 ;
- Le taux d'éclosion = (nombre des œufs éclos/ nombre total des œufs)*100 ;
- Le taux d'émergence = (nombre des œufs éclos – nombre des nouveau-nés morts dans le nid /nombre total des œufs)*100.

Un échantillon de nouveau-nés est examiné chaque année pour mesurer à l'aide d'un pied à coulisse la Longueur Droite Minimale de la Carapace (MSCL) et la Largeur Droite de la Carapace (SCW). Les différentes plaques de la dossière sont par ailleurs comptées.

Résultats et discussion

Environ un tiers de la grande Kuriat est rocheux et se situe au Nord-Nord-Est de l'île. Le reste est sableux. La plage de ponte, d'environ 900 m de longueur, coïncide principalement aux côtes ouest. Toutefois, nous avons détecté quelques nids sur la plage sud-est qui est généralement envahie par des dépôts énormes de feuilles mortes de posidonie faisant parfois obstacle aux montées des femelles nidifiantes.

Au cours des quatre ans de suivi de la nidification, 36 nids ont été recensés sur la grande Kuriat. Tous ces nids ont été déposés au cours des mois de juin et juillet.

De 1993 à 1996, Bradai (5) constate que le nombre des nids sur les îles Kuriat est relativement important tous les deux ans. Cette tendance a été confirmée pour les années 1997 à 1999 de monitoring mais l'année 2000 a fait exception (Tableau 1). Le nombre de nids élevé au cours de cette année serait expliqué en partie par des nouveaux recrutements de femelles nidifiantes ou/et l'abandon de la madrague installée les années précédentes dans les parages du site ou/et l'effet positif de l'effort de protection du site de ponte des îles Kuriat depuis 1997.

Tableau 1 : Nombre de nids déposés annuellement sur les îles Kuriat

Année	1993	1994	1995	1996	1997	1998	1999	2000
Nombre de nids	11	4	15	3	11	5	7	13

Les longueurs carapace courbe (SCCL) des cinq femelles observées varient de73 à 85cm. La moyenne étant de 79,2 cm (Tableau 2). L'intervalle inter-ponte serait de 15 jours. L'estimation de Jribi (6) de ce paramètre pour la campagne 1997 est également de cet ordre.

Tableau 2 : Mensuration des femelles nidifiantes sur la grande Kuriat

	Nombre de saisons	Moyenne (min-max)	Valeurs individuelles (min-max)
SCCL (cm)	4	73-78,5	73-85
CCW (cm)	4	66-69	63-69

Durant ces quatre années de suivi de la nidification, la taille de ponte moyenne de 30 nids non perturbés de *Caretta caretta* est de 91,27 œufs par nid. Les taux de fertilité sont élevés et varient de 81,65 à 96,62% avec une moyenne de 91,59%, ceux d'éclosion et d'émergence des nouveau-nés sont respectivement de 76,3 et 74,41%.

Les différents caractères métriques et méristiques de 349 nouveaux-nés examinés sur le site de la grande Kuriat sont consignés dans le tableau 3.

Tableau 3 : Caractères morphométriques des nouveaux-nés aux îles Kuriat (campagne 2000)

	Moyenne MSCL (cm)*	Moyenne SCW (cm)*	P.V	P.C	P.M	P.infM
N-n	4.15	3.24	5	5	12	3

Conclusion

La grande Kuriat représente le site de ponte de la tortue marine *Caretta caretta* le plus important connu en Tunisie. Après quatre années de monitoring, le nombre de nids pour l'année 2000 est relativement élevé. Doit-on voir dans ces résultats un effet heureux de ce monitoring instauré depuis 1997 ? Il est encore trop tôt pour l'affirmer mais les années qui viennent confirmeront peut-être ce fait.

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EUTROPHICATION IN IZMIR BAY (EASTERN AEGEAN) : NUTRIENT LIMITATION AND MONITORING OF LONG-TERM EFFECTS

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Abstract

The distribution of inorganic nutrients and phytoplankton chlorophyll-a are investigated in Izmir Bay during 1996-1998. The concentrations of nutrients ranged between 0.01-10 μM for o.PO_4-P; 0.11-82 μM (NO_3+NO_2)-N; 0.37-39 μM Reac-Si. The results are compared with the values obtained from the relatively unpolluted waters of the Aegean Sea. Nitrogen is the limiting element in the Izmir Bay. The eutrophication of the Inner Bay has already started, spreading progressivily to the other parts of the Bay. Phosphate which originate from detergents is an important source for eutrophication in the Bay, especially in the Inner Bay.

Keywords: Phosphorus, eutrophication, Eastern Aegean

Introduction

Izmir Bay is located in the western part of Turkey and surrounded by a densely populated community. The Bay has been divided into three sections (Outer, Middle and Inner) according to their physical characteristics related to their contents of the different water masses. The Middle Bay is separated from the Inner Bay by a 13 m deep sill (Yenikale Strait). There are series of islands parallel to the west coast of the Bay. The narrow Mordogan Strait, which is between Uzunada and the West Coast, has a sill of 14 m depth. The Gediz river which flows to the Outer Bay is the biggest river in the Izmir Bay. The Inner Bay is heavily polluted by nutrients and organic material. The main source of pollution are streams and hundreds of small domestic discharge outles which flow to the Bay. Fishing, industrial activities, port activities and tourism are the main sources of income for the region. Most of the industries in Izmir are located in the Inner Bay region. 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 characterization and influence of domestic and waste water to the Izmir Bay (1,2,3) and on measuring the oceanographic characteristics (4,5,6,7). The distributions of inorganic nutrients and chlorophyll-a were investigated in Izmir Bay. The main aim of this study is to access the level of the eutrophication and to determined the limiting nutrients.

Material and Methods

The data were collected during cruises of R/V *K.Piri Reis* in 1996-1998 at 28 sampling points, in the framework of a "Izmir Bay Marine Research Project" supported by Izmir Metropolitan Municipality. The locations of sampling areas are given in Figure 1.

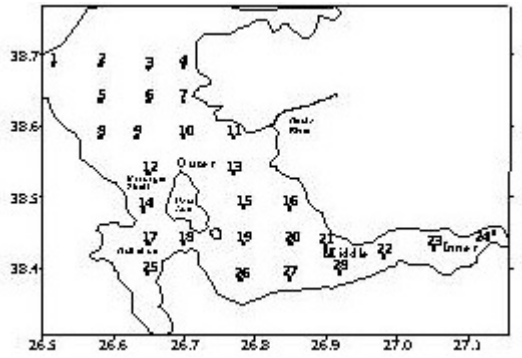

Figure 1. Location of stations in the Izmir Bay

Seawater samples were collected by Niskin bottles at standard depths and filled in 100 ml poltetilen bottles which had been prewashed with 10 % hydrochloric acid and immediately frozen until analysis. (Nitrate+Nitrite)-Nitrogen, o-phosphate phosphorus, reactive Si and chlorophyll-a were measured spectrophotometrically according to Stricland *et al*.(8).

Results and Discussion

Outer Bay : During winter and autumn, Nitrate+Nitrite concentrations were generally higher than those of spring and summer periods. The nutrient concentrations were low because of consumption for phytoplankton growth. The average of Nitrate+Nitrite concentrations were ranged between 0.11-3.5 μM (Table.1). There is no significant seasonal variation between sampling periods.

The seasonal variations of o.phosphate-phosphorus, reactive Si, (Nitrate+Nitrite)-Nitrogen and chlorophyll-a concentrations are illustrated in Figure 2. In the Outer Bay, nutrient results are similar to the Aegean Sea. There is no significantly changes with increasing depth for ortho-phosphate concentrations. Maximum values were recorded during autumn and winter periods because of low consumption by phytoplankton. In the winter periods, chlorophyll-a concentrations were increased in the Outer Bay due to Gediz River. The spatial and vertical distribution of nutrients affect the distribution of phytoplankton.

Table 1. Nutrient concentrations in Izmir Bay, Aegen and Mediterranean Seas (µM)

Parameter	Outer bay	Middle Inner Bay	Aegen Sea (9,10)	N.E Mediterranean (11)
o.PO_4-P	0.01-0.37	0.01-10	0.01-0.30	0.01-0.24
(NO_3+NO_2)-N	0.11-3.5	0.12-82	0.10-3	0.05-6
Reac-Si	0.30-7.4	0.50-39	0.30-3	1-11
N/P	5.7-13.7	2.1-8.2	13.6-36.8	

Middle and Inner Bay : The concentrations of nutrient were higher in the Middle and Inner Bay than the Outer part of the Bay. Maximum o.phosphate-phosphorus and (Nitrate+Nitrite)-Nitrogen concentrations were observed during autumn due to bacterial degradation in the Inner Bay.

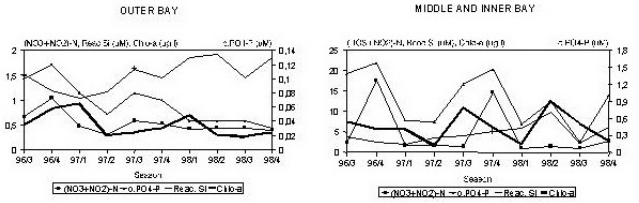

Figure 2. Seasonal changes of nutrient and chlorophyll-a concentrations in Izmir Bay

The N:P ratio are given in Table 1 and is significantly lower than the assimilatory optimal (N:P=15:1) in conformity with Redfield's ratio N:P=16:1. Nitrogen is the limiting element in the Izmir Bay. The eutrophication of the Inner Bay has already started, spreading progressivily to the other parts of the Bay. Phosphate which originate from detergents is an important source for eutrophication in the Bay, especially in the Inner Bay.

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MACROPHYTES OF THE LEBANESE COAST (LEVANTINE BASIN) BIODIVERSITY AND DISTRIBUTION

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Abstract

A phytosociological study of the Phytobenthos was carried out along the coast of Lebanon during 1998-99. Samples were collected at six sites covering the supralittoral, mediolittoral and infralittoral zones. Floristic inventory, composition, abundance and taxonomic diversity of algal community were analyzed in relation with some environmental factors. A total of 243 taxa were identified, including three phanerogams. Different sources of pollution, resulted in reducing the biomass of macroalgae and the species diversity. Several Indo-Pacific species were found within the different phytocoenoses; most of them were introduced into the Levantine Basin through the Suez Canal.These Lessepsian migrant species into the Eastern Mediterranean formed new settlements of populations; some of them were highly spread to overcame other endemic species or even they replace them.

Key-words: Macrophytes, Lebanon, Biodiversity, Distribution, Phytosociology

Knowledge related to macroalgae of the Lebanese coast is very scarce. Few studies were done showing the coastal distribution and zonation of the community species and the impact of pollution on the distribution of the species (1;2). Other works on macroalgae were performed on Syrian coast (3), Palestinian coast (4;5;6) and Mediterranean Egyptian littoral (7).In this paper we present further information concerning the distribution of species and biodiversity of the algal community along the coast of Lebanon.

Material and methods

Six sampling stations were chosen along the coast of Lebanon from 10 km south of Beirut (34º55'N;35º33'E) to 71 km northern (33º55'N-35º28'E). All stations are typically coastal limestone platforms in the subtidal to wave-wash zone. They were sampled at two seasons: spring (April-May) and summer (July-August) during 1998-99. Sampling points covered the supralittoral, mediolittoral and infralittoral zones, according to the bionomic nomenclature (8;9). Intertidal stations were sampled directly, while for the sublittoral, we used scuba diving techniques .The taxonomic diversity was determined in using the formula : D = S–1 / log B, where S is the number of species found in the quadrate; log is the natural logarithm ; B is the algal biomass in g/m^{-2} .

Results and discussion

The marine flora of the Lebanese coast is poor in biomass contrasting with a rich taxonomic diversity. At all levels, 243 species were found including 25 *Cyanophyta*, 58 *Chlorophyta*, 29 *Phaeophyta*, 127 *Rhodophyta*, 3 *Monocotyledones* .The Phanerogams are represented by *Halophyla stipulacea, Cymodocea nodosa* and *Zostera noltii*, the only Xanthophyte representative was *Vaucheria* sp. (10). Although the amplitude of the tide is very low (15-20 cm), the composition and the vertical distribution of algae are more or less similar to that of the west Mediterranean. However, some dissimilarity in the abundance and the seasonal distribution of the species between the two Mediterranean basins is reported. The most distinctive feature in the composition of the marine flora of this area is the presence of many introducing tropical species, mostly Indo-Pacific. Supralittoral level is dominated by *Hormathonema sphaericum, Hyella caespitosa, Anabaena* sp.,*Oscillatoria nigroviridis, Chroococcus turgidus, Hydrocoleus lyngbyaceus, Phormidium ambiguum, Rivularia mesenterica*. In the Intertidal zone (mediolittoral) 148 species were reported from all stations. Upper mediolittoral is characterized tolerating species to exondation and dessication.Two associations characterize this level: *Porphyra leucostica-Enteromorpha compressa* and *Nemalion-Polysiphonia* with many accompainying species. Lower mediolittoral is occasionally exposed to exondation; the algae are less tolerant to dryness. Two groups of species characterize this level: photophile group species of *Vermetus* platforms and group of *Laurencia paillosa*. Infralittoral level (subtidal) is the richest in species; maximum of 190 taxa were recorded in this zone; many of them are also common in the mediolittoral. The boundary between the medio and infralittoral is not clear because of the seawater level variations. However we can distinguish the limit between these two zones by the presence of two species that need a permanent immersiom : *Cystoseira amentacea* and *Sargassum vulgare*, indicators of low-water tide. Many tropical and subtropical species are present in the infralittoral; mostly are introduced Lessepsian species of Indo-Pacific origin. Two assemblages characterize the upper subtidal: the first is *Jania-Bryopsis-Liagora* , the 2nd includes *Jania-Padina-Dasycladus*. This level present a calm photophile environment. Sediment substratum is characterized by the dominance of the three occurring phanerogams *Zostera noltii, Cymodocea nodosa* and *Halophila stipulacea* and by populations of *Caulerpa scalpelliformis, C. racemosa* and *C. prolifera*. characteristics of the Levantine Basin algal community. The main Indo-Pacific and Eritrean species introduced in the Mediterranean were reported by many authors (11-14). The most important are : *Acetabularia parvula, A,moebii, Caulerpa racemosa, C.scalpelliformis, Derbesia boergesenii; Stypopodiumshimperi; Acanthophora delilei, Asparagopsis taxiformi, Hypnea hamulosa, Liagora farinos, Lophocladia lallemandii*; and the phanerogams : *Halophila stipulacea*. 60% of the species present on the Lebanese coast are mentioned on Syrian coast (3) and 33% are common with the Red Sea (Table 1).

Table 1: Number of species common between Lebanese coast, Syrian coast and Red Sea

Taxa	Lebanon	Syria	Red Sea
Cyanophyceaea	25	13	3
Chlorophyceaea	59	29	18
Rhodophyceaea	126	77	34
Pheophyceaea	29	22	24

In conclusion we can say that algal community of the Levantine Basin, including Lebanese coast may be distributed into six biogeographical groups:

Mediterranean group : *Corallina elongata Cystoseira* spp.

Tropical and Temperate Atlanto-Mediterranean group : *Cladophora prolifera, Amphiroa rigida ,Dasycladus vermicularis, Anadyomene stellata*.

Circumtropical group : *Hypnea musciformis , H. hamulosa, H. cervicornis, Gelidium crinale, Gigartina acicularis, Bryosis plumosa, Asparagopsis taxiformis*.

Warm Boreal : *Porphyra leucosticta, Callithamnion corymbosum, Taonia atomaria*.

Circumboreal : *Enteromorpha intestinalis, E.clathrata, Ulva rigida*.

Indo-Pacific group : *Liagora farinosa, Acetabularia parvula, Stypopodium schimperi, Asparagopsis taxiformis, Caulerpa racemosa, C. mexicana , C. scalpelliformis*

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DEPOSITIONAL SUB-ENVIRONMENTS OF THE EMERGENT SIMETO RIVER DELTA SYSTEM (EASTERN SICILY)

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Abstract
A morphological and sedimentary study conducted in the emerged sector of Simeto delta system has carried out a marked distributions in the sedimentary facies and subfacies, related to presence of artificial levees and embankments, built starting from '50 with the aim to regulate the hydrological regime of the Catania Plain. This strong anthropogenic conditioning of the emerged delta has defined some sub-environments, in which sedimentary processes are today still active and other in which has not been recognised any trace of depositional/erosion activity.

Keywords: Ionian Sea, deltas, sediments.

Our research has been performed in the region of the Simeto River mouth (eastern Sicily). In this area – about 10 km^2 in extension – the study focuses on sedimentary facies as related to emergent depositional sub-environments (Fig. 1).

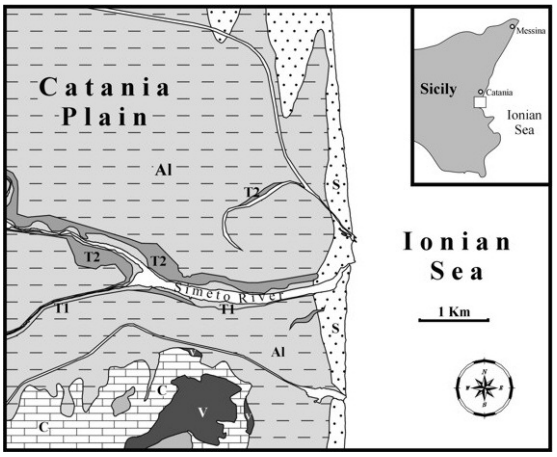

Fig. 1 Geolithological map of investigated area
Al = alluvail sands and silts. S = marine sands. T1 and T2 = fluvial terraces of 1st and 2nd order respectively. C = calcarenites. V = volcanites.

The Simeto River, 115 km long, has an drainage basin of 4.185 km2. It is the most important river of Sicily, its emergent delta dips into the Ionian Sea and it is characterised by well-defined depositional sub-environments, with marine to fluvial facies.

The emergent beach (zones of backshore and foreshore) is characterised by marine facies, with sandy sediments rich in bioclasts (facies A1 and A2). Some beachrocks (facies B) and dunes (facies C) of various extension are present as well.

Our study method has consisted in a historic cartographic analysis of the delta, aimed to define the morphologic variations that happened in the last 50 years.

In a second stage samples has been collected in the study area in order to define the textural characters of the sediments. Finally the main morphologic units has described on thematic maps.

In the innermost zone (backshore) the mapped fluvial facies are well zoned due to the artificial levees that have built in the '50, for controlling the surficial hydric discharge in the Catania Plain.

The depositional sequence is made of 2 orders of terraced fluvial deposits (facies D1 and D2). The most recent are made of flood sediments (facies E), the oldest (facies F) are made of sediments deposited outside of artificial levees and therefore associated to antecedent fluvial processes.

The study of the depositional sub-environments that characterise the emergent delta has been associated with the analysis of sediments aimed to distinguish the major morphologic units and the subfacies of the emerged system of the Simeto River (Fig. 2).

According to recent classifications in deltas (2; 3), we may distinguish:
- lower delta plain facies association. This is the area most influenced by the nearby sea where coastal swamps and abandoned meander lagoons are present;

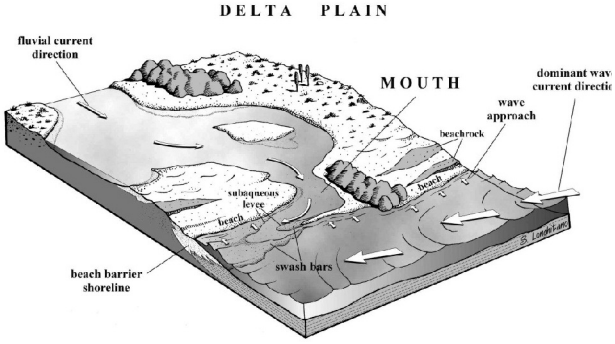

Fig. 2. 3D model of the area of the Simeto river mouth

- upper delta plain facies association. This is the internal most area of the drainage basin, including the internal stream water in which sedimentary processes are rare.

If we take into account the peculiar morphologic features of the Simeto River in its mouth we may also distinguish additional facies associations:
- inner delta plain facies, inside the artificial levees where the major fluvial sedimentation occurs;
- outer delta plain facies, external to the levees, where sedimentary processes are relatively scarce or absent.

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MORPHOLOGICAL AND SEDIMENTARY FEATURES OF THE SIMETO DELTA (EASTERN SICILY, ITALY):AN EXAMPLE OF MAN-ALTERED DELTA SYSTEM

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Abstract

This study illustrates the Simeto delta, an example of man-altered system, that during Holocene evolves from an active prograding delta to eroding coastal plain. Accelerated erosion is due, among others, to the construction of four dams, consequent entrapment of sediment, and effect of barrages and other factors of lower impact. Also considered important are natural factor, including climatic warm up of last 50 years and strong coastal current processes.

Keywords: deltas, sedimentology, coastal management.

The Simeto delta is one of the largest present-day deltas in Sicily and lies in the foothills of the Etna volcano, along the eastern coast of the island (Fig. 1). It represents a naturalistic protected area because of the characteristic faunal content.

The Olocene evolution of the delta suffered the control of both several geological hazards (earthquakes, volcanism, active tectonics) and of anthropogenic activity.

In particular the delta can be considered a man-altered system, that evolved from an actively prograding delta to an eroding coastal plain.

The drainage basin of the Simeto River consists of sedimentary terrains referable to the Apenninic Belt units and to the Plio-Quaternary cover, which occur on the right side of the river; the left side is instead represented by volcanic terrains belonging to the Etna volcano (1).

The Simeto alluvial and deltaic plain is formed mainly by sand, silt and mud, and extends for 4185 km2 with a low gradient and with over 130 km of water stream length. The delta system is located into a low-energy microtidal coastal environment, where river-mouth processes should dominate and marine influence should be minimal. During the last 10 years, however, the competence of the Simeto River decreased for natural and human influences and wave energy became predominant into other control factors.

In the '50 and '60 the emplacement of barrages and canals into the Catania Plain (2; 3), built to constrain the Simeto hydrological regime, has strongly influenced the development of sedimentary processes in the lower delta-plain sub-environments, causing a change in the distribution of the sedimentary facies.

Today the Simeto delta plain has stopped to prograde into the Ionian sea and is locally receding, causing important risks for the naturalistic heritage of the area. Accelerated erosion of the Simeto deltaic coast is attributed to the emplacement of four dams along the course of the river, to the destruction of dune ridges and their vegetation, to the emplacement of maritime and protection works, to uncontrolled withdrawal of sands and gravels from river beds and beaches. This caused a quick decrease in sediment supply, accentuated by reduction of annual meteoric precipitation and a strong environmental impact on to the entire coastal plain of the Simeto delta plain. This is mainly due to the lack of territorial planning of human constructions and of coastal management programs in this area (4).

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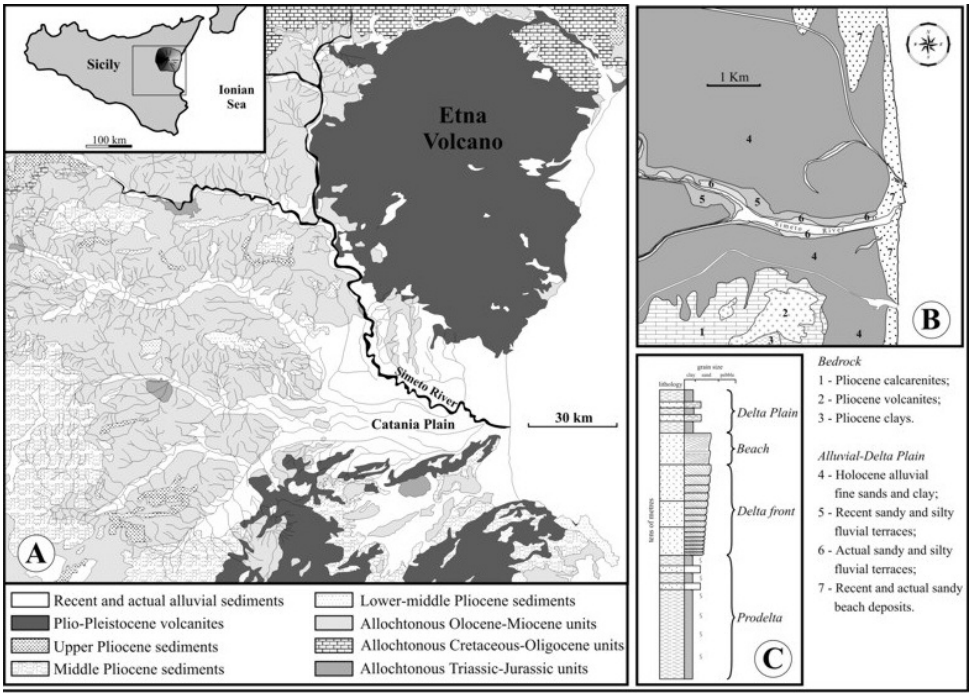

Fig. 1. Geological framework of Simeto drainage basin and its hydrologic network (A).
Lithologic setting of the delta plain of the Simeto river (B)
Presuntive stratigraphic log through the actual deltaic sequence (C)

STRUCTURE TROPHIQUE DES PEUPLEMENTS DE NEMATODES LIBRES D'UN MILIEU LAGUNAIRE ANTHROPISE : LA LAGUNE DE GHAR EL MELH (TUNISIE)

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Résume

Cette étude des peuplements nématologiques de la lagune de Ghar El Melh a révélé la prédominance des détritivores non sélectifs et la raréfaction des omnivores-prédateurs au niveau des stations continentales, les stations marinisées montrant une plus grande diversité trophique.

Abstract

The study of free-living nematode population of the Ghar El Melh lagoon revealed the predominance of generalist deposit feeders and the rarefaction of omnivores-predators at the continental stations. The nearest stations to the sea showed the greatest trophic diversity.

key words: Lagoon - Trophic relations - Metals - Salinity

Introduction

La lagune de Ghar El Melh, située au nord est de la Tunisie connaît depuis 1994 une régression de sa biodiversité. Une étude pluridisciplinaire a été entreprise avant son dans le but de décrire un état initial. Un intérêt particulier a été accordé à l'étude des peuplements de nématodes libres, ces derniers étant considérés comme indicateurs de différentes perturbations anthropiques (1, 2). Ce travail se limitera à présenter l'état actuel de leur diversité trophique en considérant 10 stations échantillonnées en juillet 1999.

Matériel et Méthodes

Pour l'étude faunistique, 3 carottes de sédiment de 10 cm^2 de section (3 ; 4) et de 18 cm de hauteur ont été prélevées à chacune des stations. Les nématodes ont été extraits par lévigation-tamisage puis observés à la loupe binoculaire. Un sous-échantillon représentatif (2 ; 3) a été utilisé pour la détermination de la structure trophique des peuplements nématologiques en se basant sur la structure de leur cavité buccale (5). Deux indices ont été considérés pour étudier la variation spatiale de la diversité des rapports alimentaires:

- l'index trophique $\Sigma\theta^2$ (1) égal à la somme des carrés des proportions de chaque catégorie trophique.
- le rapport des catégories trophiques 1B/2A (6).

Résultats

L'importance des détritivores non sélectifs (1B) varie au plan spatial. Ainsi, s'ils sont absents des sédiments de la station GM5, leur proportions sont comprises ailleurs entre 7.2 % (GM7) et 100 % (GM4). Cette catégorie alimentaire est, tous prélèvements confondus, la plus abondante et constitue 52.33 % de l'ensemble du peuplement. Les brouteurs d'épistrates (2A), qui occupent la deuxième place en terme de dominance globale (24.43 %) ont également une large distribution. Leurs dominances varient entre 0 % (GM4) et 100 % (GM5). Les détritivores sélectifs (1A), moins fréquents (15 %), sont absents au niveau des stations centrales GM5, GM6 et GM4. Leurs dominances fluctuent aux autres stations entre 0.98 % (GM3) et 43 % (GM9). Les omnivores-prédateurs (2B) ne représentent que 8.42 % de l'ensemble des nématodes recensés. Ils sont absents des sédiments de GM4, GM5 et GM10; leurs dominances fluctuent ailleurs entre 0.96 % (GM2) et 41 % (GM9).

L'indice de diversité trophique $\Sigma\theta^2$ varie de 0.36 (GM9) à 1 (stations centrales GM4 et GM5). Sa valeur maximale traduit la prédominance d'une seule catégorie alimentaire. Les valeurs du rapport trophique 1B/2A sont nulles à la station GM5 et maximales (19.2) pour le peuplement de GM10.

Discussion

La dominance des détritivores non sélectifs n'est pas directement liée à la nature des sédiments comme dans d'autres milieux (7). Leur prédominance au niveau des stations les plus continentales (GM1, GM2, GM3, GM4 et GM10) semble liée à l'abondance de matière organique provenant pour une large part d'apports terrigènes. L'abondance des détritivores non sélectifs au niveau des stations les plus chargées en sels est à l'origine de la corrélation positive (r = +0.72) enregistrée entre leurs proportions et les valeurs stationnelles de salinité. En effet, l'instabilité spatiale du paramètre halin explique la dominance, au niveau des stations continentales de la lagune, de nématodes nettement euryhalins comme les genres *Daptonema* et *Sphaerolaimus* (détritivores non sélectifs).

Les dominances des omnivores-prédateurs (2B) apparaissent négativement et significativement corrélées aux teneurs des sédiments en chrome (r =-0.87) et en plomb (r = -0.92), métaux susceptibles de favoriser la raréfaction de leurs proies. Ainsi, la proportion maximale d'omnivores-prédateurs relevée à la station marinisée GM9 paraît directement liée à l'abondance des proies et des particules alimentaires. Les omnivores-prédateurs qui regroupent généralement des espèces de grande taille comme les Encheliides se déplacent moins facilement dans les sédiments fins, ce qui explique la corrélation négative enregistrée entre leurs proportions et la teneur des sédiments en fraction fine (r=-0.95).

La corrélation positive constatée entre les valeurs du rapport 1B/2A et la salinité (r = +0.79) est liée à la prédominance des 1B au niveau des stations les plus continentales de la lagune, les plus salées en été. La corrélation positive notée entre les valeurs du rapport 1B/2A et les teneurs sédimentaires en hydrocarbures (r = +0.72) démontre d'une part la plus grande résistance des détritivores non sélectifs aux hydrocarbures (8) et au contraire la plus grande sensibilité des brouteurs d'épistrates; il s'en suit que la station GM4, la plus chargée en hydrocarbures, n'est peuplée que de détritivores non sélectifs. Ainsi, la corrélation négative observée entre les proportions des 1B d'une part et celles des 2A d'autres part (r = -0.73) traduit la divergence de leurs besoins trophiques et de leurs tolérances vis à vis des paramètres du milieu. Par ailleurs, l'index trophique $\Sigma\theta^2$ est positivement corrélé au potentiel rédox du sédiment (r = +0.65), les peuplements nématologiques étant moins équilibrés au plan trophique quand les sédiments sont moins riches en oxygène. La plus faible valeur de l'index $\Sigma\theta^2$ traduisant un meilleur équilibre trophique des peuplements nématologiques a été relevée en GM9, station la plus proche du milieu marin voisin. Celui-ci en enrichissant la lagune en nutriments et en oxygène et en stabilisant la salinité contribue à accroître la diversité trophique des nématodes libres.

Conclusion

La variation spatiale des caractéristiques environnementales de la lagune de Ghar El Melh est nettement mise en évidence par la structure trophique de ses peuplements de nématodes libres. Ainsi, il est observé une réduction de la diversité des catégories trophiques aux stations les plus chargées en sels, chrome, plomb et en hydrocarbures.

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ANALYSE EN COMPOSANTES PRINCIPALES DES RELATIONS EXISTANT DANS LA LAGUNE DE GHAR EL MELH (TUNISIE) ENTRE LES FACTEURS DU MILIEU ET LA STRUCTURE DES PEUPLEMENTS DE NEMATODES LIBRES

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Abstract

A PCA (Principal Component Analysis) was carried out on a data matrix from 10 sample sites and 24 variables to describe water and sediment qualities and the state of nematode assemblages in Ghar El Melh lagoon. According to the results, salinity and sediment quality are key factors for the nematofauna, while either dissolved oxygen and temperature are less structuring variables.

Mots-clés : Density - Biomass - Lagoons - Salinity - Sediment - Bio-indicators

Introduction

La lagune de Ghar El Melh, un plan d'eau de la Tunisie septentrionale, connaît depuis 1994, notamment en été, une réduction alarmante de ses ressources halieutiques. Ceci explique que les autorités aient commandité un vaste projet de recherche visant à diagnostiquer l'état actuel de cet écosystème. Dans le cadre de cette étude, il a été entrepris en août 1999 une analyse de la méiofaune et notamment des peuplements de nématodes libres, très sensibles à la qualité physico-chimique des eaux et des sédiments [1-3]. Afin de définir les paramètres abiotiques les plus limitants dans la lagune de Ghar El Melh, une A.C.P a été effectuée en considérant au total 10 observations (stations de collecte) et 24 variables stationnelles dont 9 descripteurs pour la qualité de l'eau, 10 représentatives de la qualité des sédiments et 5 pour définir l'état des peuplements nématologiques (Tableau 1).

Tableau 1 : Variables considérées dans la lagune de Ghar El Melh avec leur symbole ACP et leurs contributions relatives.

Compartiment	Variable	Symbole ACP	CTR F_1	CTR F_2	CTR F_3
	Densité moyenne (individus/10cm²)	DN	0,81	0,17	0,01
Nématofaune	Biomasse totale (µg/10cm²)	BT	0,76	0,19	0,02
	Biomasse individuelle (µg)	Bi	0,65	0,21	0,03
	Indice de Shannon (bits)	H'	0,72	0,17	0,00
	Equitabilité	E	0,61	0,12	0,01
Eau	NH_4 (mg N/l)	NH_4e	0,06	0,76	0,01
	PO_4 (mg P/l)	PO_4e	0,77	0,21	0,00
	Chlorophylle a (µg/l)	Ch.a	0,35	0,02	0,29
	Profondeur (m)	Pr	0,27	0,37	0,05
	Température	T°	0,18	0,02	0,48
	MES (mg/l)	MES	0,10	0,06	0,00
	pH	pH	0,58	0,06	0,05
	Salinité (g/l)	Sa	0,61	0,27	0,02
	Oxygène dissous (mg/l)	O_2	0,11	0,17	0,23
Sédiment	Carbone organique (%)	COT	0,38	0,01	0,37
	Hydrocarbures libres (mg/g)	HS	0,35	0,00	0,33
	Cr (ppm)	Cr	0,60	0,33	0,05
	Pb (ppm)	Pb	0,68	0,30	0,00
	Zn (ppm)	Zn	0,63	0,32	0,01
	Fraction fine<40 µm (%)	FF	0,68	0,30	0,00
	Hg (ppm)	Hg	0,07	0,07	0,36
	NH_4 (mg N/l)	NH_4s	0,86	0,04	0,00
	NO_3 (mg N/l)	NO_3s	0,53	0,00	0,01
	PO_4 (mg P/l)	PO_4s	0,14	0,04	0,78

Matériel et méthodes

Des échantillons d'eau et de sédiment ont été prélevés en août 1999 au niveau de dix stations de prospection. Trois carottes de sédiments de 10 cm² de section ont servi à l'étude de la nématofaune prédominante. Les animaux ont été colorés au rose bengale, extraits par lévigation-tamisage puis comptés sous binoculaire. Dans l'homogénat obtenu après mélange des trois replicats utilisés pour évaluer la densité moyenne, il a été prélevé au hasard un sous- échantillon de 100 nématodes pour la détermination spécifique et l'estimation des données pondérales. Les biomasses (poids frais) ont été calculées selon la méthode volumétrique d'Andrassy [4]. La diversité spécifique a été évaluée grâce à l'indice de diversité spécifique

$$H = -\Sigma \frac{ni}{N} \text{Log}_2 \frac{ni}{N}$$ et l'équitabilité, $$E = \frac{H'}{\text{Log}_2 S}$$

Plusieurs facteurs abiotiques ont été également mesurés (Tableau 1) et toutes les données brutes ont subi une transformation du type y = Log (x+1) pour homogénéiser les variances.

Résultats et discussions

Les trois premiers axes définissent 78,24 % de la variance totale. L'Axe F1 extrait 47,81 % de la variance totale. Son pôle positif est défini par tous les paramètres descripteurs de la nématofaune, corrélés très significativement entre eux ($r > 0,84$), avec de fortes contributions relatives (CTR)(Tabl.1). Du côté négatif, se projettent les teneurs des sédiments en ammoniaque, en fraction fine, en Pb, en Zn et en Cr ainsi que plusieurs paramètres des eaux (phosphates, salinité et pH). L'axe F2 (17,42 % de l'inertie) n'est bien défini positivement que par la teneur des eaux en ammoniaque. Sur l'Axe F3 (13 % de la variance totale) se projettent au pôle négatif la teneur des sédiments en phosphates et plus modestement du côté positif la teneur des sédiments en Hg.

L'axe F1 définit un double gradient inverse mettant en évidence la sensibilité des nématodes à la qualité du milieu avec :

➢ Un gradient croissant de richesse numérique et spécifique des peuplements nématofaunistiques de l'intérieur de la lagune vers la passe, les communautés étant appauvries au niveau des stations continentales (GM1, GM2, GM3, GM4, GM5 et GM6 et GM10).

➢ Un gradient décroissant de la qualité du milieu des stations marinisées (GM9, GM8, GM7) vers les stations continentales. La médiocre qualité du milieu au niveau de ces dernières est liée d'une part à l'état des eaux, plus salées et alcalines que la mer voisine et d'autre part à celui des sédiments chargés en ammonium et en fraction fine, laquelle favorise le piégeage de plusieurs métaux lourds tels le zinc, le chrome et le plomb.

De tous les facteurs abiotiques considérés, la salinité apparaît être la plus limitante pour la méiofaune. Ainsi, ce paramètre est négativement et très significativement corrélé aux densités de nématodes, à leurs biomasses individuelles et totales ainsi qu'à l'indice de diversité spécifique ($r > 0,76$). De fait, si plusieurs espèces de nématodes sont euryhalines [5], de récentes études menées en laboratoire ont montré que le cycle de développement des nématodes est fortement contrôlé par la salinité [6], des salinités > 35 g/l provoquant une mortalité massive des premiers stades larvaires de certaines espèces [7]. En comparant les données méiofaunistiques de plusieurs lagunes côtières, Castel [8] a montré que la salinité est un facteur clé dans la structuration des peuplements nématofaunistiques, tant au plan numérique que spécifique.

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BIOMETRIE DES HOLOTHURIES ASPIDOCHIROTES (HOLOTHUROIDEA : ECHINODERMATA) DE LA PRESQU'ÎLE DE SIDI-FREDJ – ALGERIE

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Résume

Notre étude porte sur une zone peu profonde de l'herbier à *Posidonia oceanica* de la presqu'île de Sidi-Fredj. L'échantillonnage s'est effectué entièrement en scaphandre autonome. Il consiste en des mensurations et prélèvements de cinq lots d'holothuries constitués de (115) *H. (Holothuria) tubulosa*; (46) *H. (Holothuria) stellati*; (108) *H. (Lessonothuria) polii*; (89) *H. (Panningothuria) forskali* et (88) *H. (Platyperona) sanctori*. Les relations taille-poids ont été établies pour chaque espèce. Les rapports Poids Humide du Corps/ Poids Sec du Corps obtenus sont comparés entre espèces et à la valeur standard établie pour les holothuries. Deux groupes d'espèces sont ainsi distingués.

Mot s- clés : Echinodermata, Biometrics, Posidonia, Algérian basin.

Les holothuries aspidochirotes sont des représentants majeur du compartiment benthique de l'écosystème à *Posidonia oceanica* [1, 2]. Elles jouent un rôle important dans le "detritus food web" [*in* 3] et participent activement au recyclage de la matière organique [4]. L'holothurie a la forme d'une "saucisse" [5, 6] molle à l'état de relâchement, rigide et dure à l'état de contraction [7]. En raison de la contractilité de leurs corps, très peu de travaux leurs ont été consacrés [8, 9]. Pour standardiser la technique de mesure, plusieurs méthodes ont été proposées : la longueur contractée [10, 8]; la mesure dans l'eau douce [11] et la longueur anesthésiée [12-4].

Matériel et méthodes

Les holothuries sont prélevées dans l'herbier de Posidonies de la presqu'île de Sidi-Fredj (Fig.1) sur une période s'étalant de juin à décembre 1994, avec une fréquence d'échantillonnage de 10 jours. La longueur contractée (LC) de chaque individu a été mesurée sous l'eau à l'aide d'une règle semi -cylindrique, avec une précision de ± 0.5 cm. Après mesure, chaque individu de chacune des espèces est mis dans un sachet. Les holothuries récoltées sont disséquées et vidées de leur tube digestif, rincés et lavés, puis égouttés. Le poids humide de la paroi du corps (PHC) et le poids sec de la paroi du corps (PSC) sont mesurés. Pour chaque espèce, des relations biométriques ont été établies entre : PHC-PSC; PHC-LC et PSC-LC. Les relations d'allométrie ont été calculés selon la formule PH= b LC^a (Huxley et Teissier [15]). Les coefficients d'allométrie (a) sont comparés à une valeur théorique C= 3. Les paramètres, ont été examinés par régression linéaire et par analyse de corrélation. Le test "t" de Student a été appliqué.

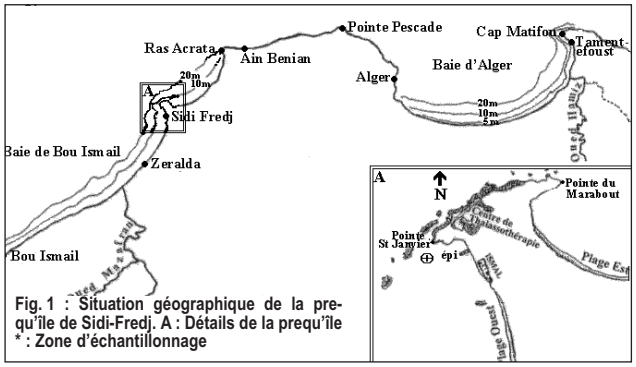

Fig. 1 : Situation géographique de la presqu'île de Sidi-Fredj. A : Détails de la prequ'île * : Zone d'échantillonnage

Résultats

1- Relations entre le poids humide du corps (PHC) et le poids sec du corps (PSC) (Fig.2)

2- Relations biométriques entre le poids humide du corps (PHC) et la longueur contractée (LC); poids sec du corps (PSC) et la longueur contractée (LC) (Tab. 1)

Discussion

Pour *H. (H.) tubulosa, H.(L.) polii et H. (H.) stellati* le PHC et le PSC évoluent dans la même direction (Fig. 2) ("t" de Student, p <0.05). Donc les proportions d'eau dans la paroi du corps montrent une petite variabilité. Ceci serait dû à leurs paroi coriace. Par contre, pour *Holothuria (P.) forskali* et *H. (P.) sanctori*, une légère déviation des droites par rapport à l'origine est observée (Fig. 2) ("t" de Student, p <0.05) exprimant une proportion d'eau plus importante. Ceci serait dû à l'élasticité de leurs corps. Les valeurs des pentes représentant le rapport PHC/ PSC (Tab. 1) se rapprochent de la valeur 10/1 établie par Newell et Courtney (13). Le rapport obtenu pour *H. (P.) forskali* diffère du résultat obtenu par [13] (Tab. 1). Ceci serait dû à la différence de l'effectif et à la méthode de mesure. Les équations obtenues pour *H. (H.) tubulosa* (Tab. 1) confirment les résultats obtenus par [6]. Le coefficient d'allométrie (b) étant inférieur à 3 pour les cinq espèces ("t" de Student, p <0.05) met en évidence une allométrie minorante : le poids du corps croit moins vite que sa taille. Les résultats obtenus pour *H. (H.) tubulosa* se rapprochent de ceux obtenus par Francour [8] (Tab. 1). Par contre, *H. (L.) polii* présente un coefficient d'allométrie plus élevé que celui trouvé par Francour [8] (Tab.1).

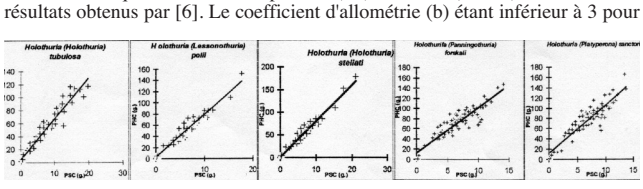

Fig. 2 : Relations biométriques établies entre le poids humide du corps (PHC) et le poids sec du corps (PSC) des deux groupes d'holothuries de laprequ'île de Sidi-Fredj

Tab 1. Relations biométriques établies à partir des paramètres mesurés pour les holothuries étudiées.

*LC (Longueur contractée en mm), PHC (Poids humide du corps en g.), PSC (Poids sec du corps en g.). r = coefficient de corrélation; N= effectif de l'échantillon ; * = longueur anesthésiée.*

Espèces	Y	x	N	Relations Biométriques (droites de régression)	r	Intervalle de taille (mm)
	PSC	PHC	115	$Y = 8.970\ x^{0.895}$	0.99	
H.(H.) tubulosa				(Y = 6.5336 x + 4.8502)	0.93	20 – 192
(1)	LC	PHC	115	$Y = 0.0013\ x^{2.1665}$	0.95	
	LC	PSC	115	$Y = 0.00006\ x^{2.378}$	0.94	
	PSC	PHC	108	$Y = 7.769\ x^{0.962}$	0.99	
H.(L.) polii				(Y = 6.4435 x + 2.0387)	0.96	10 - 180
(1)	LC	PHC	108	$Y = 0.0005\ x^{2.4035}$	0.95	
	LC	PSC	108	$Y = 0.00004\ x^{2.5019}$	0.96	
	PSC	PHC	46	$Y = 10.775\ x^{0.852}$	0.99	
H.(H.) stellati				(Y = 7.9771 x + 1.3318)	0.98	35 - 230
(1)	LC	PHC	46	$Y = 0.0035\ x^{1.9808}$	0.91	
	LC	PSC	46	$Y = 8.90265.10^{-5}\ x^{2.3034}$	0.91	
	PSC	PHC	89	$Y = 13.784\ x^{0.877}$	0.97	
H.(P.) forskali				(Y = 8.8945 x + 12.77)	0.93	15 - 170
(1)	LC	PHC	89	$Y = 0.0021\ x^{2.2286}$	0.93	
	LC	PSC	89	$Y = 0.00008\ x^{2.4158}$	0.91	
	PSC	PHC	88	Y = 14.035 x0.889	0.97	
H. (P) sanctori				(Y = 9.3865 x + 12.6841)	0.91	20 - 170
(1)	LC	PHC	88	$Y = 0.0043\ x^{2.0718}$	0.93	
	LC	PSC	88	$Y = 0.0002\ x^{2.2407}$	0.91	
H. tubulosa	LC	PHC	32	$Y = 0.0540\ x^{2.5267}$	0.96	30 - 190
(2)	LC	PSC	32	$Y = 0.0057\ x^{2.6539}$	0.96	
H. polii	LC	PHC	58	$Y = 0.4826\ x^{1.6640}$	0.89	40 - 140
(2)	LC	PSC	58	$Y = 0.0963\ x^{1.6577}$	0.86	
H. tubulosa (3)	PSC	PHC	577	$Y = 6.719\ x^{1.024}$	0.99	-
H. forskali (4)	PSC	PHC	49	(Y = 8.8945 x + 12.77)	0.95	155 - 275*

***(1)** Mezali, présent travail, (Sidi – Fredj - Algérie) - **(2)** Francour, 1990, (Port cros-France)*
***(3)** Bulteel et al., 1992 (Ischia-Italie) - **(2)** Astal et al., 1991, (Plymouth)*

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LA GESTION INTEGREE DES ZONES COTIERES : UNE STRATEGIE AU SERVICE D'UN EQUILIBRE DURABLE ENTRE TERRE, MER ET SOCIETE DANS LE BASSIN MEDITERRANEEN

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Résumé

Environ 60% de l'humanité vivant à moins de 60 kilomètres de la mer, le développement durable des régions côtières représente un des grands défis du temps présent. Il suppose une gestion intégrée de l'espace littoral à la fois terrestre et marin, la connaissance des interactions complexes entre ces milieux, l'étude des impacts des activités humaines actuelles ou projetées, et sur la base de synergies renforcées entre scientifiques et décideurs, l'élaboration et la mise en oeuvre de politiques de protection de l'environnement côtier. Une approche méthodologique novatrice adaptée aux spécificités de la façade méditerranéenne française est présentée.

Mots-clés : Protection de l'environnement littoral

La mobilisation internationale en faveur de la gestion intégrée des zones côtières, enjeu majeur pour les pays maritimes

Une fraction croissante de la population mondiale est concentrée dans des régions côtières. L'espace littoral terrestre et marin subit donc de plus en plus des nuisances résultant d'activités socio-économiques intensives dans la bande côtière (notamment industrie, agriculture, transports, urbanisation et tourisme). Ce milieu constitue de ce fait une des zones de la planète où l'impact de l'homme sur l'environnement se fait sentir avec le plus d'acuité. On comprend dès lors que la Conférence Mondiale des Nations Unies sur l'Environnement et le Développement tenue à Rio de Janeiro en 1992 ait mis l'accent sur le besoin d'une protection accrue des zones côtières (cf. chapitre 17 de l'Agenda 21). Celle-ci suppose que les Etats maritimes mettent en œuvre des stratégies de gestion intégrée et durable de l'éco-sociosystème littoral prenant en compte les interactions entre terre, mer et activités humaines. Diverses organisations internationales se sont préoccupées de cette question, en particulier l'OCDE (1), l'UNEP (2) et la Commission Océanographique Intergouvernementale de l'UNESCO-COI, qui a favorisé l'édition d'ouvrages pertinents (3,4,5) et a lancé récemment le programme ICAM (Integrated Coastal Area Management). En Méditerranée, la Convention de Barcelone marque la volonté des Etats riverains de protéger ce bien commun contre les pollutions. Complétant les investigations déployées sous l'égide de la CIESM, les initiatives du Plan d'Action pour la Méditerranée de l'UNEP visent à promouvoir des politiques de développement durable impliquant une réduction des émissions polluantes, notamment au niveau des zones côtières (6). Fin 1999, la COI a pour sa part organisé un séminaire de sensibilisation de chercheurs et décideurs de 9 pays méditerranéens aux enjeux de la gestion intégrée de l'espace littoral (7) ; par ailleurs, une conférence internationale sur ce sujet s'est tenue peu après en Turquie (8). La COI a contribué aussi à la mise sur pied, avec l'Université de Nice - Sophia Antipolis, du cours avancé international MICAM 2000 – Mediterranean Integrated Coastal Area Management-, principalement soutenu par la Commission Européenne et l'UNESCO, qui a rassemblé 51 participants de 20 pays et a fait ressortir une attente des pays méditerranéens en matière de formation dans ce domaine.

Les besoins de recherche interdisciplinaire et de synergies entre scientifiques et décideurs pour une gestion durable du littoral

L'élaboration de politiques de gestion intégrée du littoral doit s'appuyer sur une connaissance approfondie des processus naturels et des perturbations d'origine humaine affectant l'espace côtier, fortement soumis à des interactions entre la mer et son environnement terrestre. Celui-ci alimente le milieu marin en divers constituants provenant d'émissions naturelles et anthropiques dans l'eau et dans l'air, introduits par les fleuves et par la pluie ou par dépôt d'aérosols secs, après dispersion par les vents au dessus de la mer. Il s'y ajoute des apports de pollutants rejetés directement en mer, comme par exemple ceux évacués par les eaux usées des émissaires urbains côtiers ou les hydrocarbures résultant d'un trafic maritime peu respectueux de l'environnement. Il y a donc là de multiples voies d'altération du milieu marin et de ses écosystèmes. A l'inverse, le milieu littoral terrestre est exposé à des influences venues de la mer : tempêtes pouvant causer de graves dégâts sur les côtes, action mécanique des vagues contribuant à l'érosion côtière, marées noires que les courants amènent sur les plages, apport d'aérosols marins, ceux ci étant susceptibles de véhiculer des polluants déversés en mer. De plus, la contamination par des rejets anthropiques de produits de la pêche et de l'aquaculture peut avoir des conséquences nocives sur la santé humaine, de même que la dégradation de la qualité des eaux de baignade. On mesure donc l'importance des enjeux socio-économiques d'une gestion véritablement intégrée des zones côtières prenant en compte l'espace littoral tant terrestre que marin, ainsi que l'interdépendance et les rétroactions entre ces milieux au fonctionnement complexe. L'expertise des scientifiques est fondamentale pour définir des stratégies de protection de l'environnement et fournir des éléments d'aide à la décision de nature à privilégier le développement durable des régions littorales. Cela suppose un engagement de leur part dans de nouvelles formes de science-action au service de la société et une mobilisation des compétences autour de projets fédérateurs interdisciplinaires associant les sciences de l'univers, de la vie, de l'homme et de la société et de l'ingénieur. Le renforcement des synergies entre scientifiques, pouvoirs publics, acteurs du développement économique, élus et société civile est d'autre part essentiel pour mettre en œuvre des pratiques avisées de gestion intégrée des zones côtières.

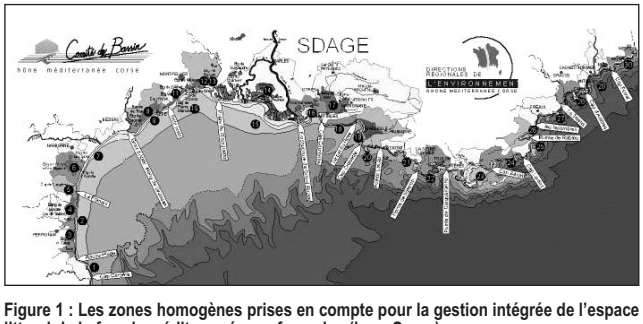

Figure 1 : Les zones homogènes prises en compte pour la gestion intégrée de l'espace littoral de la façade méditerranéenne française (hors Corse)

Exemple de gestion intégrée des zones côtières adaptée aux spécificités de la façade méditerranéenne française

L'Agence de l'Eau Rhône Méditerranée Corse et ses partenaires ont mis au point une approche méthodologique novatrice en vue d'une gestion intégrée du littoral de la façade méditerranéenne française. Elle prend en considération les bassins versants adjacents, leurs apports et rejets (9) et leur zone d'influence en mer, la qualité des eaux côtières et des enjeux économiques majeurs tels que le tourisme, la conchyliculture et la pêche. S'appuyant sur un découpage du littoral en unités de gestion englobant une double bande à la fois terrestre et marine, les zones homogènes (Figure 1), le Schéma Directeur d'Aménagement et de Gestion des Eaux (SDAGE) du Bassin Rhône-Méditerranée-Corse résulte de la loi sur l'eau de 1992 (10). Il reconnaît le littoral comme un milieu à haute valeur patrimoniale et vise à préserver ou à restaurer ses éco-systèmes. La gestion intégrée des unités spatiales homogènes définies précédemment repose sur des compétences inter-communales et des acteurs locaux. Elle implique la compréhension des phénomènes mis en jeu dans l'espace littoral, basée sur l'acquisition de données dans des zones observatoires, en particulier dans des réserves marines, l'évaluation de la qualité du milieu marin, l'étude du devenir des polluants et la modélisation des courants. Ces informations sont utiles aux décideurs en vue de l'ajustement de mesures de réduction des émissions polluantes à terre.

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ARTIFICIAL REEF FISH ASSEMBLAGE COMPARED WITH THAT OF NATURAL AREAS IN PALMA BAY (BALEARIC ISLANDS, WESTERN MEDITERRANEAN)

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Summary

The fish assemblage present in a production block artificial reef moored 30 m deep in Palma Bay, is studied and compared with that of two natural areas with similar environmental features. The results show differences in both areas and that the aggregation effects can not prove the production effects, as well as the need for a real fishing management to prevent the risk of overfishing the whole area by fishing the reef area.

Key words: Artificial Reefs, Balearic Islands, Western Mediterranean

Introduction

As part of the evaluation of the effects of the artificial reefs moored in Palma Bay (1) the fish assemblage of the reef compared with that of natural areas has been studied. The reef is situated between Cap Enderrocat and Cap de Regana (29 º 26.59' N, 2º 43.00' E), located on degraded *Posidonia oceanica* beds and sand bottom. The work has been carried out in the reef area, as well as in two natural areas (39º 27,46' N; 02º 28,23' E and 39º 34,60' N; 02º 18,40' E). with similar environmental factors.

The data were collected by scuba diving visual census (2). In order to evaluate spatial variation in each area, 18 replicates per area have been taken, distributed in three sites, with a total of 54 replicates per year, in the months of June of 1999 and 2000. In the control areas the transect method was used. (3, 4, 5) and in the artificial reef that method has been adapted (2). The descriptive indexes were calculated with the Primer Program and analysed by Anovas (6). A pot-hoc test (Tuckey) has been performed to show possible differences between sites in each zone.

Because of the different sampling area, and in order to compare the abundance of common species between areas, both data sets (artificial reef and natural areas) have been referred to a normalised area of 10 m^2 and analysed by Anovas. The density of categories and ten vulnerable species common to the three areas has been studied with Anovas.

The fish size distribution of ten vulnerable species was made by grouping the specimens in three size classes: large, medium and small, according to the common maximum size for each species (7). The collected data have been analysed with Kolmogorov-Smirnov test. The statistical tests have been made with SPSS and Statistica programs.

The species present, total abundance and density of the different spatial categories (8), as well of ten vulnerable species, specific richness, diversity, evenness and specimen size distribution of the assemblage has been taken into account.

Results

The number of species present has always been lower in the reef (25-26) than in the control areas (32-37), with 18 species present in both areas and no species only present in the artificial reef.

In the reef the total abundance increased in the year 2000 in comparison to 1999. In relation to the abundance of the different spatial categories, only the species belonging to categories 5 and 6 showed significant differences. In both cases the density was higher in the reef and in the year 2000 increased in the reef area as well as in the natural ones.

The diversity, measured by Shannon diversity index, was also lower in the reef area than in the control ones.

The density of the following ten vulnerable species, common to the reef and the control areas were studied separately : *Diplodus vulgaris, D. puntazzo, D. sargus, Sciaena umbra, Spondyliosoma cantharus, Epinephelus costae, E. marginatus, Labrus merula; L. viridis* and *Muraena helena*. The only species showing differences between the reef and the control areas were : *D. puntazzo* and *E. marginatus*, being in higher density on the reef in both study years. .

In both years the size were smaller on the reef than in the natural areas. This could be due to the difference in the fishing gear used in each area. No juvenile recruits were observed.

Both abundance and indexes, in 1999 and in 2000, present spatial differences in the reef area but there was not temporal variability, while the natural areas do not show spatial variability but time variability.

We believe the artificial reefs are effective in very damaged, homogenous seabed areas. Nevertheless in such a man-influenced area as Palma Bay, the number and variety of factors make it difficult to understand the cause–effect relationship.

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HYDROCARBURES DANS LES MOULES DE LA LAGUNE DE BIZERTE (TUNISIE)

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Résumé

Des échantillons de moules, considérés comme organismes bio indicateurs de pollution sont prélevés de 3 stations mytilicultures de la lagune de Bizerte située à l'extrême Nord de la Tunisie. Ces prélèvements sont réalisés en deux saisons (saison sèche :S.S et saison hivernale S.H). Ce travail est entrepris dans le but d'évaluer l'état de la pollution de la lagune de Bizerte par les hydrocarbures aromatiques polycycliques (HAP) et les hydrocarbures totaux. Parmi les 21 HAP analysés, 16 font partie de la liste de l'Agence Américaine de Protection de l'Environnement "EPA" et jugés comme polluants prioritaires. Les hydrocarbures totaux et les hydrocarbures aromatiques polycycliques sont déterminés respectivement par UV-Fluorescence et GC-MS. L'analyse de la totalité de la chair des moules dans les trois stations d'élevage de la lagune de Bizerte montre l'existence des HAP et hydrocarbures totaux a des concentrations faibles calculées par rapport au poids sec de l'échantillon.

Mots clés : HAP, Hydrocarbures totaux, Moules, Lagune de Bizerte

La lagune de Bizerte est considérée comme la deuxième lagune en Tunisie [1]. Elle est située au sud ouest de la ville de Bizerte et à l'extrême Nord de la Tunisie. Cette lagune est utilisée pour un élevage expérimental des moules et d'autres coquillages. Deux compagnes d'échantillonnage de moules ont été effectuées respectivement en Août 1999 (S.S) et en Janvier 2000 (S.H) aux trois stations mytilicultures de Menzel Jemil (MJ), Menzel Abderrahmen (MA), Menzel Bourguiba (station FMB). Dans chacune des stations une vingtaine de spécimens par échantillon sont lyophilisés ensuite analysés. Les hydrocarbures aromatiques polycycliques (HAP) représentent un groupe important de micropolluants organiques vu leur distribution dans l'environnement [2]. Parmi la liste des 21 HAP analysés, 16 sont jugés par l'Agence Américaine de Protection de l'Environnement "EPA" comme polluants prioritaires [3, 4]. Les HAP analysés dans le présent travail sont les suivants: Naphthalène (Naph), 2-menaphthalène (2-menaph), 1-menaphthalène (1-menaph), Acénaphthylène (Ac), Acénaphthène (Ace), Fluorène (Flu), Phénanthrène (Phe), Anthracène (Anth), 1-mephenanthrène (1-mephe), Fluoranthène (Fluo), Pyrène (Pyr), Benzo(a)anthracène (BaAn), chrysène (Chr), Benzo(b)fluoranthène (BbFl), Benzo(k)fluoranthène (BkFl), Benzo(e)pyrène (BePy), Benzo(a)pyrène (BaPy), Perylène (Pe), Indeno(123cd)pyrène (InPy), Dibenzo(ah)anthracène (DiAn), Benzo(ghi)perylène (BePe).

L'extraction et la purification ont été réalisées suivant la méthode citée par J. P Villeneuve [5]. Les HAP sont analysés par chromatographie gazeuse couplée à un spectromètre de masse GC-MS et les hydrocarbures totaux sont déterminés par spectroscopie de fluorescence UV par rapport à deux standards : le chrysène et l'huile de ropme [6, 7].

Résultats

Sur le tableau 1 sont rassemblés les résultats des concentrations (μg/g en poids sec) des hydrocarbures totaux trouvés. Elles sont comprises entre 2,5 et 11 μg/g en équivalent chrysène et entre 21 et 94 μg/g en équivalent huile de ropme. Le tableau 1 présente les moyennes des résultats de 3 lectures pour chaque expérience.

Tableau 1. Concentration exprimée en µg/g en poids sec des hydrocarbures totaux (valeurs moyenne ± la déviation standard) dans les différentes stations (Menzel Abderrahmen, Menzel Bourguiba (FMB) et Menzel Jemil) pendant les deux saisons sèche et humide.

Stations	µg/g eq chrysène	µg/g eq huile de Ropme
MA (S.S)	5.33 ± 0.9	48.7 ± 1.7
MA (S.H)	2.5 ± 0.52	66.14 ± 1.83
FMB (S.S)	2.47 ± 0.51	21.31 ± 1.7
FMB (S.H)	3.48 ± 0.5	52.55 ± 1.94
MJ (S.S)	2.47 ± 0.47	21.01 ± 1.14
MJ (S.H)	11.2 ± 0.6	93.37 ± 1.2

On aurait pu penser trouver au niveau de la station de Menzel Bourguiba (FMB) des taux d'hydrocarbures assez élevés en raison de l'intense activité industrielle et portuaire de cette zone. En réalité, des taux d'hydrocarbures assez faibles ont été décelés au niveau des moules de cette station (tableau 1).

On constate pour chacune des stations et en saison hivernale que la présence d'hydrocarbures aromatiques polycycliques à 3 et à 4 noyaux aromatiques (phénanthrène, fluoranthène, pyrène et le chrysène) est plus importante et que les concentration sont faibles pour les dérivés aromatiques à 2 noyaux (naphthalène, acénaphthylène, acénaphthène et fluorène) (figure 1).

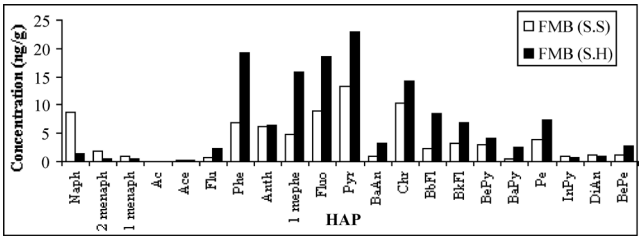

Figure 1. Concentration des HAP exprimée en poids sec dans les échantillons des moules de la station de Menzel Bourguiba (FMB) dans les deux saisons sèche et humide.

On constate d'après le tableau 1 que les concentrations trouvées pour toutes les stations en saison estivale sont relativement faibles par rapport à la saison hivernale sauf à Menzel Abderrahmen où nous avons calculé la concentration par rapport au standard chrysène.

Les taux des hydrocarbures totaux trouvés dans les moules qui sont considérés comme organismes bio indicateurs de pollution sont inférieurs à 100 μg/g en poids sec.

Les concentrations trouvées après extraction de la totalité des chairs des moules prélevés des trois stations d'élevage ne montrent pas une pollution significative.

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LE CRABE AMÉRICAIN *RHITHROPANOPEUS HARRISII* ÉTEND-T-IL ACTUELLEMENT SON AIRE DE DISTRIBUTION EN MÉDITERRANÉE ?

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Résumé

Le crabe américain *Rhithropanopeus harrisii* est signalé pour la première fois des côtes françaises de Méditerranée, dans la région de Marseille, où il est abondant dans l'étang de Berre. Des prospections n'ont pas permis de trouver d'autres individus en dehors de l'étang de Berre. Il est probable que son arrivée y est récente.

Mots-clés: Species introduction, Crustacea, Decapoda, Brackish water, Rhône delta.

Introduction

De plus en plus d'espèces marines sont déplacées et introduites suite aux activités humaines. Ainsi, une cinquantaine d'espèces de crustacés décapodes ont été introduites en Méditerranée (1). La plupart sont des espèces dites "lessepsiennes" ayant profité du Canal de Suez pour s'installer dans les parties les plus chaudes de Méditerranée. D'autres espèces, originaires d'Amérique, ont été apportées en Europe par l'aquaculture ou les bateaux et s'implantent d'abord dans les ports et les zones de trafic maritime intense. C'est le cas sans doute du crabe *R. harrisii*, le premier décapode a avoir été introduit en Europe. Trouvé pour la première fois dans le Zuiderzee (2, 3), il a colonisé les eaux saumâtres de la Mer du Nord et de la Mer Baltique, et plusieurs grands estuaires de la façade Manche-Atlantique (4, 5, 6); il est également implanté depuis longtemps en Mer Noire (7). Sa distribution en Europe n'a cessé de s'étendre sur la façade atlantique où il a progressé vers le Sud jusqu'à la péninsule ibérique [réfs in (8)] et il a été observé pour la première fois en Méditerranée en 1994 à Venise (9).

Observations

Un petit crabe récolté dans l'étang de Berre nous a été adressé début 2000 par M. Philippe Carenco pour identification. La comparaison avec des spécimens de référence du Muséum a permis d'identifier le spécimen à *R. harrisii*. Plusieurs missions sur le terrain ont été réalisées par la suite pour déterminer s'il s'agissait d'un spécimen isolé ou si l'espèce était implantée localement. Dans ce dernier cas, il convenait alors d'essayer de préciser la distribution actuelle de l'espèce dans la région de Marseille et d'analyser l'importance des populations. Les localités et dates d'observation sont les suivantes (avec mention des 232 spécimens en collection étudiés provenant de cette localité).

1) 9 mars 2000, ville de Berre, 1 mâle de 11 mm, coll. P. Carenco.

2) 9 juillet 2000, anse du Ranquet, 31 mâles de 7,5 à 16,5 mm + 6 femelles de 8 à 15,5 mm + 1 femelle ovigère de 13 mm, coll. P. Noël.

3) 9 juillet 2000, Martigues, 14 mâles de 9,5 à 17 mm + 3 femelles de 10 à 12 mm, coll. P. Noël.

4) 3 septembre 2000, ville de Berre, 2 mâles de 13 & 18 mm + 2 femelles de 10 & 11 mm, coll. P. Noël.

5) 3 septembre 2000, port de la Pointe, nombreux spécimens desséchés dans les laisses de plage : 92 mâles de 8 à 20 mm + 80 femelles de 9 à 17 mm, coll. P. Noël.

Une seule femelle ovigère a été récoltée. Le sexe ratio est en faveur des mâles, avec un total de 140 mâles pour 92 femelles, en particulier pour les spécimens récoltés sous les pierres près du rivage (48/12). Plusieurs spécimens parmi les plus gros présentent des épibiontes (salissures) ou des cirripèdes (*Balanus improvisus*) sur la carapace. Dans le même milieu ont été observés les crustacés décapodes *Carcinus aestuari* et *Palaemon elegans*, les gastéropodes *Cerithium vulgatum, Ocenebra erinacea* et *Nassarius reticulatus*, et les bivalves *Mytilus galloprovincialis, Cerastoderma glaucum* et une espèce introduite récemment dans la région *Mya arenaria* (10) également originaire des côtes américaines nord-atlantiques. Notons que le 23 janvier 2001, nous n'avons observé aucun crabe à la côte, là où ils étaient très nombreux en été.

Discussion et conclusions

Les spécimens récoltés sont de taille comparable aux spécimens de Venise (9). Ils ont été obtenus soit sous des pierres dans des milieux faiblement dessalés pas ou peu envasés, soit en laisse de plage.

R. harrisii a donc été récolté en été dans tous les secteurs favorables de l'étang de Berre où il a été recherché. L'espèce apparaît donc implantée dans tout l'étang. Par contre, nous n'avons pu le récolter à l'extérieur de cet étang en conditions plus ou moins dessalées, ni à la côte (Marseille), ni dans les eaux intérieures plus ou moins éloignées (canal de Fos-sur-Mer). Il est possible que l'espèce puisse coloniser ultérieurement différentes lagunes littorales de Provence et du Languedoc-Roussillon. Notons à ce propos qu'il existait dans les anciennes collections du Laboratoire Arago à Banyuls-sur-mer des échantillons malheureusement sans étiquette d'un gros *Eriocheir sinensis* mâle et de trois *R. harrisii* mâles de 14,5 - 15 et 16,5 mm respectivement. *Eriocheir* ayant été signalé vers 1960 à plusieurs reprises les lagunes du Languedoc, il est possible qu'à la même époque des *R. harrisii* aient pu également y être présents.

Etant donnée l'abondance de *R. harrisii* dans l'étang de Berre, il est vraisemblable que son arrivée y soit passée inaperçue plusieurs années. L'origine des *R. harrisii* ayant colonisé l'étang de Berre est inconnue; des études de biologie moléculaire pourraient permettre de déterminer l'affinité de cette population avec celles d'autres localités.

Remerciements :

Nous tenons à remercier M. Philippe Carenco pour l'envoi du crabe non identifié, point de départ de cette étude, M. René-Pierre Carriol pour l'identification du Cirripède et Mlle Stéphanie Tachoires pour l'aide technique sur le terrain.

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TAILLE A LA PREMIÈRE MATURITÉ SEXUELLE, PÉRIODE DE PONTE ET RELATION TAILLE-POIDS CHEZ LE SPARAILLON *DIPLODUS ANNULARIS* (L. 1758) DES CÔTES D'ANNABA

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Résumé

Sur les côtes d'Annaba, *Diplodus annularis* commence à se reproduire lorsqu'il atteint une longueur totale de 12,6 cm. La maturation de ses gonades se déroule au cours des mois d'avril et mai; elle est suivie par l'émission des gamètes qui a lieu essentiellement au courant des mois de juin et juillet. Des variations importantes du rapport hépato-somatique et de l'adiposité indiquent le stockage de réserves lipidiques et leur utilisation progressive pour les besoins de la gamétogenèse. La croissance pondérale relative est globalement allométrique majorante.

Mots clés: Sparaillon, reproduction, Méditerranée Ouest. Algérie

Bien que commun aux côtes méditerranéennes, le sparaillon *Diplodus annularis* est un poisson côtier encore peu connu. Il est essentiellement cité dans les travaux d'inventaires ou de recensements ichtyologiques, notamment dans les espaces protégés (1, 2), ou lors d'études sur la sélectivité des engins de pêche (3, 4). Cependant, sa biologie et son écologie restent insuffisamment abordées. Récemment, Santos *et al*. (4) ont étudié quelques aspects de sa reproduction sur les côtes du Portugal, alors que Gordoa et Balbina (5) ont précisé son âge et décrit sa croissance sur les côtes Nord-Ouest de la Méditerranée. Auparavant, Divanach *et al*. (6) avaient étudié les performances de sa croissance dans des conditions d'élevage. Nous fournissons ici les premières données sur la biologie de *D. annularis,* notamment sur son cycle sexuel et sur sa croissance relative sur les côtes de l'Est algérien.

Matériel et méthodes

Les poissons ont été recueillis auprès des mareyeurs ou à la poissonnerie centrale de la ville d'Annaba durant 1999 et 2000. Les sparaillons sont capturés par la pêche côtière à l'aide de filets maillants. 719 individus de longueur totale comprise entre 10,4 et 18,8 cm, et de poids total compris entre 17,5 et 118,5 g, ont été examinés. L'évolution du pourcentage des individus sexuellement matures en fonction des différentes classes de longueur, nous a permis de déterminer la taille à la première maturité sexuelle. Celle-ci correspond à la taille pour laquelle, en période de reproduction, 50% des individus présentent des signes d'activité sexuelle. Pour les besoins de l'étude du cycle reproducteur, les rapports gonado-somatique (RGS = poids des gonades x 100 / poids total) et hépato-somatique (RHS = poids du foie x 100 / poids total) ont été calculés chez les poisons mâtures. L'adiposité qui correspond à la quantité de graisses au niveau du mésentère a également été évaluée en s'inspirant de l'échelle de Nikolsky (7). La relation entre la longueur totale (Lt) et le poids total (Pt) des individus matures est établie annuellement et mensuellement à l'aide du logiciel Fishparm (8). Elle est de la forme P = aLb. La valeur du coefficient d'allométrie "b" est comparée statistiquement à la valeur 3 au seuil a = 0,001, à l'aide du test de Student.

Résultats et discussion

La fréquence des individus matures en fonction de la longueur totale des sparaillons (fig. 1) nous a permis de situer la taille à la première maturité sexuelle à 12,6 cm. Celle ci est de 13,4 cm sur les côtes du sud du Portugal (4). L'évolution du rapport gonado-somatique (fig. 2a) montre globalement trois phases: une phase de repos sexuel de la fin de l'été jusqu'en hiver (août à mars), une phase de maturation des gonades au printemps (avril et mai) et une phase de ponte au cours des mois de juin et juillet. Les variations du rapport hépato-somatique (fig. 2b) montrent qu'il tend à augmenter progressivement d'octobre à mai, puis chute brusquement au moment de la ponte. Ce parallélisme atteste de l'utilisation graduelle des réserves graisseuses accumulées dans le foie pour les besoins de la maturation des gamètes. Pratiquement constante d'octobre à mars, avec des valeurs évoluant entre 1,1 et 1,9, l'adiposité présente une tendance antagoniste à celle du RGS dès le début de la saison de reproduction (fig. 2c). Les graisses mésentériques commencent à diminuer avec le début de la maturation des gonades jusqu'à s'épuiser au mois de juin, lorsque commence l'émission des gamètes. Globalement, pour l'ensemble du cycle annuel, la relation taille-poids est allométrique majorante (tab. 1), ce qui n'est pas le cas sur les côtes d'Algrave où elle est isométrique avec P = 0,0132 Lt3,096 (4); ceci indique un meilleur embonpoint des sparaillons sur nos côtes. Néanmoins, le coefficient "b" présente des valeurs isométriques pour la plupart des mois.

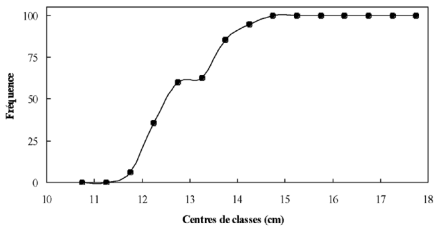

Fig. 1. Fréquence des individus mâtures en fonction de la taille et longueur à la première maturité sexuelle ( ) chez *D. annularis* des côtes d'Annaba.

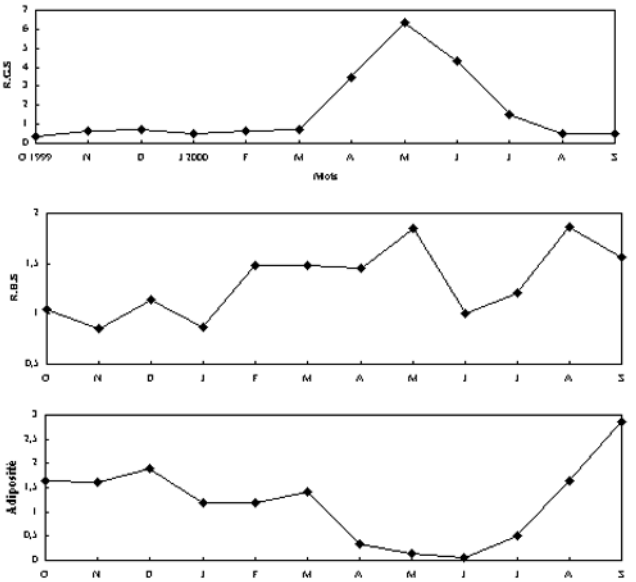

Fig. 2. Rapport gonado-somatique (R.G.S), rapport hépato-somatique (R.H.S) et adiposité chez les individus matures de *D. annularis* des côtes d'Annaba.

Tableau 1. Relations taille – poids chez les individus matures de D. annularis des côtes d'Annaba (-: allométrie minorante; =: isométrie; +: allométrie majorante; Lt: longueur totale; Pt: poids total).

Mois	Effectif	P = a.L^b	r	Valeurs limites (Lt en cm, Pt en g)	b = 3 ?
Oct. 99	52	Pt = 0,017 Lt^{3,036}	0,973	12,6 ≤ Lt ≤ 17,8 - 31,7 ≤ Pt ≤ 110,2	=
N	45	Pt = 0,003 Lt^{3,663}	0,958	12,6 ≤ Lt ≤ 16,3 - 30,5 ≤ Pt ≤ 95,5	+
D	37	Pt = 0,019 Lt^{3,136}	0,982	12,6 ≤ Lt ≤ 18,8 - 28,5 ≤ Pt ≤ 118,4	=
Janv.00	21	Pt = 0,004 Lt^{3,541}	0,990	12,7 ≤ Lt ≤ 18,4 - 30,9 ≤ Pt ≤ 115,9	+
F	53	Pt = 0,009 Lt^{3,235}	0,936	12,6 ≤ Lt ≤ 17,6 - 27,5 ≤ Pt ≤ 107,7	=
M	24	Pt = 0,064 Lt^{2,482}	0,931	12,6 ≤ Lt ≤ 16,4 - 27,2 ≤ Pt ≤ 61,3	-
A	66	Pt = 0,115 Lt^{3,057}	0,955	12,6 ≤ Lt ≤ 17,1 - 30,2 ≤ Pt ≤ 89,5	=
M	74	Pt = 0,01 Lt^{3,194}	0,949	12,6 ≤ Lt ≤ 17,8 - 27,4 ≤ Pt ≤ 105,9	=
J	48	Pt = 0,01 Lt^{3,122}	0,927	12,6 ≤ Lt ≤ 16,1 - 29,8 ≤ Pt ≤ 63,7	=
J	49	Pt = 0,005 Lt^{3,378}	0,947	12,6 ≤ Lt ≤ 16,4 - 29,8 ≤ Pt ≤ 74,1	=
A	10	Pt = 0,128 Lt^{2,19}	0,906	13,1 ≤ Lt ≤ 15,8 - 36,6 ≤ Pt ≤ 49,5	-
S	21	Pt = 0,015 Lt^{3,068}	0,958	12,7 ≤ Lt ≤ 15,6 - 35,4 ≤ Pt ≤ 65,8	=
Global	500	Pt = 0,01 Lt^{3,191}	0940	12,6 ≤ Lt ≤ 18,8 - 27,2 ≤ Pt ≤ 118,4	+

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MAPPING OF ASSEMBLAGES AND BOTTOM TYPES IN LITTORAL LAGOONS OF CORSICA : A FRAMEWORK FOR SETTING UP A MONITORING PROGRAM

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Abstract

The wetlands of the Mediterranean are now considered to be of major ecological and economic value. They are characterized by an exceptional productivity and biological diversity and appear to be increasingly threatened by anthropogenic activity. In light of this, and in order to implement monitoring programs in these ecosystems, an assessment must be made of the living resources present and of their distribution. To this end, the mapping of three Corsican lagoons was performed using image analysis. The results reveal extensive fluctuations over time, with the regression of phanerogam meadows and the spread of silt substrates. The reason behind these phenomena must be sough out and closely monitored.

Key words: western Mediterranean; mapping; aquatic phanerogams

Introduction

Wetlands are biotopes whose fragility is exacerbated by their presence along the Mediterranean coastline, narrow region which is the site of a great number of anthropogenic activities. Although they are included in the Ramsar Convention, the Mediterranean lagoons are rarely the object of efficient protective measures and remain very sensitive to the quality of the surrounding environment. They are characterized by a high productivity, which makes them ideal for fisheries and aquaculture activities (1). At present, the management of these zones necessitates the drawing up of a reference state with respect to the resources to be managed, in particular since very little data is available to aid the decision makers in their task of managing these environments. The objectives of the present study were thus to map, using image treatment, the three main/largest Corsican lagoons (Biguglia, Diana and Urbino) with a view to subsequently implementing a monitoring program.

Materials and methods

The most important/largest Corsican lagoons are located on the eastern coast. They are, from north to south, Biguglia, Diana and Urbino lagoons. These three lagoons are noticeably different in terms of both their typology and the anthropogenic pressures to which they are subjected (Table I). Image analysis was performed using photographs (scale of 1/10,000) taken in June 1999 (Compagnia Generale Ripresaeree®). These photographs (from 5 to 12 per lagoon) were digitized in order to obtain a pixel size of 2 m. Image treatment was performed using the Multiscope software (Matra Système et Information®; 3). Field observations were made in June 1999 and 2000 to identify the assemblages and bottom types, either from the surface when visibility was good, or by SCUBA diving. Each data was situated using a differential GPS.

Table I: Characteristics of the study sites. The scale used for salinity is that adopted by the Venice Committee/Commission (2).

Lagoon	Max. depth	Surface area (ha)	Salinity	Anthropogenic sources
Biguglia	1.8 m	1500	4 - 26 ‰ (Mesohaline)	Urban and industrial wastes Agriculture Leaching of watershed
Diana			26-44 ‰ (Euhaline)	Aquaculture activities Agriculture
Urbino	9.2 m	760	26-44 ‰ (Euhaline)	Aquaculture activities Agriculture

Results and discussion

Following image treatment, we obtained a map of the assemblages and bottom types for each of the lagoons, thus allowing us to identify four main biotopes : sand, silt, photophilous algae and phanerogam meadows (Table II). The type of phanerogams present differs from one lagoon to the next. Due to a low salinity, phanerogam meadows made up of *Ruppia sp*. and *Potamogeton pectinatus* dominate in Biguglia lagoon, the latter species being poorly represented (less than 10 ha versus over 177 ha for *Ruppia sp*). In Diana and Urbino lagoon, the phanerogam meadows are mainly made up of *Cymodocea nodosa*, with small formations of *Ruppia sp* in the north-western section of Diana and in proximity to the region of freshwater influx in Urbino lagoon. Small phanerogam meadows of *Zostera noltii* are also observed in this last lagoon. Regardless of the lagoon examined, the meadows are present mainly along the edge of the lagoon and occupy small surface areas as compared to the silt biotopes (Table II). The macrophyte formations are only present within the phanerogams, with the exception of Biguglia in which large sections of the lagoon are covered by photophilous algae, particularly in the northern reaches of the lagoon. In Biguglia lagoon, literature data reveal that a regression of the phanerogam meadows has been occurring over the past years. Indeed, in 1973 the meadows occupied almost all of the lagoon (4), whereas they only covered 50 % of the lagoon bottoms in 1992 (5). The dense *Zostera noltii* meadows described in the northern section of the lagoon in 1994 (6) has completely disappeared. This decrease in phanerogam bottom cover is concomitant to an increase in the percentage of silt bottoms, which have gone from 43.7 % of the lagoon in 1996 (7) to 77 % (Table II). A regression of the meadows since 1970 can also be observed in Diana lagoon (4), with an apparent stabilization of the situation since 1996 (8), although this site tends to fluctuate from one year to the next. In addition, a decrease in the fine and conchiferous sand biotope is observed in the central portion of the lagoon (9), this biotope being replaced by silt. In Urbino lagoon, the situation appears comparable to that observed in 1990. The seagrass bed regressions observed in 1994, following exceptionally high rainfall values in November 1993, are no longer visible, although the location of the phanerogam meadows has changed somewhat, with a spread of the phanerogams in the central region of the lagoon and a regression in the northern and western regions.

Table II: Surface area (expressed as a %) of the assemblages and bottom types in the Corsican lagoons of Biguglia, Diana and Urbino.

Biotope	Biguglia lagoon	Diana lagoon	Urbino lagoon
Sand	2.6	7.9	9.2
Silt	77.0	88.1	70.1
Photophilous algae photophiles	6.5		
Phanerogam seagrass beds	13.9	4.0	20.7

Conclusion

The mapping efforts made have allowed us to identify the different assemblages and bottom types present in the largest Corsican lagoons, which include aquatic phanerogams. These phanerogams meadows are well represented in the lagoons of Biguglia and Urbino. Fluctuations in phanerogams bottom cover over time are observed in the three lagoons and extensive silting phenomena are detected in Biguglia and Diana lagoons. In light of their probable impact on meadows, these phenomena should be monitored and their origin determined in order to ascertain whether they correspond to limited and reversible meteorological events, or if they reflect a general silting up of the lagoons. The results obtained confirm the value of image treatment based on aerial photographs within the framework of littoral lagoon monitoring programs and demonstrate that such techniques could be generalized to the monitoring of other Mediterranean coastal lagoons.

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EFFECTS OF MECHANICAL CLAM HARVESTING ON BOTTOM SEDIMENT IN THE VENICE LAGOON

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Abstract

In order to evaluate the direct effects of clam fishery in the Venice Lagoon, a research project which compare two different mechanical harvesting gears was carried out. The preliminary results showed that the gear action removes the first sediment layers (5-7 cm) of the bottom with significant immediate effects on bottom features (morphology, oxidized layer depth).

Keywords: fishery, sediment, lagoon.

Fishing activity can disrupt the entire ecosystem (1) as it exploits target species, damages/kills non-target species, alters/destroys habitats, also inducing indirect effects such as changes in trophic webs (1; 2; 3). This is more evident for mobile demersal fishing gears (mostly trawls and dredges) that can remove large amount of epi and infauna specimens, since they scrape the surface off, or dig into the seabed (3).

Venice Lagoon is a 'sensitive ecosystem' that experienced in the last decade a growth of mechanical clam (*Tapes philippinarum*) harvesting, with a fishing fleet at present estimated to reach ca. 600 boats with total annual landings of 35000-50000 MT (4).

T. philippinarum is an alloctonous species introduced in the Venice Lagoon since 1983 in order to improve aquaculture production, but, due to its morphological and physiological features (robustness and higher reproductive capacity), presented a demographic boom with a wide dispersion in all the area, becoming an important economic resource.

In order to evaluate the direct effects of clam fishery in the lagoon a research project which compare two different mechanical harvesting gears (one locally named 'rusca' (5) and a prototype gear) was carried out.

In this paper preliminary results concerning the fishing effects on sediment and resuspension are reported; results are discussed in the light of fishing gear efficiency data.

Sediment profiles images were acquired by means of a REMOTS® (Remote Ecological Monitoring of the Seafloor) sediment camera (6) that allows the upper 20 cm of the sediment to be documented by photo (7).

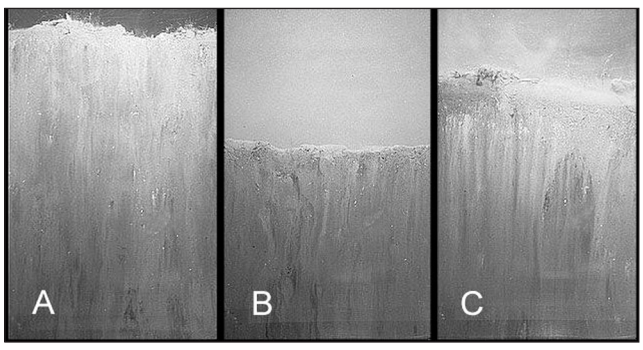
A number of 3 images in 5 stations were acquired in a previously undredged muddy bottom area (mean depth 1.0 m) in order to describe the undisturbed habitat.

Then two experimental hauls (with 'rusca' and 'prototype' dredge) were carried out and two sets of 15 images were acquired into the disturbed areas (tracks).

To characterize the dredge induced sediment plumes in terms of total Carbon, organic Carbon and Nitrogen contents, two water samples were collected respectively before and after 'rusca' dredging, and before and after 'prototype' dredging.

Fishing gears efficiency was assessed by comparing pre-dredging clam densities (investigated by means of 10 Day grab (0.1 m^2) replicates) with the catches for square meter of 7 experimental standard hauls.

In figure 1, three examples of digitally analysed sediment profile images, acquired before (1A) and after dredging (1B and 1C), are reported.



Sediment profiles images showed no significant changes in bottom grain size after dredging; whereas average redox potential discontinuity (RPD) depth indicates that the oxidized layer thickness was significantly ($p<0.05$, Mann Whitney U Test) reduced by 'rusca' dredging and only disturbed by the 'prototype'.

After 'rusca' dredging, mean penetration depth, measured by means of REMOTS, showed a significant decrease ($p<0.01$) from 23.7 to 16.8 cm, whereas no significant differences were observed after 'prototype' dredging.

Both 'rusca' and 'prototype' dredging produced a significant sediment plume, as confirmed by the significant increase ($p<0.05$) in total and organic C and N concentrations after dredging.

These preliminary results shows that the effects of mechanical clams harvesting on bottom sediments are 'gear specific', being the 'rusca' more disruptive than the 'prototype'. All this is connected with the different observed efficiencies (40% in 'rusca; 13% in 'prototype'), since the higher 'rusca' performance could be the consequence of deeper or stronger interactions of the gear with the bottom. Even if 'prototype' seems to induce lower disturbance on the bottom, it must be considered that, to gain the same 'rusca' catch level, the 'prototype' has to sweep a 3 times larger area.

The digging action produced by mechanical harvesting activity removes the first sediment layers (5-7 cm), as described also for other fishing gears (8), with significant immediate effects on bottom features (morphology, oxidize layer depth).

On long term scale, the continuos dredging could produce permanent changes, such as modifications of grain size towards coarser fractions (9) and of geochemical features. All this could be quite stressful for a sensitive ecosystem such as the Venice Lagoon.

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METHODOLOGICAL CRITERIA FOR THE SELECTION OF MARINE DISPOSAL SITES

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Abstract

In Italy the most common management of harbour dredged material is sea dumping; nevertheless, several alternatives destinations are suggested in the recent Italian Guidelines according to the international procedures. In order to develop methodological criteria to locate marine disposal sites a multidisciplinary project was developed, integrating literature information, experimental data and G.I.S. elaboration. The attention was focused on Tyrrenian and Adriatic Sea, where five areas of interest in potential discharge operations were located. This allowed developing tools for policy makers in the decision making of environmental planning.

Keywords: coastal management, GIS, sediments

The coastal management directed to the sustainable development of human activities is a complex process that involves the systematic use and integration of different kind of information regarding environmental quality, political and economical aspects. In this context environmental planning is a process for deciding how to control the anthropogenic effects on the environment and to operate in order to protect its health.

In 1998 the Italian Ministry of the Environment, with the aim to encourage the environmental planning, financed an ICRAM (Istituto Centrale per la Ricerca scientifica e tecnologica Applicata al Mare) research program to indicate the methodological criteria for the selection and management of marine disposal sites.

Dredging activities are necessary to allow the functionality of the harbours and large amount of dredged sediments have to be removed and disposed off every year.

According with the international criteria (1,2,3) about the management of the dredged material the Italian Guidelines (4) suggest different alternatives in relation with the integration of chemical-physical and ecotoxicological characteristics, to define several classes of sediment quality. In relation to the harbour sediment quality the guidelines advise the destination of clean sediments for beach nourishment, as first management solution; secondly, different kinds of reuse, after or without specific mechanical treatment are proposed. Several examples of the most common international reuses and destinations are on confined disposal sites in harbours, manufacture of building material and wetlands creation. When is not possible to pursue these aims the clean material can be dumped in to the sea.

In Italy, at the moment the cleanest harbour dredged material is still disposed in marine dumping sites, after the assessment of its environmental suitability to receive sediments. As reported in the Guidelines, the sites have to be monitored during and after the dumping activities, in order to investigate possible environmental and economic impacts.

In this paper is briefly described the methodological way adopted to individuate suitable dredged material disposal sites.

The main objectives of the project were related to :

- creation of a database of environmental parameters;
- data management and maps creation by using a Geographic Information System (G.I.S);
- rationalisation of the use of sea bottom and protection of the natural resources;
- implementation of a balanced relation between the economic activities and the ecosystem.

In this study lasted two years we took in consideration the environmental characteristics (geochemical, biological, ecotoxicological) and economical aspects of two different Mediterranean Sea areas: the first one from La Spezia (Ligurian Sea) to the Circeo Promontory (Tyrrhenian Sea), the second from the Po River to the Conero Promontory (Adriatic Sea).

We collected all the bibliographic information about the presence of protected areas, the localisation of the fisheries nursery areas, the grain size distribution, the organic (IPA, PCB, DDTs) compounds, trace metals and the macrobenthic characteristics of the sea bottom from the coast to the isobath of 200 m. Particular attention was given to the information about all the marine disposal sites used in the past to dump dredged material and the amount of sediments discharged for each single site, to the localisation of marine optic fiber cables, platforms, no anchorage area, rifle ranges, etc. In figure 1 an example of a map reporting this information for a limited coastal region is represented.

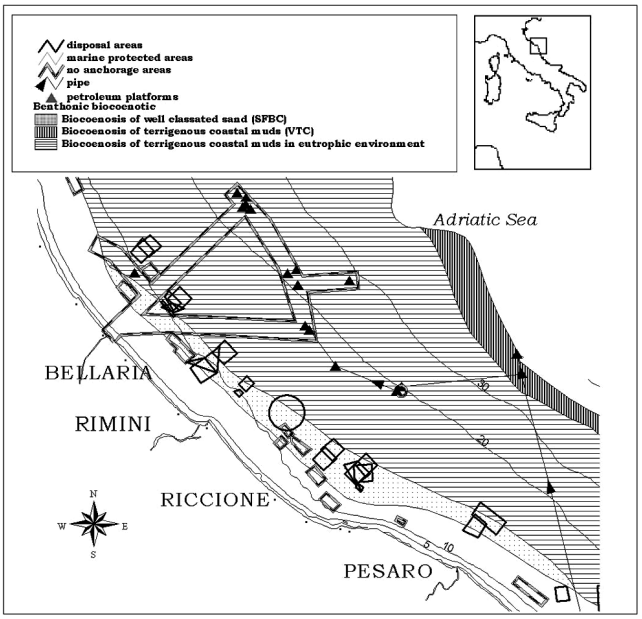
In order to make up for local insufficient literature information, in 1998 and 1999 two field sampling activities in some marine areas were carried out. Considering the total lack of ecotoxicological data regarding Italian coasts, particular attention to the application of bioassays using different specie-test was given, in order to evaluate the bioavailability of contaminants.

From the economical point of view we analysed the most important fishery activities in the investigated areas and the requirements of each harbour, such as the amount of dredged material per year, in order to create a specific database to utilise in mapping creation and GIS elaboration. At the same way all the information obtained from bibliography and surveys were mapped by G.I.S; subsequently, different maps have been overlapped, in order to integrate the available information and to select specific marine areas to locate dumping sites with the aim to limit as possible environmental impacts (5,6).

The integration of bibliographic information, surveys data and GIS elaboration's allowed to identify five possible zones (one site in the Adriatic Sea and four in the Tyrrenian Sea), to locate dumping sites considered compatible with marine environmental and social-economical conditions.

This project represents one of the first Italian attempts to provide new methodological criteria of environmental planning available for policy makers and planners in the decision making regarding the protection of the environment and other social values.

Figure 1. Example of map overlay between sea use and biocoenotic information in a limited area of adriatic coast.



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ORGANISATION STRUCTURELLE DU MACROBENTHOS DES PORTS DE BÉJAIA ET SKIKDA

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Résumé
Les peuplements macrobenthiques ont été étudiés dans le port de Béjaia et les deux ports de Skikda. L'étude dynamique et structurelle a mis en valeur des analogies. L'organisation structurelle du macrobenthos des ports étudiés a permis d'identifier les espèces indicatrices des facteurs abiotiques comme l'hydrodynamisme, la nature et de la texture du sédiment et des facteurs biotiques comme les ressources trophiques ainsi que l'influence des eaux du large. Une zonation, selon les critères de classification déterminés pour le port d'Alger, a été réalisée.

Mots clés : macrobenthos, milieux portuaires, bioindicateurs,

Présentation du site et méthodologie

Ces trois ports sont situés dans l'est algérien, soit à 250 km d'Alger pour Béjaia, et à 510 km pour les deux ports de Skikda. Dans le cadre de l'étude de la macrofaune benthique des milieux portuaires (1 et 2), les prélèvements ont été réalisés, en juin 1995, à l'aide d'une benne Van Veen sur 1/4m de surface. L'analyse du peuplement a été réalisée à partir de la méthode mise au point par Picard (3). Les mesures de température, salinité, oxygène dissous et pH, ont été effectuées.

Résultats

Les conditions du milieu

L'hydrologie des ports est constante dans leur individualité; chaque port présente une seule et même masse d'eau. La profondeur des stations comprise entre 10 et 16 m donne de faibles variations des paramètres température et salinité. En effet, pour la température, de faibles écarts (2°C) aussi bien en surface qu'en profondeur sont notés pour l'ensemble des bassins et des stations des différents ports qui révèlent une homogénéité thermique de la masse d'eau avec une moyenne de 23 °C . Les rejets des eaux usées et pluviales en hiver font baisser la température et la stagnation des eaux à l'intérieur des bassins ou darse la font augmenter en été. Il en est de même pour la salinité ; l'eau est dessalée par rapport à celle des eaux du large par les rejets des eaux usées et pluviales. La sous saturations des eaux en oxygène dissous est nette pour l'ensemble des ports, avec cependant de petites variations d'un port à un autre ; le port de Béjaia est le moins saturé avec une moyenne de 4,2 mg/l. Les mêmes observations sont faites pour le pH et le port de Bejaia présente les valeurs les plus faibles.

Le peuplement : La richesse spécifique et la densité varient d'une station à une autre, et d'un bassin à un autre suivant un gradient décroissant, de ces paramètres, de l'entrée des ports vers les secteurs les plus internes ou encore les plus confinés. Ceci met en évidence l'influence marine des eaux du large vers les zones confinée des ports ; les secteurs les plus confinés peuvent être azoïques.

Le faible nombre d'espèces ainsi que la dominance d'une espèce fait chuter les valeurs des indices de Shannon et de l'Equitabilité. Ainsi le peuplement des ports est constamment en rupture d'équilibre. Les facteurs tels que l'ensablement, l'hydrodynamisme et le dragage des ports ne permettent pas l'installation stable d'un peuplement ; ils induisent une structure du peuplement en déséquilibre permanent où une espèce prédomine entraînant avec elle un groupe d'espèces. Les espèces qui ne supportent pas ces conditions agressives ou instables disparaissent ou s'éliminent. Ainsi, les peuplements des fonds de darse de part l'activité navale, serait juvénile ; la remise en suspension du sédiment ne permet pas une installation permanente du peuplement qui dépend de l'enrichissement en éléments nutritifs. Pour l'ensemble du port le peuplement tend vers une stabilité du peuplement sans l'atteindre réellement et à l'entrée du port, il semble correspondre au stade de maturité dans la succession écologique décrite par Frontier et Pichon-Viale. (4).

Dans le port de Béjaia (5), l'espèce principale du peuplement est *Corbula gibba*; cette espèce à Large répartition écologique, indicatrice de matière organique, est maintenue en permanence ; la prolifération de cette espèce suspensivore qui se nourrit de particules en suspension nécessite non seulement une certaine quantité d'oxygène dissous (6) mais aussi une certaine modalité de recyclage de la matière organique en l'absence de forte perturbation hydrodynamique (7).

Pour l'ensemble de l'ancien port de Skikda (8), les Mollusques représentent plus des 2/3 du peuplement et *Abra alba,* vasicole, déposivore et indicatrice d'instabilité sédimentaire, est la principale espèce à l'exception du secteur où le Polychète Chaetosone setosa, de même signification écologique que la précédente, domine et préfère les fond de décantation; l'état juvénile ou immature du peuplement dû à l'instabilité sédimentaire a été également observé par Grimes (9).

Pour le nouveau port (5), son orientation et la configuration géologique du golf de Skikda posent périodiquement le problème d'ensablement ; un dragage régulier est inévitable, ce qui perturbe la distribution naturelle des sédiments et donc du peuplement. L'espèce principale du peuplement est *Corbula gibba*; cette espèce suspensivore, indicatrice de matière organique, est maintenue en permanence entraînant avec elle un groupe d'espèces de Vasicoles indicatrices d'instabilité.

Conclusion

La constitution d'un peuplement, soumis à une perturbation quel qu'elle soit, se trouve modifiée et sa composition faunistique n'est plus constitué par des espèces de biocénoses mais par des espèces indicatrices (10) en fonction de la texture ou de la nature du sédiment et de la disponibilité de la ressource trophique . L'organisation structurelle est peu différente d'un port à un autre et est fonction des facteurs abiotiques, comme le sédiment par exemple et/ou biotique, comme la compétition interspécifique pour la ressource nutritive des organismes qui les composent.

Les résultats obtenues montrent pour les trois ports étudiés, que sous l'influence des eaux du large, les peuplements correspondent à la zone de transition 3 (T3) et le reste des ports à la zone de déséquilibre (D); ces zones ont été déterminées à partir d'un cycle annuel du macrobenthos du port d'Alger (11).

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ESPÈCES DE MEGAFAUNE LIÉES AUX RÉCIFS ARTIFICIELS DANS LA MER CATALANE

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Résumé

On a étudié la composition des communautés de poissons, mollusques et crustacés qui habitent le récif artificiel de Calafell, placé à la côte catalane. L'échantillonnage a consisté en 2 campagnes de censes visuels et 4 campagnes de pêche expérimentale avec filet maillant. On a identifié 15 espèces de poissons et 1 céphalopode avec les censes visuels et 26 espèces de poissons, 4 mollusques et 2 crustacés avec les pêches. Les familles plus abondantes sont Sparidae, Scorpaenidae, Soleidae et les espèces *Sepia officinalis* et *Chromis chromis*.

Mots clés : Récif artificiel, eaux côtières, mer Baléare

Introduction

Les communautés d'organismes littoraux sont très sensibles aux activités humaines. L'installation des récifs artificiels vise à protéger ces communautés des activités de pêche au chalut ou des engins qui ont un impact agressif sur les fonds marins comme dragues et chaluts à perche. D'autre part, les récifs artificiels ont un impact sur les zones où ils s'installent, donc représentent l'introduction d'un espace rocheux dedans une zone de fonds sableux ou fangeux. L'Union Européenne subventionne l'installation des récifs artificiels en Méditerranée avec une partie du budget destinée aux études de poursuite de la colonisation des structures et l'impact sur la pêcherie. Dans le cas du récif artificiel de Calafell placé à la côte Catalane, une étude de poursuite s'est déroulé de septembre 1999 à décembre 2001 et les premiers résultats sont exposés ici.

Matériel et méthodes

Le récif artificiel de Calafell, placé à 41°10.3'N et 01°35'E, entre 15 et 30 mètres de profondeur, est composé de 20 modules de production installés en 1987 (Phase I), et 20 modules de production et 215 modules mixtes (production-protection) installés en 1997 (Phase II). Pendant l'année 2000 on a réalisé 2 campagnes de censes visuels (avril et septembre) et 4 campagnes de pêches expérimentales (février, avril, juillet et septembre) pour déterminer la composition faunistique de la communauté qui habite le récif et les espèces commerciales susceptibles d'exploitation. Les campagnes de censes visuels ont été faites suivant la méthodologie proposée par Harmelin-Vivien et Harmelin.(1) avec 3 répliques sur les modules de production phase I, production phase II, mixtes et 3 transects sur une zone de sable sans modules. Dans ces campagnes, on a effectué l'identification des exemplaires de poissons, mollusques et crustacés, et on a quantifié l'abondance en nombre d'individus observés. Pour les campagnes de pêche expérimentales, on a utilisé un bateau de pêche artisanale du port de Calafell équipé avec un filet maillant comme échantillonneur. À partir des captures obtenues, on a identifié les espèces commerciales de poissons, mollusques et crustacés.

Résultats et discussion

Dans les censes visuels (Table 1), les espèces qu'on trouve aux 2 saisons étudiées et dans tous les modules sont *Diplodus sargus, D. vulgaris, Serranus cabrilla* et *Chromis chromis*. Autres espèces importantes liées au récif : *Scorpaena porcus, S. notata, Mullus surmuletus* et *Octopus vulgaris* Si on regarde la saisonnalité, septembre présente des valeurs d'abondance un peu plus grandes que avril, comme dans le cas de *C. chromis, D. vulgaris* et *M. surmuletus*. D'autre part, il y a des espèces qu'on trouve seulement sur les modules de production comme *Pomadasis incisus* et *Scorpaena porcus*. Aux censes faites sur une zone de sable on n'a pas trouvé de poissons. D'autre part, les espèces cibles qu'on pêche dans le récif (Table 2) sont *Pagellus erythrinus, Scorpaena notata, S. porcus, Sepia officinalis, Solea senegalensis* et *S. vulgaris*. Elles sont aussi les plus abondantes dans les captures. Les autres espèces ayant intérêt commercial mais plus occasionnelles sont au printemps *Lophius piscatorius*, *Octopus vulgaris* et *Palinurus elephas* et en automne *Scophtalmus rhombus*.

Table 2. Nombre total d'individus obtenus dans les pêches experimentales.

	Février	Avril	Juillet	Sept.	Total
Bolinus brandaris	31	--	10	1	42
Bothus podas	2	--	1	24	27
Diplodus sargus	--	--	1	--	1
Diplodus vulgaris	1	--	2	1	4
Hexaplex trunculus	22	--	13	4	39
Lithognatus mormyrus	--	--	3	--	3
Lophius piscatorius	3	3	--	--	6
Mullus surmuletus	3	--	1	--	4
Octopus vulgaris	--	6	--	--	6
Pagellus acarne	1	--	--	2	3
Pagellus erythrinus	26	--	19	1	46
Pagrus pagrus	--	--	4	--	4
Palinurus elephas	--	2	--	--	2
Pomadasis incisus	--	--	--	1	1
Raja asterias	--	--	--	2	2
Scophtalmus rhombus	--	--	--	13	13
Scorpaena notata	67	3	55	1	126
Scorpaena porcus	4	2	1	3	10
Scorpaena scrofa	--	--	1	--	1
Sepia officinalis	4	8	5	--	17
Serranus cabrilla	1	3	3	--	7
Solea senegalensis	2	--	--	13	15
Solea vulgaris	2	1	--	7	10
Squilla mantis	1	1	--	3	5
Trigla lucerna	2	4	--	--	6

Les différences observées entre les campagnes des censes visuels et les pêches expérimentales sont dues principalement au comportement de quelques espèces, qui vivent enterrées au fond. C'est le case des poissons plats (*Solea* spp) et de la seiche (*Sepia officinalis*) . Dans d'autres cas comme *Pagellus erythrinus*, leur absence au censes visuels est due au fait que leur abondance maximale est en hiver et en été, saisons pendant lesquelles il n'y a pas eu de campagnes de censes visuels. D'autre part les espèces avec un comportement plus pélagique comme *Boops boops* et *Chromis chromis* ne se trouvent pas dans les captures avec le filet maillant parce que cet engin de pêche se place sur le fond avec une hauteur de seulement 1 m.

On peut dire finalement que la communauté qui habite le récif est composée par des espèces permanentes comme les Scorpaenidae, les poissons plats, quelques Sparidae (*Diplodus* spp) et *Serranus cabrilla* et des espèces qui visitent le récif occasionnellement comme *Lithognatus mormyrus* et les espèces du genre *Pagellus*.

Table 1. Nombre d'individus obtenus dans les campaignes des censes visuels. M = moyenne, SD = Desviation standard.

	Production Phase I				Production Phase II				Mixte Phase II			
	Avril		Sept.		Avril		Sept.		Avril		Sept.	
Espèce	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Boops boops	1.3	2.3	34.7	59.2	--	--	37.7	22.2	--	--	167	289
Chromis chromis	39.7	37	122	83.1	33	14.7	175	40.9	0.7	0.6	60.7	36.1
Conger conger	--	--	--	--	0.3	0.6	0.3	0.6	0.3	0.6	--	--
Coris julis	3.3	3.1	16.3	12.7	--	--	--	--	--	--	3.7	4
Diplodus annularis	17.3	20.6	12	4	5	2.6	4.7	1.2	--	--	1.3	1.2
Diplodus sargus	3	1	1	1	2.7	1.5	0.3	0.6	1.3	1.5	2.3	2.3
Diplodus vulgaris	8	1	30.7	28.9	5	1.7	23.7	7.5	4.3	5.9	22.7	4.6
Mullus surmuletus	4.3	7.5	4.7	3.1	--	--	8.3	1.5	1.3	2.3	6.7	4.6
Octopus vulgaris	--	--	0.3	0.6	--	--	0.3	0.6	0.3	0.6	0.3	0.6
Pagellus acarne	1.3	2.3	--	--	--	--	--	--	--	--	--	--
Pagrus pagrus	--	--	0.3	0.6	--	--	1.7	2.9	--	--	--	--
Pomadasis incisus	10	9.5	22.3	9.3	5.7	1.5	33	2	--	--	--	--
Scorpaena porcus	3.3	3.1	0.3	0.6	1	1	0.3	0.6	--	--	--	--
Scorpaena notata	3	3	6.7	7.6	--	--	0.3	0.6	8.3	5.8	6.3	1.5
Serranus cabrilla	2.3	1.5	3	1	2.7	1.5	2.3	1.2	2	2	2	1

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THE RECENT INVESTIGATIONS OF THE SEA WATER QUALITY IN THE MONTENEGRIN COASTAL SEA

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Abstract
The recent results from the Montenegrin coastal sea were realized by measuring of some parameters known as main indicators of eutrophic level and microbial pollution. The obtained data have shown that eutrophication has progressed mostly in the inner and middle parts of the Boka Kotorska Bay, as in front of the Bojana river mouth. The situation is better outside the Bay, where the influence of the open waters of the Southern Adriatic is stronger. Bacterial (sanitary) quality is mostly satisfying, yet. From 55 localities, 30% of them in Boka Kotorska and 50% outside the Bay were the first category (up to 500 TC 100 ml-1 of the sample).

Keywords: sea-water eutrophication, microbial pollution

The Montenegrin coastal waters are very precious resource of Montenegro and whole Yugoslavia. Suitable for tourism, fisheries, mariculture, maritime transport etc., they are simultaneously exposed to all human activities from the land. As 25% of Montenegrin inhabitants live at 293.5 km long coast-line, increased number of inhabitants throughout summer and yet unsolved problem of waste-waters (1) have already caused anthropogenic eutrophication (2, 3, 4). Microbial pollution also appeared, from time to time. For all reasons mentioned above, investigations of this precious area have been started again in 1995. Material was collected from 28 localities in the inner, middle and outer parts of the Boka Kotorska Bay, 26 outside the Bay, along the Montenegrin coast, and one in the Bojana river mouth (Fig. 1).

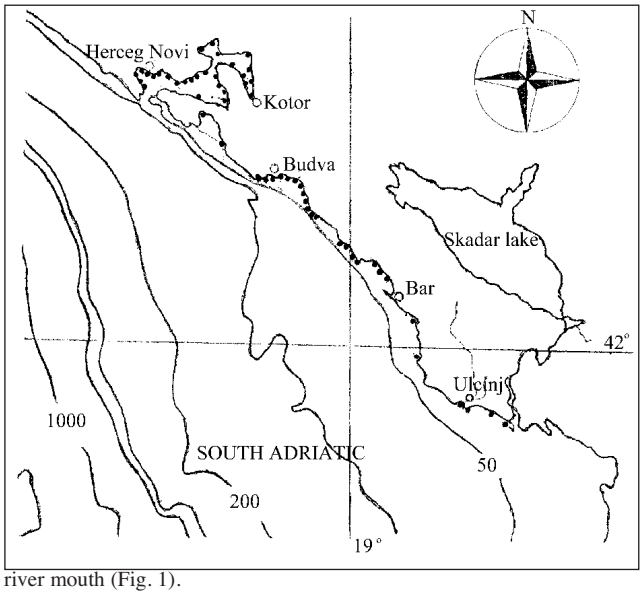

Fig. 1 The investigated area

The samples were taken most intensively throughout summer, during calm, hot weather (when the number of inhabitants was many a time higher), and some of them were taken during colder periods, as a control.

Due to natural characteristics (position, shape, freshwater springs and river mouths, rain, wind, sea-water dynamics) the basic hydrographic factors oscillated a lot throghout the year in Boka Kotorska Bay, while in the Bojana river mouth, and otside the Bay, especially, these oscillations were smaller, because of stronger influence of the open Southern Adriatic (2).

Having in mind classification of eutrophic levels (5), the results about transparency, sea water color, oxygen saturation, nutrients, composition and density of phytoplankton and zooplankton and density of heterotrophic bacteria will be presented, firstly.

So, oxygen saturation at the sea-surface oscilates from 95.08 to 162.65 % O2 in the Boka Kotorska Bay, between 54.89 and 158.82 % outside the Bay and from 79.50 to 127.97 % in the Bojana river mouth, which indicates that all area is eutrophic.

Transparency is between 3 and 6 metres in the Bay, from 10 to 11.5 m outside the Bay (1 NM from the coast), and about 2 m in the Bojana river mouth. All these values are typical for eutrophic areas, too.

Sea-water color (in comparison with Forell-Uhle scale) is ussualy changed at some localities in the inner (Kotor Bay) and middle (Tivat Bay) parts of Boka Kotorska to greenish, yellowish or even brownish, as in the Bojana river mouth. Such frequently changes indicate to eutrophication, too. Outside the Bay, sea-water color is changed very rarely.

Maximal quantity of phosphates is measured in the Kotor Bay. This value of 9.34 mmol l^{-1} is found near the outfall and it characterizes extremely eutrophic areas.

In 1995 – 1998 period, phytoplankton investigations have shown the prevailing of microphytoplankton biomass (which prefers areas rich in nutrients) in the Boka Kotorska Bay. Microphytoplankton density was up to $1.7x10^6$ cells dm^{-3} in Kotor Bay, with high dominance of *Chaetoceros affinis* and *Skeletonema costatum* throughout summer, especially. Besides them, the presence of another 12 species-indicators of eutrophication (6) was confirmed in the Bay during recent investigations. Simultaneously, maximal microphytoplankton density was $9.8x10^4$ cells dm^{-3} outside the Bay, with lower percentage of dominant species. At the Bojana river mouth microphytoplankton density reaches $3.93x10^5$ cells dm^{-3} and *Cyclotella striata* was dominant between other species with percentage of 15%. So, we can conclude that only in the Boka Kotorska Bay the obtained results on the microphytoplankton density excede 10^6 cells dm^{-3} – a value established for eutrophic areas. Besides, the biomass of phytoplankton has shown third – unusual summer maximum, with even higher values then in spring and autumn (5).

Investigations of copepods, dominant net zooplankton group (with the percentage of 90% among other groups), show some changes, too. Besides, rather high values of their density in Boka Kotorska Bay and in the Bojana river mouth (up to $6x10^4$ m^{-2}), unusual summer maximum appears at the same areas from the beginning of ninetieths, together with high percentage of two or three dominant species.

All these changes are the most visible in the closest part of the Bay – Kotor Bay, which is not so shallow, but by reason of its shape and position, is exposed to the strongest impact of the land and freshwater.

Bacterial contamination (sanitary quality) has been studied out at the very same 55 well-known beaches of the Montenegrin coast, using the method of membrane filtration. The first category of the sea-water quality (up to 500 TC 100 ml^{-1} of the sample) was found at about 30% of the localities in the Boka Kotorska Bay, and at about 50% of the investigated stations outside the Bay. In 1995-1998 period, five stations at the Bay and three outside the Bay sometimes exceeded allowed criterion.

In general, we can conclude that some changes were found in non-living and even living components of marine ecosystem of the Montenegrin coastal sea, caused by human impact from the land (in the inner and middle parts of Boka Kotorska Bay and in the Bojana river mouth, predominantly).

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THE SPREAD OF TWO ALLOCHTHONOUS CAULERPA ALONG THE LIGURIAN COAST

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Abstract

Studies carried out on the presence of *Caulerpa taxifolia* and *C. racemosa* along the Ligurian coast since 1992 are summarized. Increase of species richness of benthos and fishes on soft bottoms colonized by *C. taxifolia* and interactions with fishing gear are discussed.

Key words: allochthonous species, invasion, benthos, fishes, Mediterranean.

Introduction

The present paper summarizes and updates information obtained on invasion of *Caulerpa taxifolia* (Vahl) C. Agardh and *Caulerpa racemosa* (Forsk) J. Agardh, that are two new species in respect to the indigenous Caulerpa prolifera (Forskal) Lamoroux, in the nerithic water of Gulf of Genoa. *C. taxifolia*, recorded for the first time in Italian water in 1992 (1) is spreading eastward from the French boundary. *C. racemosa*, recorded for the first time in Liguria, at Genova Quinto in 1995 (2), seems to come from south-east (Tuscany) and recent settlements in the Ligurian Sea have been reported by Modena *et al*. (3). Investigations have been carried out since 1992 also with the support of Regione Liguria (4) and in cooperation with E.U. Life Program - DG XI "Control of the spread of *Caulerpa taxifolia* in the Mediterranean Sea" (5).

Materials and methods

1) Two main methods were used to monitor distribution and spreading of *Caulerpa* algae. The first was to control sites where people told the algae were present and thanks to kind cooperation of the Genoa Coast Guard a register for the records was organized. The second way was direct, monitoring by scuba-divers, video-recordings and sometimes by fishing gear. All harbours and marinas from French border to Arenzano (20 km west from Genoa) were checked for the presence of *Caulerpa*. During summer 1998 five harbours (Imperia Porto Maurizio, Imperia Oneglia, the old harbour of San Remo, Alassio and Varazze) and an area of about 25.8 Km^2 off Imperia were mapped to 50 m depth. In the Genoa Quinto area, *C. racemosa*, was mapped in 1998 and 1999 while in area around Tino island (La Spezia) was mapped in autumn 2000.

2) To study changes in biodiversity, zones colonized by *C. taxifolia* were compared with non-colonized ones. A first set of data was collected from October 1994 to October 1995 (6). From October 1997 to October 1998 four stations were selected for the study of benthos associated with *C. taxifolia* (see 7, 8): A) Imperia San Lazzaro, 4-5 m depth, *C. taxifolia* coverage 90-100% (CSL); B) Imperia, open sea, 9-10 m depth, 25% total cover of both *C. taxifolia* and *Cymodocea nodosa* (CMA); C) Imperia, open sea west of Porto Maurizio, 9 - 10 m depth, covered by *C. nodosa* (CY); D) Alassio, entrance to the harbour, *C. taxifolia* coverage 80-100% (AL).

3) To study fish assemblages visual censuses (50 or 100 m long and 4 m wide) and trammel nets (200 m long and 3 m length) catches were used. Three sets of data were collected between 1994 and 1999. Three stations (CSL, CMA, CY) were the same as those used for benthos; the fourth one was selected on a *Posidonia oceanica* meadow (P) (6, 8, 9, 10, 11).

4) Interaction between fishing gear and spread of *Caulerpa* were observed inside and outside the ports. A particular attention was paid to the harbour areas where fishing boats are moored or trammel nets are cleaned, by means of scuba-divers and videocamera observations and recordings.

Results

1) The presence of *C. taxifolia* was recorded in September 1998 in twelve harbours (Varazze, Alassio, Andora, S. Bartolomeo al Mare, Diano Marina, Imperia San Lazzaro, Imperia Porto Maurizio, Imperia Oneglia, S. Stefano al Mare, San Remo Porto Commerciale, Bordighera) among the twenty ports and landing places along the western Ligurian Riviera; at eight of them the alga was not found (Arenzano, Savona, Finale Ligure, Loano, Marina degli Aregai, Arma di Taggia, Ospedaletti, Marina di San Giuseppe di Ventimiglia (except at "Calandre") (4, 12, 13). The bottom of Imperia Porto Maurizio harbour was colonized by *C. taxifolia* showing a cover of more than 75%. In front of Imperia a map of the principal biocenosis and distribution of *C. taxifolia* with different coverage indices was prepared (12, 13).

2) Dealing with research carried out between 1994 and 1995, there are clear qualitative and quantitative differences between the ephiphytic fauna found on *C. taxifolia* and *C. nodosa* (5). From a quantitative point of view fauna is greater on *C. taxifolia* if data are taken as referring to the sampling surface (n°/dm^2), on *C. nodosa* if in terms of plant biomass (n°/g). At all four stations in the period 1997-1998 a total of 122 benthos taxa were identified (CSL: 68 taxa, CMA: 61, AL : 48 and CY : 38 taxa), confirming previous data (7, 8). A further confirmation comes from data collected between 1999 and 2000 : among 142 taxa, 95 were found at CSL, 65 at CMA and 15 at CY.

3) Detailed results about fish studies are described in the papers listed in bibliography (6, 8, 9, 10, 11, 14). During 1998 at the four stations (CSL, CMA, CY, P) where trammel net and visual censuses were used, 55 fish species were listed. The highest species richness was observed in CSL (34 species) followed by 26 species on P and CMA and only 14 species on CY. If the comparison is made only at CSL and CY from October 1994 to November 1999, a total of 50 different species of fishes were caught in the two stations, 41 at CSL and 31 at CY. Thirty-five species were observed by visual census, 32 at CSL and 8 at CY.

4) Along the Ligurian coast the spread of *Caulerpa* species, in particular *C. taxifolia*, is clearly linked to fishery activities in particular to trammel net and illegal otter trawling inside 50 m depth. The first colonization of the bottom in some harbours correspond exactly to sites where trammel net boats are moored or where nets are commonly cleaned (10, 11).

Conclusions

The two allochthonous algae are currently spreading in the Ligurian Sea and new areas are colonized, though in some shallow mobile and unprotected sites *C. taxifolia* has disappeared due to the strong wave action. This alga seems less adapted than *C. nodosa* to surf and bottom currents. On soft bottoms of Liguria the presence of *C. taxifolia* can considerably increase the number of benthic and fish species differently from what assessed on hard substrata by Harmelin-Vivien (15). Fishing activity seems to be the main cause of the rapid spread of the two *Caulerpa*, but in the meantime fishermen suffer the main damage because fish community has changed and because algae fronds interfere with the performance of gear and much time is required to clean the gear.

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COUPLING DINOFLAGELLATE CYSTS AND GEOCHEMISTRY IN THE NORTH ADRIATIC SEDIMENTS: CLUES TO POLLUTION AND EUTROPHICATION

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Abstract

In this preliminary work we tried to investigate the relationships between geochemistry and organic-walled dinoflagellate cyst assemblages in sediments from the North Adriatic Sea. The area is strongly influenced by the Po river that transports large amount of heavy metals (Cu, Zn and Pb) and nutrients to the open sea. Direct relations between heavy metals and dinocysts were observed only for Zn in the core close to the Po delta front.

Keywords : Adriatic Sea, Dinoflagellate cysts, Geochemistry, Sediments

Dinoflagellates are one of the important phytoplankton groups and the motile stage has been correlated to the fossilizable benthic cysts about 30 years ago (1). Dinoflagellate assemblages consist of autotrophic and heterotrophic species: gonyaulacoids and gymnodinioids (except for *Polykrikos*) are autotroph, whereas protoperidinioids are heterotroph. Since heterotrophs can predate both solitary and colonial diatoms (2) they are considered a proxy for eutrophication in coastal waters. Cysts can be used as potential indicators of anthropic impact, both reflecting eutrophication and industrial pollution, but results concerning links between dinocysts and pollution and between dinocysts and eutrophication are still unclear (3). The studied area is strongly influenced by the Po river that supplies large amounts of nutrients and dissolved and particulate heavy metals (4, 5, 6, 7).

Material and methods

Surface sediments from the coastal area of the Po River delta (five stations) and from offshore Ancona (two stations) and 2 shallow cores (one for each area) were collected by means of a box-corer. The Po sampling sites are located one north and one south of the delta and three along a transect seaward from the mouth. The Ancona stations are also located along a transect. A total of 19 sediment samples were treated with standard marine palynological methods for quantitative preparation (8) and analysed for dinocysts. Geochemical analyses were performed by X-ray Fluorescence spectrometry.

Results and discussion

A total of 38 dinoflagellate cyst species were identified. The most representative groups or species in all the assemblages are Protoperidinioids, *Spiniferites* spp. (cysts of *Gonyaulax scrippsae* group and *G. spinifera* complex), *Operculodinium centrocarpum* (cyst of *Protoceratium reticulatum*), *Lingulodinium machaerophorum* (cyst of *Lingulodinium polyedrum*). In surface sediments, cysts of the heterotrophic group dominate the samples in the Po area, while in Ancona area *Spiniferites* spp. and *O. centrocarpum* are more abundant. Total cyst concentrations in the Po area range from about 1500 cysts/g sediment north of Po delta to about 12000 cysts/g sediment closer to Po River mouth where the influence of the nutrient enriched water outflow is much higher. Offshore Ancona, cyst concentration ranges from about 3500 to about 6000 cysts/g and decreases with increasing distance from the coast. Concerning the two shallow cores, the highest total cyst concentration offshore Ancona is found in the upper section, while in the Po core the maximum value (about 16000 cysts/gram) is found in a deeper section. Distribution of selected heavy metals (Cr, Cu, Zn, Pb) gradually decrease from the delta seawards and southwards. Zinc and Pb reach values of 200 ppm and 55 ppm respectively close to the Po delta, being fairly constant downcore. Zinc shows a positive correlation with Corg and an unexpected low correlation with Al_2O_3. In the Ancona core Zn and Pb display lower concentrations (100 ppm Zn, 20 ppm Pb) both showing peaks at the top. In this core Pb is slightly correlated with Corg whereas the other elements result uncorrelated.

We divided dinocysts in three groups (autotroph, heterotroph, total cysts) and chose some species considered as possible indicators of pollution and eutrophication (3). These groups were hence statistically compared with some important geochemical parameters in order to identify possible eutrophication and pollution signals. The most significant results are shown in Fig. 1. In the Po core a good correlation between concentration of heterotrophic species (particularly *Selenopemphix quanta*) and both Corg and Zn content is observed while autotrophic species show poorer correlation. Since Zn values are very high in this area, we can conclude that heterotrophic species and mainly *Selenopemphix quanta* (cyst of *Protoperidinium conicum*) might be used as indicators of pollution more than eutrophication. Cr, Pb and Cu are not correlated with any dinocyst groups but are better correlated with lithological parameters.

In the Ancona core no correlation between dinocysts and geochemical parameters was obtained. In surface samples a good matching between autotrophic dinocysts and both lithological parameters (Al_2O_3, indicating fine sediment) and Ni or Cr (marking Po river plume) occurs. This group thus benefits from high nutrient levels.

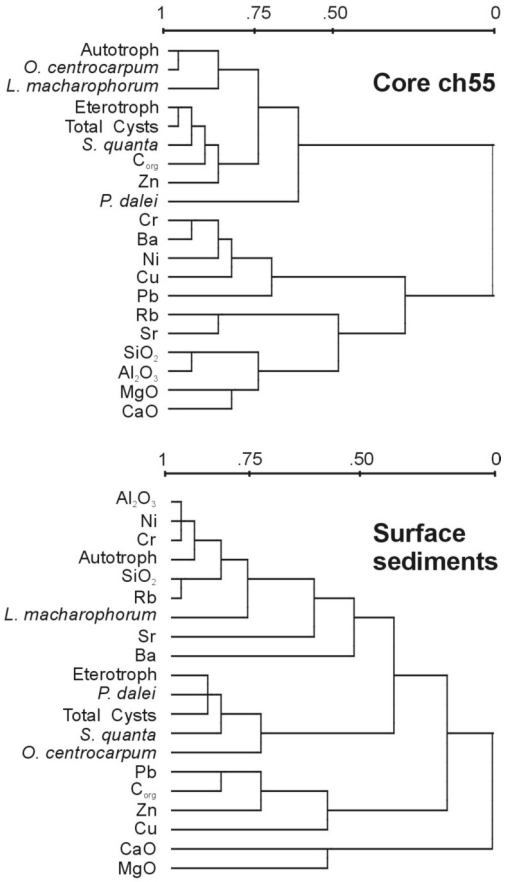

Fig. 1 – Dendrograms relative to the Po area core and surface samples. Correlations are statistically significant for r > 0.87 in both cases.

Conclusions

Our results indicate the existence of some good correlations between degree of pollution and species distribution which is more evident in the stations close to the Po river delta. The species Selenopemphix quanta is abundant in highly polluted sediments and could be an indicator of heavy metal contamination. Autotrophic species distributions in surface sediments are associated to a geochemical signal indicative of Po-derived sediments, which reflects nutrient dispersion patterns.

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ELEMENTS DE REPRODUCTION DE L'OURSIN *PARACENTROTUS LIVIDUS* (LAMARCK, 1816) DANS LE GOLFE DE TUNIS

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Résumé

L'étude du cycle reproducteur de *Paracentrotus lividus* dans le golfe de Tunis au cours de la période allant de septembre 1993 à août 1994 a mis en évidence une ponte très étalée dans le temps avec des émissions gamétiques se produisant à partir du mois de février correspondant à la fin de l'hiver pour se terminer au mois d'août soit en début d'automne.

Mots clés : Mediterranean ridge – Echinodermata – reproduction.

Introduction

Dans le monde il existe cinq espèces d'oursins exploitées et commercialisées et dont la production moyenne ne cesse de décliner depuis quelques années (1). En Méditerranée l'exploitation ne concerne que *Paracentrotus lividus* et n'est intensive que dans le secteur Nord Occidental du bassin. Dans les pays du sud de la Méditerranée, la pêche et la consommation de cette espèce restent plutôt traditionnelles et locales. De nos jours plusieurs investisseurs de la rive nord de la Méditerranée essayent de s'implanter dans la partie sud du bassin méditerranéen afin d'exploiter cette ressource. Devant cette situation et pour rationaliser l'exploitation de cette espèce sans pour autant entraîner une dégradation du stock, le besoin de connaissance de la biologie de l'espèce dans son milieu se fait ressentir. Dans ce contexte, le présent travail est réalisé traitant d'un aspect de la biologie de l'oursin à savoir sa période de reproduction.

Matériel et méthodes

L'étude a été réalisée dans la région sud-est du golfe de Tunis, réputée par l'existence d'une pêche artisanale aux oursins. Mensuellement, durant une année de septembre 1993 à août 1994, une centaine d'oursins a été récoltée au hasard, par plongée autonome, dans un site dont le fond est recouvert d'un herbier de posidonies, et par une profondeur ne dépassant pas les 3 mètres. Les différents compartiments de l'oursin (gonades, contenu digestif et test) ont été séparées puis pesés après un séjour de 48 heures dans une étuve thermostatée à 60°C. Les sexes ont été déterminés selon la couleur des glandes génitales. L'observation microscopique a été utilisée à cette fin en cas de doute dans la détermination du sexe. Le cycle reproducteur a été étudié par observation macroscopique et par analyse des variations de l'indice gonadique IG, défini comme étant le rapport entre le poids sec des gonades (g) et le poids total sec (g) le tout exprimé en pourcentage (2, 3). L'IG a été calculé uniquement pour les individus différenciés. Une étude préliminaire ayant montré une même évolution des IG chez les mâles et chez les femelles, la présente étude a traité des IG en tenant compte de l'ensemble des individus différenciés indépendamment des sexes.

Résultats et discussion

L'observation macroscopique des gonades d'oursins (couleur, aspect, texture et volume) a permis de mettre en évidence 4 stades illustrant les principales étapes de la gamétogenèse :

1 – stade 1 : la gonade est filiforme peu discernable et de couleur claire. Ce stade existe chez les jeunes oursins qui sont pour la plupart encore indifférenciés et dont la taille ne dépasse pas les 35 mm.

2 – stade 2 : les gonades sont fermes et discernables par la couleur, elles prennent alors une teinte jaune orange et orange mandarine ; ce stade s'observe pendant la période de croissance des gonades.

3 – stade 3 : les gonades sont plus développées que celles du stade précédent et bien plus discernables par la couleur. Elles sont caractérisées par d'abondantes émissions gamétiques spontanées à partir des pores génitaux.

4 – stade 4 : les gonades sont petites, minces, flasques et visqueuses. Cet état s'observe en fin de ponte durant la période de résorption des gonades. Lors de cette période les oursins ayant déjà subi une maturation présentent des gonades de couleur brune ou rouge sombre.

L'évolution annuelle de l'IG montre des variations de grandes amplitudes (figure 1). La valeurs minimale est enregistrée en octobre et la valeur maximale en avril. L'indice gonadique montre un accroissement régulier à partir de décembre jusqu'en février. Au mois de mars la valeur de l'IG diminue significativement se traduisant par une émission des produits sexuels. En avril l'IG augmente considérablement une seconde fois pour atteindre un pic. La chute brutale de l'IG en mai évoque la présence d'une ponte plus importante que celle du mois de mars. Pendant la période allant de juin à août l'IG subit une autre baisse indiquant une ponte estivale.

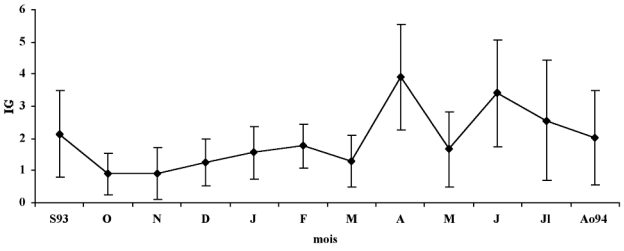

Figure 1 : Variations mensuelles de l'indice gonadique moyen de *Paracentrotus lividus*. *(les barres verticales correspondent à l'écart type).*

Le cycle de reproduction de *Paracentrotus lividus* dans le golfe de Tunis est donc caractérisé par une période de ponte très étalée débutant en février-mars se poursuivant en mai-juin et s'achevant en août septembre. La plupart des travaux relatifs à la reproduction de l'espèce en Méditerranée (2, 4, 5, 6) rapportent que l'espèce présente généralement deux périodes de ponte par année. Toutefois il est à noter que ces pontes ne sont pas synchrones d'une région à une autre et sont probablement liées aux conditions environnementales dans lesquelles vivent ces organismes.

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MORTALITÉ MASSIVE D'*EUNICELLA SINGULARIS* (ANTHOZOA, GORGONACEA) AU NORD DE LA MER EGÉE (GOLFE DE KAVALA, GRÈCE)

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Résumé

L'étude de la population de la gorgone *Eunicella singularis* au Golfe de Kavala a mis en évidence la nécrose partielle ou totale des colonies pour la première fois en Méditerranée orientale. Les variations saisonnières du taux de la partie nécrosée met en évidence la capacité de régénération des colonies. Les principaux causes qui induisent la nécroses des gorgones sont l'anomalie thermique (réchauffement global de la Méditerranée) et le bloom printanier des algues mucilagineuses.

Mots-clés : Aegean Sea, Cnidaria, Mortality

Les gorgones sont des organismes coloniaux sensibles aux variations du milieu. Leurs limites de tolérance sont très strictes. Les causes qui induisent la nécrose partielle ou totale des gorgones sont biotiques (prédation, infection bactérienne, bloom des algues) ou abiotiques (température, apport des sédiments, courants, tempêtes). Actuellement il existe plusieurs références des nécroses des colonies de gorgones en Méditerranée (1, 2,). Néanmoins le présent travail constitue la première référence à ce phénomène en Méditerranée orientale. Le but de la présente étude est de fournir de nouveaux éléments concernant la nécrose des gorgones, et de mettre en évidence, pour la première fois, la présence de ce phénomène en Méditerranée orientale.

Matériel et méthodes

Le site où la présente étude a eu lieu se situe au Nord de la Mer Egée dans le Golfe de Kavala, dans la région de Arethoussa (Figure 1). La profondeur du biotope prospecté varie entre 5 et 15 mètres. 14-16 colonies d'*Eunicella singularis* ont été prélevées aux quatre saisons de 1997. La densité de population des gorgones a été estimée à l'aide d'un quadrat de 1m^2. L'échantillonnage a été réalisé en plongée autonome, au hasard. Un total de 60 colonies en a été prélevé. Sous le terme de "nécrose" nous définissons la dénudation des branches (branches dépourvues de coenzyme). Sur chaque colonie nous avons mesuré la longueur totale des branches dénudées (TBLm) et non dénudés (TBLv), la surface des branches dénudées (Sm) et non dénudées (Sv) et le Poids Sec des branches dénudées (PSm) et non dénudées (PSv). La température a été enregistrée au site d'étude.

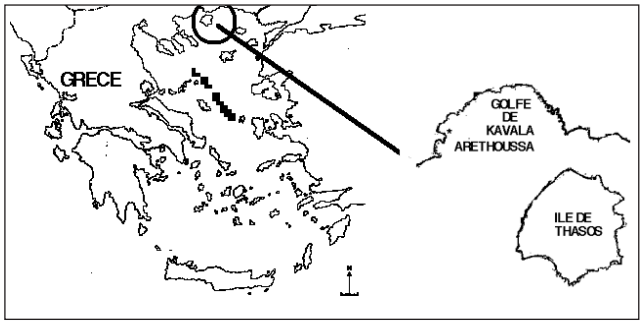

Figure 1. Carte du biotope de la gorgone *Eunicella singularis* dans le Golfe de Kavala (Grèce).

Résultats

Pendant la période d'étude (1997) les températures moyennes saisonnières enregistrées étaient: hiver=9°C, printemps=14°C, été=18°C, automne=12°C. Il est à souligner que le niveau de la thermocline établie durant le printemps et l'été se situe au-delà des limites du biotope. Pendant la prospection du site en plongée autonome nous avons observé que presque la totalité des colonies était affectée d'une dénudation plus ou moins importante. 100% des colonies prélevées étaient affectées sauf 2/15 colonies non affectées en été et 2/16 en printemps. Les données biométriques des colonies d'*E. singularis* sont présentées au Tableau 1. En ce qui concerne la longueur totale des branches nous constatons que la partie nécrosée de la colonie occupe sur la totalité des colonies 55, 4% en hiver, 64,9% en printemps, 33,5% en été et 30,2% en automne.

Discussion

Ce travail constitue la première référence de nécrose des colonies de la gorgone *Eunicella singularis* en Méditerranée orientale (Nord de la Egée). Néanmoins le phénomène de la nécrose des gorgones ne constitue pas une observation exceptionnellement en Méditerranée occidentale (3, 4, Velimirov et Poulicek observations non publiées en baie de Calvi). Nos observations ont mis en évidence que le phénomène de la nécrose est plus aigüedurant le printemps. Ceci peut se justifier par le fait que durant le printemps les colonies d'*E. singularis* subissent un double stress : d'une part un approfondissement de la thermocline au-delà de la limite inférieure du biotope (-15m) et d'autre part un bloom important d'algues mucilagineuses du groupe des Ectocarpales essentiellement. L'augmentation de la température

Tableau 1. Variations saisonnières des paramètres biométriques des colonies d'*Eunicella singularis* affectées de dénudation des branches. H: hiver, P: printemps, E: été, A: automne. Longueur totale des branches dénudées (TBLm, mm) et non dénudées (TBLv, mm), la surface des branches dénudées (Sm, mm^2) et non dénudées (Sv, mm^2) et le Poids Sec des branches dénudées (PSm, mg) et non dénudées (PSv, mg).

H	P	E	A	
	n:14	n:15	n:15	n:16
TBLm	500.3 ±475.1	636.3 ±280.5	233.5 ±239.5	182.6 ±197.2
TBLv	402.5 ±386.7	343.1 ±263.6	463.9 ±356.0	423.0 ±172.0
Sm	1442.1 ±1368.5	1047.7 ±807.9	673.0 ±690.5	526.4 ±567.6
Sv	1498.9 ±1439.5	1277.9 ±981.4	1727.4 ±1324.2	1575.3 ±639.7
PSm	320.8 ±298.6	258.7 ±266.7	202.0 ±234.7	114.2 ±169.4
PSv	721.1 ±739.6	636.5 ±573.8	681.5 ±540.4	661.5 ±328.9

ambiante est considérée comme un des causes principales qui induisent la nécrose des gorgones (3) : les colonies soumises à un stress thermique sont plus vulnérables à une infection bactérienne ou mycétienne. Cette observations est à mettre en parallèle avec le phénomène de blanchiment des coraux. L'impact des algues mucilagineuses aux gorgones a aussi été observé en Méditerranée occidentale (5). Une observation intéressante est que les colonies d'*E. singularis* possèdent une capacité de régénération de sorte que la proportion de parties nécrosées par rapport aux parties saines diminue durant l'été et l'automne. Cette observation concorde avec celles d'autres (6,7). Néanmoins il est à noter que la capacité de régénération de gorgones est nettement plus limitée si les colonies se trouvent sous des conditions de stress : maintien de températures élevées, présence d'une strate importante des algues epiphytiques, fréquentes passage des plongeurs. Selon nos observations, le stress thermique induit par le réchauffement global de la Méditerranée et le bloom des algues mucilagineuses sont les causes les plus importantes qui induisent la nécrose des colonies d'*E. singularis* implantées à faible profondeur en baie de Kavala. L'anomalie thermique et le réchauffement globale de la Méditerranée (effet de serre) ont un impact catastrophique sur la plupart des animaux fixés (8).Un parallèle peut être établi, dans ce sens entre le phénomène de nécrose des gorgones et le phénomène de blanchiment des coraux. Puisque la nécrose des gorgones semble un phénomène généralisé à toute la Méditerranée, il est impératif de constituer un réseau de biosurveillance qui couvrira toutes les zones affectées afin d'estimer l'ampleur de ce phénomène (qui pourrait se révéler catastrophique) et de mettre en état un projet de conservation des populations des gorgones.

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PREDOMINANCE OF THE COPEPOD *CENTROPAGES KROYERI* (GIESBRECHT, 1892) IN THE BAY OF TUNIS DURING THE SPAWNING PERIOD OF THE ANCHOVY *ENGRAULIS ENCRASICOLIS*.

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Abstract

A spatio-temporal survey of zooplankton and ichthyoplankton realised in the Bay of Tunis (south-western Mediterranean) between December 1993 and November 1995 resulted in the identification of a spawning area during the summer of the anchovy *Engraulis encrasicolus*. It is suggested that *E. encrasicolus* adults fed on the patches of the copepod *Centropages kroyeri* dominating the zooplankton community over this period. This species, very abundant in the Tunisian coasts, showed high preferences for warmer waters, whereas the species *Centropages typicus* is more abundant in the northern Mediterranean coasts.

Keywords: Centropages, anchovy, Bay of Tunis.

Introduction

European anchovy (*Engraulis encrasicolis*) is a highly important fish resource of the western Mediterranean coasts. Several studies concerning the ecology of this species in the gulf of Lions [1] and the Catalan Sea [2] already exist. These works show that the diet of adult anchovies constituted primarily of copepods over the spawning period. The copepod *Centropages typicus* is one of the most abundant species of the northwestern Mediterranean coasts [3]. It also can dominate other copepods in the diet of anchovy [2]. Consequently, this copepod-anchovy interaction may play a determinant role in the Mediterranean pelagic ecosystem [4]. However, due to the lack of feeding ecology information in the present study area, the former conclusions are difficult to assume. Recently Daly Yahia [5] studied the dynamics of zooplankton communities in the bay of Tunis over two years. With this information the presence of anchovy eggs and larvae is used to identify the spawning period and the temporal evolution of the copepod *Centropages kroyeri*, the dominant species in summer, is described.

The main aim of this paper results in discussing the biogeographic importance of this copepod and its possible interaction with anchovy.

Sampling area

The bay of Tunis is located between 10°17' to 11°37' longitude East and 36°42' to 36°53' latitude North); its surface area and average depth are about 361 km^2 and 15m respectively. A monitoring program of hydrology, phytoplankton, zooplankton and ichthyoplankton was developed between December 1993 and November 1995 [6]. Zooplankton groups including copepods were identified and counted down to species level.

Results and discussion

The species *Centropages kroyeri* considered rare for the northwestern Mediterranean coasts [7,8] can dominate the copepod communities in the Bay of Tunis, especially during summer (Figure 1B). Abundant also off the southern Tunisian coasts it can tolerate high salinity ranges [9]. Its reproductive activity has been correlated to increasing temperature during spring and summer [5]. So, this species can be considered as a biogeographic indicator for the warm waters in the Mediterranean coasts.

A peak in abundance of anchovy eggs and larvae was observed in July (Figure 1C). Both copepods and anchovy showed high spatial heterogeneity during July (Figure 1). Comparing the maps of *E. encrasicolus* eggs and *C. kroyeri* adults, Daly Yahia [5] concluded that anchovy adults fed and spawned in the patches of *C. kroyeri*. During the summer stratification period, *C. typicus* showed a daily patchy vertical distribution in the Catalan Sea [10]. In the same area, several schools of anchovy were observed in day time at the same depths of copepod patches [2].

On the basis of these first results, it is suggested that research programmes should be enlarged to be able to study and compare copepod-anchovy interactions for both sides of western Mediterranean coasts.

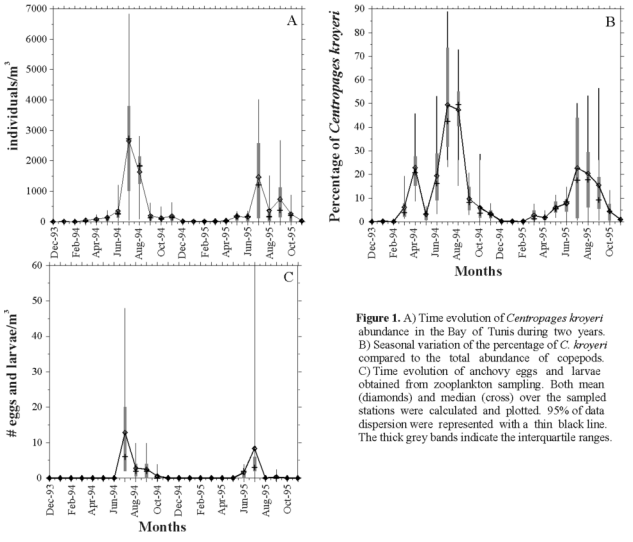

Figure 1. A) Time evolution of *Centropages kroyeri* abundance in the Bay of Tunis during two years. B) Seasonal variation of the percentage of *C. kroyeri* compared to the total abundance of copepods. C) Time evolution of anchovy eggs and larvae obtained from zooplankton sampling. Both mean (diamonds) and median (cross) over the sampled stations were calculated and plotted. 95% of data dispersion were represented with a thin black line. The thick grey bands indicate the interquartile ranges.

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TEMPORAL VARIATIONS OF NUTRIENTS AND CHLOROPHYLL A IN URLA COAST (IZMIR BAY-AEGEAN SEA-TURKIYE)

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Abstract

The aim of this research is to determine the temporal changes of physico-chemical environmental parameters and chlorophyll a concentrations. For this purpose, water samples were taken from Urla coast weekly period in 1999-2000.

Keywords : Nutrients, chlorophyll a, Izmir Bay

Marginal marine environments including estuaries, lagoons, bays, gulfs, etc., are especially sensitive to long and short term external factors. In particularly coastal areas are subject to diverse antropogenic influences including industrial development domestic wastes, maritime transport and agricultural activities. In addition, the effects of the nearby soils also have to be considered. For all these reasons water analysis of coastal areas play a very important role in the quality assessment of the marine environment. The domestic and industrial wastes of this densely populated settlement discharge through the bay water. Hence, Izmir Bay has become an important focal point for potential marine pollution in Türkiye. The aim of this study is to investigate the temporal changes of physico-chemical environmental parameters and chlorophyll a concentrations and to assess the environmental state of the Urla coast.

Study area

Izmir Bay, situated in the western coast of Anatolia, lies between 38° 20´-38° 42´ N latitude and 29° 25´-27° 10´ E longitude. From topographic and hydrografic point of view, it is divided into the inner, middle and outer bay regions. (1) (Fig.1). Urla coast is located at the middle part of Izmir Bay.

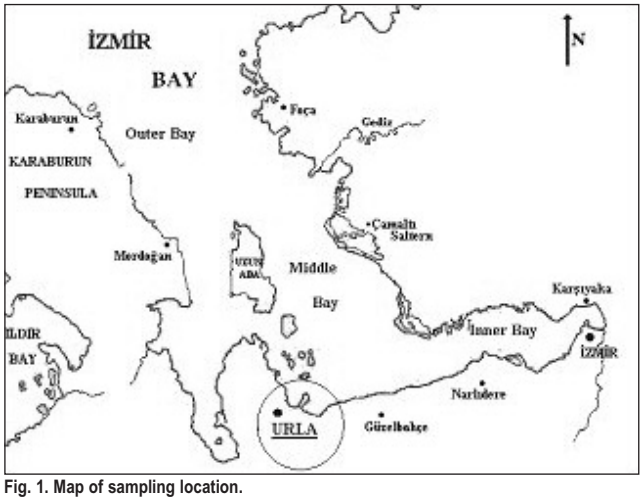

Fig. 1. Map of sampling location.

Material and method

Water samples were taken weekly during the period October, 1999 to October 2000 from Urla coast. Salinity were analysed in the base of Mohr-Knudsen method, temperature has been measured by 0.1°C sensitive electronic thermometer and pH values were measured by pH-ep pH Electronic Papier (Hanna Ins.). Nutrients were estimated by standart methods (2,3). These were carried out by using Hach-DR2000 UVD model spektrophotometer and also chlorophyll a analysis were performed by using Turner 10-AU model Fluorometer.

Results and discussion

In this study, minimum maximum and average concentrations of temperature, pH and salinity have been given in Table 1. Rainfall, evaporization, streams and land-base discharge affect the variations of salinity in Urla coast. As a result of rain, salinity has decreased to 33.93 ‰. pH values measured at Urla coast are relatively higher in comparison with the other regions of the Izmir Bay (4). The land-base discharges, biological activities and water temperature affects the values along the shore.Minimum, maximum and average values of nitrogen forms have been given in Table 1. Nitrite has one major peak at the end of the April. During this sampling time nitrate and ammonium values decreased significantly. At the beginning of the April, nitrate and ammonium concentrations were low. But one week later these nutrients' concentrations increased remarkably caused by rainfall. At the end of the April nitrate and ammonium concentrations decreased depending on phytoplanktonic activity. For nitrate and ammonium values, from the early spring to the end of the May, great fluctuations have observed. During this period chlorophyll a concentrations have also showed fluctuations. At the summer period nitrite was below the detection limit. But from the beginning of the July, nitrite concentration was increased. At this period, ammonium and nitrate concentrations decreased. In winter period the phosphate concentrations were almost in the same level. In early spring phosphate concentrations increased. At the beginning of the April PO_4^{-3}-P decreased but chlorophyll a concentrations increased and showed great peak. Silicate concentrations were high in early spring. At the beginning of the April, silicate levels decreased gradually except some fluctuations. These are the indirect proofs of phytoplanktonic activity.

Table 1. Minimum, maximum and average values of physico-chemical parameters from Urla coast.

Parameters \ Values	Minimum	Maximum	Average
Temperature (°C)	9.00	26.50	17.96
pH	6.41	8.09	7.81
Salinity (‰)	33.93	40.36	36.99
NO2--N (µM)	0.00	4.14	0.56
NO3--N (µM)	0.00	23.57	6.68
NH4+ -N (µM)	0.00	6.85	2.27
PO4-3-P (µM)	0.32	23.52	6.40
SiO2-Si (µM)	0.00	29.85	11.27
Chlorophyll a (µg/l)	0.00	1.75	0.21

Table 2. Minimum and maximum nutrient concentrations from different regions of Urla.

Regions \ Nutrients	NO_2^--N (µM)	NO_3^--N (µM)	NH_4^+-N (µM)	PO_4^{-3}-P (µM)	SiO_2-Si (µM)	Ref
Urla coast	0.00-0.15	0.08-1.34	0.00-32.14	0.14-6.07	-	5
Urla coast	0.00-0.82	0.00-5.4	0.00-15.00	0.02-4.00	-	6
Urla coast	0.02-0.28	0.00-2.39	0.18-6.43	0.20-6.00	0.36-23.85	7
Urla offshore	0.08-0.18	0.03-3.58	0.60-1.52	0.08-0.75	-	8
Urla coast	0.00-4.14	0.00-23.57	0.00-6.85	0.32-26.52	0.00-79.85	*

** this study*

This study indicates that significant long-term changes of nutrient compounds have occurred in Urla coast due to changes of their content inner part of Izmir Bay. Since the mid-1980's nutrient concentrations in sea water have increased remarkably in Urla coast. The detected increase of nutrients have resulted in a higher primary production in this region and consequently in a higher degree of eutrophication in inner part of Izmir Bay. This is very important because eutrophication of the inner part of the Izmir Bay represents a serious regional problem. Recent years this problem has spread over the Urla coast.

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SPONGE FAUNA IN THE LITTORAL ZONE OF THE MARMARA SEA

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Abstract

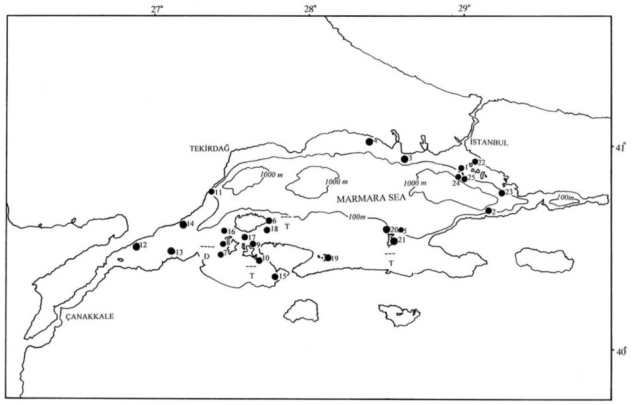
In this study, the samples were collected from 28 stations at depth of 0-65 meters both SCUBA diving and using dredge, grap, and beam trawl. This is first systematical study on sponge fauna in the the Marmara Sea. As a result 19 species were found from the Marmara Sea littoral zone Four of these taxons are new records for the Turkish sponge fauna (*C. penicillus, D. plicata, M. strepsitoxa and P. pulitzeri*).

Key Words : Porifera, Sea of Marmara.

Although, there are many studies on marine sponges of the Mediterranean Sea, there is little studies in the Marmara Sea. This paper presents results from the research on the sponge fauna of the Marmara Sea.

Material and method

The samples were collected by SCUBA diving, trawling, beam-trawling, dredging and by using grab by research cruise R/V *Yunus* from 25 sampling stations. Maximum depth was 52 m. for diving and 65 m for trawling (Map 1.). All sampling stations were situated in the upper infralittoral zone. All samples were fixed by formaldehide solution (4%). Following fixation spicules were isolated by Rütztler's standart method and observed by using a binocular microscope. The identification of species was determinate at The Station Marine d'Endoume-Marseille.



Map 1. Sampling stations in the Marmara Sea (T : trawl; D : dredge; o : Scuba diving)

Table 1. Sponge species in the sampling stations

Station Number	1	2	3	4	5	Erdek	6	7	8	9	10	11	12	K.Köy	13
Geodia cydonium								+							
Tethya aurantium	+		+	+			+		+	+	+	+			+
Cliona celata				+											
Suberites carnosus							+								
Ficulina ficus						+	+		+						
Aaptos aaptos							+	+							
Acanthella acuta							+	+							
Axinella cannabina							+	+							
Axinella damicornis								+							
Axinella polypoides							+								
Agelas oroides							+								
Ciocalypta penicillus							+								
Dictyonella plicata							+								
Microciona strepsitoxa		+	+		+		+						+		
Haliclona mediterranea							+		+	+	+				+
Petrosia pulitzeri							+								
Spongia officinalis												+		+ (S.sp.)	

Station Number	14	15	16	17	18	Mar.Isl	19	20	21	Imr.Isl.	22	23	24	25
Tethya aurantium		+	+	+	+		+							+
Cliona celata		+									+	+		+
Suberites domuncula							+						+	+
Ficulina ficus	+		+	+		+			+	+				
Aaptos aaptos					+									
Axinella cannabina					+									
Axinella damicornis					+									
Axinella polypoides					+									
Ciocalypta penicillus														+
Haliclona mediterranea								+	+		+	+	+	+
Petrosia ficiformis					+									
Petrosia pulitzeri					+									
Spongia officinalis					+									

Results and discussion

19 taxons were reported from the Marmara Sea littoral zone in this study. - see Table.1. Four of these taxons are new records for the Turkish sponge fauna; descriptive characters of these species is as follows.

Halichondriidae - *Ciocalypta penicillus* Bowerbank, 1864

The samples were 8- 9 cm. length, typically palmate. The color is yellow. The spicules are, 200-400 μm. length and, 3-13 μm. thick fusiform oxea.

Hymeniacidonidae - *Dictyonella plicata* (Schmidt, 1862)

The samples were an encrusting cover on a hard subtratum mostly on the bivalves. The color is orange. The spicules 2000-2300 μm. length and, 22 μm. thick style.

Microcionidae - *Microciona strepsitoxa* Hope, 1889

The samples are an easily removable thin cover on a hard substarum. The color is red, The spicules from 350-700 μm. to 70-200 μm. length and, from 5-7 μm. to 4-6 μm. thick acanthostyle; 15--500 μm. length, 2-3 μm. thick subtylostyle; 11-15 μm. palmate isochela and 200-400 μm., 91-140 μm. curved toxa.

Petrosiidae -*Petrosia pulitzeri* Pansini, 1996

The samples looks likes *P. ficiformis* morphologically. Most marked difference is that the color of the *P. pulitzeri* yellowish-white. Usually lives in the underwater caves. The spicules from 200-240 mm.to 70-90 mm. length and, 15-25 mm. thick. Strongyles; 300 mm. length and; 25 mm. thick oxeas and, 70-200 mm. length, 10 mm. thick small oxeas.

Petrosia pulitzeri is reported in the Marmara Sea for the Turkish sponge fauna for the first time. This taxon was mentioned as a new species by Pansini (1). Besides, *Microciona strepsitoxa* was reported as a new record from stations 2., 3., 5. and 12; *Ciocalypta penicillus* from satations 6. and 25.; and *Dictyonella plicata* from station 6.

Besides this, *Ficulina ficus* was found at stations 6., 8., 14., 16., 17., 21. and, Imralı Island. This species was reported by Topaloglu (2) as a new record for the Turkish sponge fauna. 12 sponge species were reported from the north of the Marmara Sea by Demir (3). The results of this study confirm 19 species from the whole Marmara Sea.

Most of the taxon were collected from stations 6 and 18 which were a natural reef with depths of 2 to 60 meters. This sampling point was relatively protected from negative antropogenic effect. On the other hand, species of Mediterranean origin were found deeper than 20 meters of the reef. This situation can explained by oceanographic conditions of the Marmara Sea. The lower layer of the Marmara Sea is consisted of Mediterranean Sea originated waters (4).`

Acknowledgments

I wish to thanks of Dr. Bayram Öztürk for to supervising of the study; to Dr.Jean Vacelet for the cooperation in the identification of samples, Dr Ayhan Dede for assistance of SCUBA diving; personnel of R/V *Yunus* for cooperations of survey and thanks to Med.Dr. Cumhur Erenel for assistance with the English of this text.

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PARAMÈTRES PHYSICO-CHIMIQUES, PHYTOPLANCTON ET COPÉPODES D'UN MILIEU LAGUNAIRE RESTAURÉ : LE LAC NORD DE TUNIS

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Résumé

Les prospections réalisées durant la période allant de septembre 1999 à juin 2000 au niveau de cinq stations du Lac nord de Tunis et les analyses des eaux ont mis en évidence un statut trophique oligo-mésotrophe, un peuplement phytoplanctonique diversifié et un rôle de nurserie du Lac pour les copépodes.

Mots clés : Lagune - Restauration - Plancton - Phytoplancton - copépodes

Le Lac nord de Tunis est une lagune d'origine marine, peu profonde, situé au fond du Golfe de Tunis (Fig. 1, [1]). Il se trouve entre les parallèles 36° et 37° de latitude nord et entre 10° et 11° de longitude est.

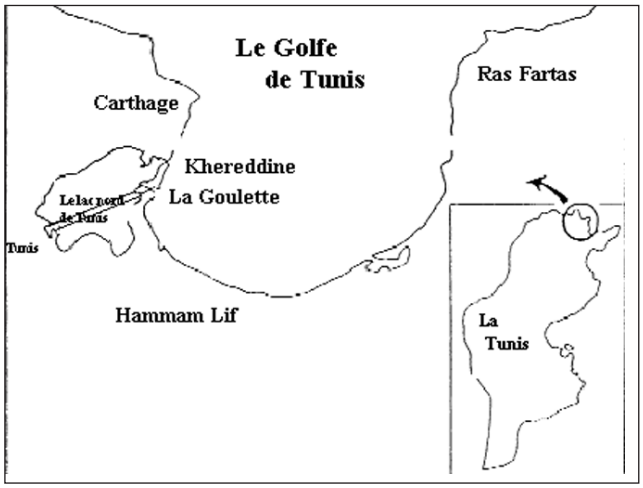

Fig. 1: Situation géographique du Lac nord de Tunis (1)

Ce milieu a été marqué par un phénomène d'eutrophisation qui s'est accentué vers les années quatre-vingt suite à l'amplification des rejets urbains de la ville de Tunis [2]. En 1985, des travaux d'aménagement et de restauration ont été réalisés sur la base d'un système de renouvellement naturel des eaux. Ces travaux ont permis au milieu d'évoluer vers un état plus ou moins équilibré traduit par des diverses améliorations sur le plan abiotique et biotique [3, 4, 5, 6, 7].

Lors de cette étude, le suivi de l'évolution des paramètres physico-chimiques et biotiques ont confirmé l'impact de la restauration. En effet, la transparence s'avère bonne dans tout le lac avec le plus souvent une visibilité du fond. Les valeurs de la MES, variant entre 21,4 mg/l et 38,8 mg/l, sont assez faibles concordant avec la bonne transparence. Les valeurs d'oxygène dissous sont proches de la saturation. Les rapports atomiques entre l'azote et le phosphore totaux qualifient le Lac d'un milieu lagunaire oligo-mésotrophe (Tableau 1).

Tableau 1: Variation spatiale du rapport azote total/phosphore total dans le Lac nord de Tunis.

Stations	1	2	3	4	5	Moyenne
Nt/Pt	66,7	124,4	115,5	106,4	81,7	98,1

Ces résultats en physico-chimie, plaidant en faveur d'un état oligo-mésotrophe, sont confirmés par les mesures de la chlorophylle a.

L'évolution temporelle des teneurs moyennes en chlorophylle a montré un degré faible de variabilité. Ces dernières varient entre 1 μg/l au mois de février et 2,3 μg/l au mois de novembre (Fig. 2) indiquant un statut oligotrophe.

Le peuplement phytoplanctonique du Lac nord de Tunis est très diversifié avec 6 classes et 43 genres. Ce sont les Diatomées qui constituent le groupe taxinomique le plus diversifié (26 genres) suivi des Dinoflagellés (12 genres). De point de vue abondance et fréquence, ce sont les Cryptophycées, identifiées pour la première fois dans ce milieu aménagé et représentées par le genre Plagioselmis, qui dominent. Les Euglénophycées et les Cyanophycées, indicateurs d'une surcharge en fertilisants, sont en faibles quantités par rapport aux autres classes. Les Chlorophycées ,représentées par le genre Chlorella, n'apparaissent qu'en compartiment sud où on enregistre le maximum des phosphates. D'ailleurs, les Chlorophycées sont plus exigeantes en phosphore que les autres groupes [8].

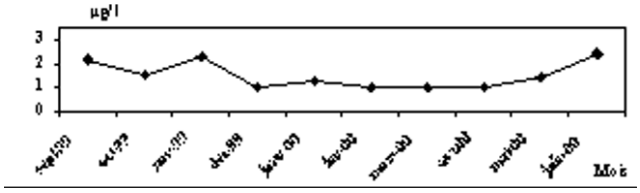

Fig. 2 : Variations mensuelles de la teneur en chlorophylle a dans le Lac nord de Tunis.

L'étude de la systématique des copépodes a révélé l'existence de 15 espèces appartenant à 7 genres. Les espèces Calanoïdes sont plus nombreuses que celles Cyclopoïdes. Malgré cette richesse spécifique relative du Lac, les copépodes n'arrivent pas à leur maturité et ce sont surtout les stades larvaires qui dominent. En effet, les nauplii constituent 93,6 % du total des stades copépodiques avec une moyenne de 3440 inds/m^3 (C.V = 30 %). Les Calanoïdes présentent une moyenne de 182 inds/m^3 ((+/-) 74). Quant aux Cyclopoïdes, leur densité moyenne avoisine 220 inds/m^3 ((+/-) 124) et les Harpacticoïdes présentent une moyenne de 37 inds/m^3 ((+/-) 11,202

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PRELIMINARY RESULTS OF MAPPING OF THE COASTAL AND HALOPHYTIC HABITAT TYPES (DIRECTIVE 92/43/EEC) IN THE GULF OF KOUKOUNARIES (SKIATHOS, NORTH AEGEAN SEA)

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Abstract

Inventory, identification, evaluation and mapping of the coastal and halophytic habitat types (Directive 92/43/EEC) in the Gulf of Koukounaries (Skiathos, N. Aegean Sea) was accomplished by the use of aerial photographs and SCUBA diving sampling. Five habitat types were identified: 1110 (Sandbanks which are slightly covered by seawater all the time), 1120 (*Posidonia oceanica* beds), 1150 (Lagoons), 1170 (Reefs) and 119A (Unvegetated sand bed). The type 1110 is characterized by vegetation of *Cymodocea nodosa* beds and the type 1170 by vegetation of *Cystoseira* spp. communities.

Key words: Aegean Sea, conservation, mapping, Posidonia.

Introduction

Beds of *Posidonia oceanica*, an endemic mediterranean marine phanerogam, constitute the fundamental richness of coastal waters. As a result of their importance in primary production, the richness of their flora and fauna and their role in maintenance of biological equilibrium and coastal sedimentology, the *Posidonia oceanica* meadows are regarded as the "key" ecosystems in the Mediterranean Sea (1). Likewise, the *Cystoseira* spp. communities constitute a source of floristic richness, form a productive belt which plays an important ecological role as shelter and food and shape most of the rocky underwater landscape in the Mediterranean Sea (2, 3). *Posidonia oceanica* meadows and most of the species of the genus *Cystoseira* are particularly sensitive to natural and anthropogenic stress, resulting in reduction of species diversity over extensive areas (4).

The knowledge of the distribution of the main marine biocenoses is of fundamental importance. Cartography of the sea bottom plays a "key" role in coastal management and it is realized by combination of direct (SCUBA diving) and indirect (aerial photographs, satellite images, etc) methods.

The aim of the present study is to invent, identify, evaluate and map the habitat types in the Gulf of Koukounaries (Skiathos, N. Aegean Sea).

Materials and methods

The gulf of Koukounaries is located in the South part of Skiathos island (North Aegean Sea) and it is characterized by great touristic impact especially during the summer months.

Aerial photographs (1:5000), in combination with SCUBA diving sampling were used for mapping the site in May 2000. Thirty samples (400 cm^2) of macroalgae and marine phanerogams were collected. Two Way Indicator Analysis (TWINSPAN) was used for grouping the sapling areas.

Results and discussion

According to the results of mapping in the Gulf of Koukounaries, five habitat types (Directive 92/43/EEC) were identified (Fig. 1). They, with their 4-digital NATURA 2000 codes, are:

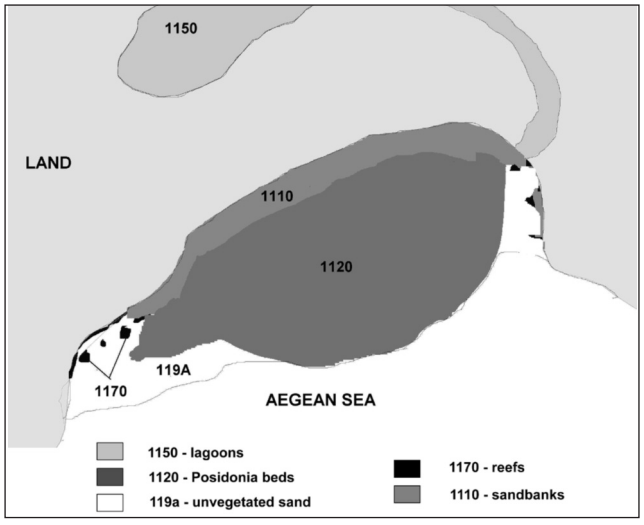

Figure 1. Map of the habitat types in the Gulf of Koukounaries. (Scale 1:208000)

1. Sandbanks which are slightly covered by seawater all the time (1110). This habitat type is characterized by a good representativity and conservation status. 1110 occurs in this site both as sandbanks without vegetation and sandbanks with vegetation of *Cymodocea nodosa* (Group 1 of sampling areas after TWINSPAN analysis).

2. *Posidonia oceanica* beds (1120) (Group 2 of sampling areas after TWINSPAN analysis). This habitat type is of priority, due to its important ecological role and the extensive areas it covers in the Mediterranean Sea (Directive 92/43/EEC). In Koukounaries, 1120 is the dominant habitat type and shows an excellent representativity and conservation status.

3. Lagoons (1150). It concerns expanses of shallow coastal salt water, of varying salinity and water volume, with or without vegetation of *Ruppia maritima*, etc. In this site, the representativity and conservation status of 1150 are satisfactory. No vegetation was found.

4. Reefs (1170). Rocky substrates in the sublittoral or littoral zone, which support a zonation of benthic communities of algae and animal species. The representativity and the conservation status of 1170 are good. The total coverage of this type is extremely low. The type is characterized by vegetation of *Cystoseira* spp. communities. The dominant association is that of *Cystoseira amentacea* (Group 3 of sampling areas after TWINSPAN analysis). Significant is, as well, the appearance of the association of *Cystoseira corniculata* (Group 4 of sampling areas after TWINSPAN analysis). There also exist dense populations of *Acetabularia acetabulum* and *Dictyota dichotoma*.

5. Unvegetated sand bed (119A). The representativity and the conservation status of 119A are good. The total coverage of this type is relatively low.

Although the gulf of Koukounaries is under great touristic development the habitat types that were identified are characterized by satisfactory global assessment. The associations of *Posidonia oceanica* and *Cystoseira* spp., which are sensitive to natural and anthropogenic stress are in a good condition.

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DISTRIBUTION OF NUTRIENTS AND PHYTOPLANKTON IN THE KARSTIC ESTUARY (THE ZRMANJA RIVER, EASTERN ADRIATIC SEA)

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Abstract

The abundance of phytoplankton and concentration of nutrients were determined in the highly stratified Zrmanja Estuary, eastern Adriatic coast, Croatia, in the period from June 1998 to October 2000. Marine phytoplankton was more abundant in the middle than in the upper reach of the estuary. The Zrmanja river and the estuary are oligotrophic, and orthophosphate was detected as a limiting growth factor in the estuary.

Key–words: Estuary, nutrients, phytoplankton, stratification, Adriatic Sea

Highly stratified estuaries are maintained in areas where a high volume of river discharge is combined with low tides. Such phenomena are well known along the karstic, eastern Adriatic coast. The Zrmanja River (69 km long) discharges into the eastern–central Adriatic Sea (Fig. 1) forming highly stratified estuary. The average outflow equals 38 m^3/s, but may be as high as 456 m^3/s and as low as 0.09 m3/s. The upper reach of the estuary is mostly about 5 m deep, while the middle and lower reaches are up to 40 m deep. The surrounding area is scarcely inhabited. The settlement Obrovac in the upper reach of the estuary counts 1200 inhabitants. We present the first data on physico-chemical and ecological characteristics of the Zrmanja Estuary.

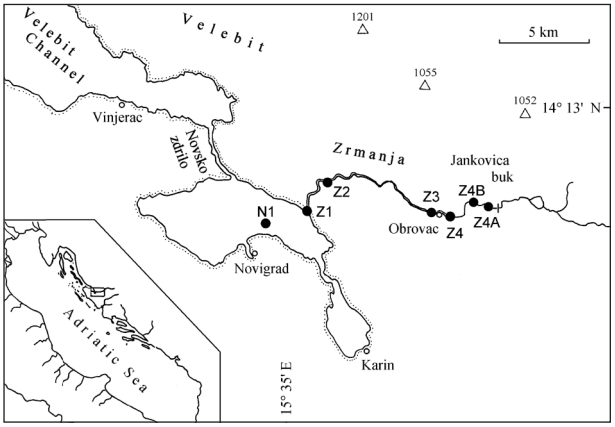

Fig. 1. Position of stations in the Zrmanja River estuary

Materials and methods

This study shows the results about environmental conditions in the middle (Stations N1) and upper (Stations Z1, Z2, Z3, Z4, B4B, Z4A) reach of the Zrmanja Estuary, in the period from June 1998 to October 2000. Phytoplankton and nutrients were sampled using 5-liter Niskin bottles at one-meter intervals of the water column. Salinity and temperature were determined using a conductivity, temperature and depth profiler (SEA Bird Electronics Inc., USA). The 0–1 m layer was always above the sharp halocline. Halocline, except for station N1, was less sharp and closer to the surface in summer. Phytoplankton was preserved in a 2 % neutralized formaldehyde solution and counted by the inverted microscope method (1). Nutrient concentrations were measured using standard methods (2, 3).

Results and discussion

The concentrations of orthophosphate were low (mostly below 0.1 μmol l^{-1}), slightly increased below the halocline and shortly downstream the Obrovac settlement (Fig. 2). The Zrmanja River was an important source of total inorganic nitrogen (TIN), probably due to the influence of pasture upstream the river. The river was the source of silicates. Most frequent Redfield ratios (TIN/PO_4) were considerably higher than 16, especially at lower salinities, indicating phosphates as the limiting growth factor of phytoplankton. The water column was well oxygenated.

Phytoplankton was mostly composed of marine species (diatoms) below the halocline (Fig. 3). Maximum abundances of diatoms (not higher than $2x10^6$ cells l^{-1}) and micro–dinoflagellates (not higher than $6x10^5$ cells l^{-1}) were detected at N1 and Z1, in the area where marine influences abruptly increase, and just below the halocline, due to the more favorable nutritive and light conditions, and currents below the outflowing surface brackish layer. However, nanoplanktonic dinoflagellates and cryptophytes (mostly mixotrophic species), as well as naked ciliates were more abundant in the area of slight anthropogenic influence. The euphotic layer ceased by the bottom, mostly about 5 m deep in the upper reach of the estuary. The presented results indicate the Zrmanja Estuary as an oligotrophic, coastal environment, with a slight anthropogenic impact.

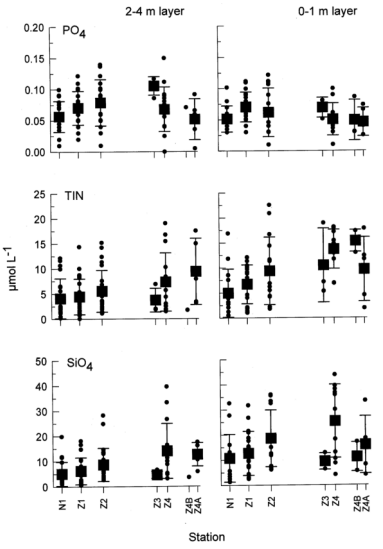

Fig. 2. Distribution of nutrients along the Zrmanja Estuary (1998–2000).

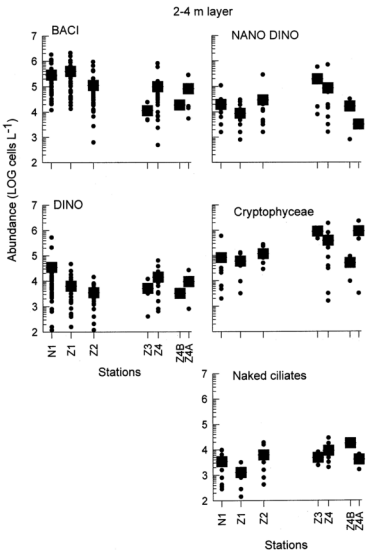

Fig. 3. Distribution of phytoplankton along the Zrmanja Estuary (1998–2000).

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INFLUENCE DU PRÉDATEUR L'*OCTOPUS VULGARIS* (MOLLUSQUE, CÉPHALOPODE) SUR LA DYNAMIQUE DE LA PALOURDE *Ruditapes decussata* (MOLLUSQUE, BIVALVE) DANS L'ESTUAIRE DE SEBOU (CÔTE MAROCAINE)

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Résumé

Le poulpe (*Octopus vulgaris*) effectue des migrations trophiques dans l'estuaire de Sebou. Vers la fin du printemps de 1995, presque 60.000 individus d'*O. vulgaris* ont envahi et détruit en moins de trois mois le gisement infralittoral à *Ruditapes decussata*. La stratégie de la prédation, consistait à s'attaquer d'abord aux juvéniles, puis aux adultes. L'étude de la répartition des abondances de *R. decussata* par l'analyse factorielle des correspondances (A.F.C) a montré les anomalies dans l'évolution annuelle de la structure démographique, de la croissance et de mortalité. La population médiolittorale de *Ruditapes decussata*, dont le milieu est défavorable à l'Octopus surtout à marré basse, a réussi après une année à reconstituer le gisement infralittoral suite à la sédentarisation des larves lors du flot. Malgré l'épuisement du gisement, cette migration a permis aux pêcheurs locaux d'exporter vers l'Espagne plus de 30 tonnes d'*O. vulgaris*.

Mots clés: Estuaire, Octopus vulgaris, Ruditapes decussata, prédation, structure démographique, Maroc.

La palourde *Ruditapes decussata* forme d'importants gisements naturels au Maroc. Les études concernant la dynamique de cette espèce au Maroc sont relativement rares (1), et rien n'est connu concernant l'impact des prédateurs sur la dynamique de cette espèce. L'objectif de cette étude est de mettre en évidence la prédation spatio-temporelle de l'*Octopus vulgaris*, sur une population infralittorale de *R. decussata*, analysée au cours d'un cycle annuel complet de décembre 94 à novembre 95 (fig.1).

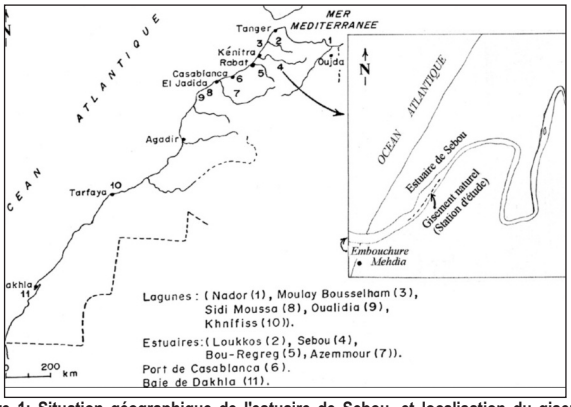

Figure 1: Situation géographique de l'estuaire de Sebou, et localisation du gisement naturel à *Ruditapes decussata*.

Matériel et méthodes

Les prélèvements de *R. decussata* dans le gisement infralittoral ont été effectué par plongée sur une surface variant entre 3 et 8 m^2. Les abondances (362 ind.) ont été mesurées selon la longueur antéro-postérieure (L), et regroupées en classes d'amplitude 2 mm, et traitées par l'A.F.C (2), analyse qui permet de décrire les abondances (point-tailles) et des périodes de prélèvements (point-dates) dans un plan factoriel F1x F2.

Résultats-discussion

La Figure 2, montre que, l'axe F1 (49,61% de l'inertie totale) est expliqué par le point-date (9/07), situé du côté négatif de l'axe F1, de contribution relative (C.R = 84%), et qui est caractérisé par l'abondance des individus de *R. decussata* adultes de 37 à 55 mm. A ce point-date la taille moyenne y est de 42,6 mm, nettement supérieure à la valeur moyenne annuelle (21,78 mm), donc un pourcentage des adultes (37 mm à 55 mm) constitue plus de 62% de la population totale (45 individus). Du côté positif de cet axe, sont groupés le reste des point-dates (excepté le 4/06), avec une abondance des adultes de moins de 4%. La taille moyenne de la population totale (289 ind.) est de 18,55 mm. Le point-date (4/06) est situé entre ces deux pôles, l'abondance des adultes est de 35,7% de la population totale (28 ind.), pour une taille moyenne de 22,2 mm .

L'axe F2 (17,51% de l'inertie totale) explique la répartition des tailles juvéniles de 7 à 11mm (C.R = 28%) et aussi les tailles de 17 à 29 mm (C.R=56%). Cet axe permet d'isoler, de son côté négatif, le point-date 2/02 (36% de C.R) pendant lequel les tailles de 17 à 29 mm constituent plus de 81% de la population totale (53 ind.), alors que de son côté positif se concentrent les point-tailles 8/04 et 2/05 qui totalisent 45% de contribution relative, et où les tailles comprises entre 7 et 11 mm représentent plus de 41% de l'effectif total (102 ind.). Les tailles moyennes de ces deux groupements sont de respectivement de 22,33 mm et 18,74 mm. A proximité du barycentre, se regroupent des autres point-dates (excepté le 9/07), dont les abondances des tailles comprises entre 7-11 mm et 17-29 mm sont respectivement de 29,6% et 53% pour une population totale (162 ind.). L'emplacement du point-date (9/07),est expliqué par l'absence des tailles juvéniles comprises entre 7 et 11 mm, et un faible pourcentage (4,44%) des tailles comprises entre 17-29 mm, puisque la population est constituée par plus de 95 % des tailles supérieures à 30 mm. Les étapes de la prédation par l'*Octopus vulgaris* sont visualisées sur les histogrammes de fréquences de la Figure 2; en effet, avant la migration (27/11 au 2/05) la structure démographique évoluait normalement, la croissance passe de 15,38 mm le 27/11 à 19,76 mm le 2/05. A partir du 4/06, on assiste à des anomalies dans la structure démographique, par la disparition des tailles juvéniles dans un premier temps (structure du 4/06) puis en second lieu, celles des tailles adultes (structure de 9/07). Lors de cette période, la croissance moyenne de la population passe de 22,21 mm à 42,6 mm, soit une anomalie de croissance de 20,4 mm.

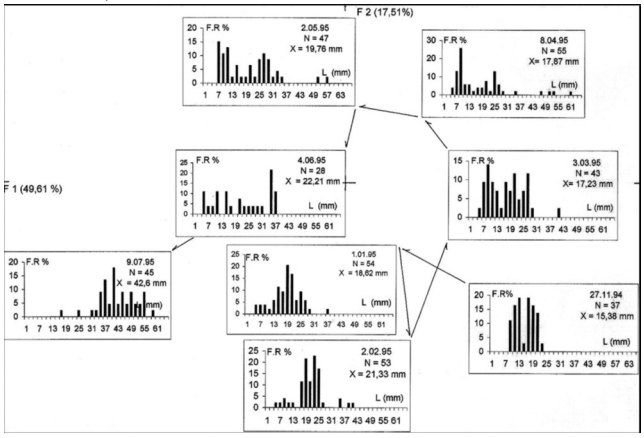

Figure 2: Distribution des point-dates et des structures démographiques de Ruditapes decussata dans le plan factoriel F1 x F2.(L: longueur antéro-postérieure en mm; F.R %: fréquence relative en pourcentage; N: nombre d'individus; X: taille moyenne de la population en mm).

Discussion-conclusion

Cette double analyse, a permis de mettre l'effet de la prédation par le poulpe (*O. vulgaris*) sur l'évolution de la structure démographique de *R. decussata* dans l'estuaire de Sebou, en effet:, l'A.F.C, a isolé trois ensembles morphométriques différents:

- les point-dates (du 27/11 au 2/05) situés côté positif de l'axe F1, dont l'évolution et la structure pourraient être considérées comme normales.
- un deuxième groupe constitué du point-date 4/06 (centre du plan) caractérisé par le début de la prédation où l'on observe des disparitions des tailles juvéniles de *R. decussata*.
- un troisième groupe correspondant point-taille 9/07 (côté négatif de l'axe F1), présentant une structure totalement formée par des tailles grandes, qui seront à leur tour attaquées par le prédateur.

La migration trophique de l'*Octopus vulgaris* a lieu après le recrutement hivernal (60.000 individus, environ, de densité égale à 1.ind/m^2), et qui coïncidait avec l'arrêt des captures en mer par les céphalopodiers espagnols. Alors que la migration en mer (lieu de reproduction), elle a lieu vers la fin automne à l'état adulte, et qui peut être anticipée si une dessalure engendrée par les précipitations se produit. Malgré la destruction du gisement naturel de *R. decussata*, la population s'est reconstituée après une année environ, à partir des larves provenant de l'étage médiolittoral qui constitue un biotope défavorable pour l'*Octopus vulgaris*, l'engraissement de ce dernier dans cet estuaire, a permis aux pêcheurs locaux d'y exporter plus de 30 tonnes vers l'Espagne.

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STRUCTURE ET LA STRATÉGIE DÉMOGRAPHIQUES DE LA PALOURDE (*Ruditapes decussata*) DANS DES MILIEUX PARALIQUES ATLANTICO-MÉDITERRANÉENS DU MAROC

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Résumé.

L'analyse de la structure démographique de quatre populations atlantico-méditerranéennes de *Ruditapes decussata*, a montré qu'il existerait des variabilités de structure et de stratégie démographiques (types r, ou/et K) entre les sites étudiés, qui ne peuvent s'expliquer que par des adaptations aux conditions du milieu. Ainsi en milieu lagunaire (Nador et Moulay Bousselham) les stratégies seraient de type r, alors quand milieu estuarien surtout le Sebou elle serait plutôt de type k. Dans l'estuaire de Bou-regreg l'espèce semblerait avoir les types r et K, en effet en médiolittoral (milieu instable), la stratégie serait de type r, alors que dans l'infralittoral c'est probablement le type k. L'analyse des cohortes a montré que *R. decussata* présente en moyenne dix cohortes, soit six en milieu lagunaire et huit en milieu estuarien, avec des tailles maximales respectivement de 45 mm et 61 mm.

Mots clés: Estuaire, lagune, Ruditapes decussata, structure démographique, croissance, stratégie, Maroc

La palourde européenne *R. decussata*, est largement répartie au Maroc. Ceci est probablement dû à des adaptations aux conditions des milieux. Le but de ce travail est donc de mettre en évidence la variabilité des paramètres de structures (recrutement, croissance, nombre des cohortes.) induits par le milieu, et déduire à partir de ses résultats le ou les type (s) de stratégies démographiques (r ou K) dans chacun des sites, et qui sont les lagunes de Nador et Moulay Bousselham, et les estuaires de Sebou et Bou-regreg (fig. 1).

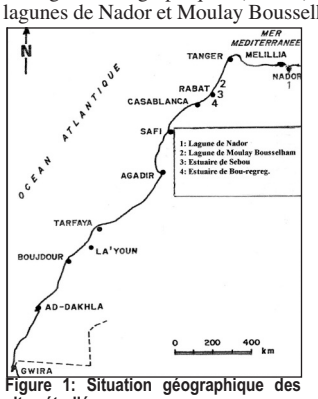

Figure 1: Situation géographique des sites étudiés.

Matériel et méthodes

Les prélèvements de *R decussata* ont été réalisés mensuellement et pendant une année dans les quatre sites, soit par draguage à Moulay Bousselham, à l'aide d'une bêche plate à Nador et au Bou-regreg ou par plongée dans le Sebou. La surface prélevée variée entre 3 et 8 mètres de manière à avoir un échantillon représentatif des différentes classes de la population. Les abondances ont été mesurées selon la longueur antéro-postérieure (L), et regroupées en classes l'amplitude 2 mm puis traitées par l'analyse factorielle des correspondances, ou A.F.C méthode essentiellement descriptive (1), et qui consiste à étudier l'évolution des échantillons (distribution des tailles) en fonction du temps. L'énumération des cohortes des populations, a été déterminée par la méthode de Battacharya (2).

Résultats

La Figure 2, montre que le plan factoriel F1 x F2 (89,6% de l'inertie totale), l'axe F1 (58,43%) est essentiellement expliqué par les point-sites Moulay Bousselham et Bou-regreg (95% de contribution relative: C.R). Le point-site Moulay Bousselham (C.R= 62%), situé du côté positif de l'axe F1, est caractérisé par les point-tailles de 19 à 27 mm, La taille moyenne de la population y est de 24,36 mm contre 21,49 mm pour l'ensemble des sites. Le côté négatif de l'axe F1, est surtout expliqué par le point-site (Bou-regreg; C.R = 31%), et où sont regroupées les point-tailles 5,7,9,11, et 13 mm, la une taille moyenne y de 19,1 mm, et qui est inférieure à la moyenne des l'ensemble des sites (21,49 mm). L'axe F 2 (31,17 % de l'inertie totale) explique la différence de tailles qui existe surtout entre le Sebou et Nador.

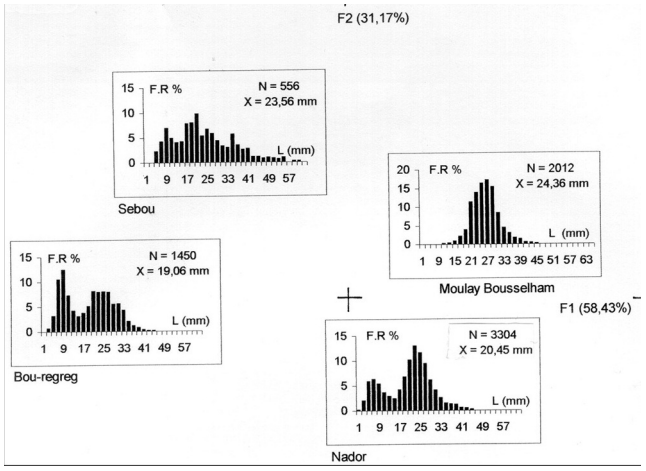

Figure 2: Distribution des point-sites et des structures démographiques de *Ruditapes decussata* dans le plan factoriel F1 x F2.
(L: longueur antéro-postérieure en mm; F.R %: fréquence relative en pourcentage; N: nombre d'individus; X: taille moyenne de la population en mm).

L'estuaire de Sebou, (C.R près de 80%), avec des tailles entre 35 à 61 mm, constituent plus de 20,5% de la population de ce site (556 ind) et prés de 28% de cette catégorie de taille pour l'ensemble des quatre sites. La lagune de Nador où cette catégorie de taille ne constitue que 4,72% de la population de ce site (3304 ind), alors que les tailles entre 1 à 17 mm constituent presque 33% de la population de ce site et presque 53 % de cette taille dans l'ensemble des sites, puisque la taille moyenne de la population à Nador est de 20,45 mm, contre 23,56 mm au Sebou. Le nombre des cohortes par la méthode de (2), est égale à 10 dans l'ensemble des milieux paraliques, soit: 6 cohortes en milieu lagunaire et 8 ou 9 cohortes en milieu estuarien (tab.1) L'amplitude du recrutement moyen (tailles inférieures à 17 mm), est de 29,31 %, avec un maximum de 44,43% dans le Bou-regreg, et un minimum de 6,95% à Moulay Bousselham, de 32,17 % à Nador et 33,81% au Sebou.

Tableau 1: Enumération des cohortes des populations de *Ruditapes decussata* dans les sites étudiés.

Sites Cohortes (mm)	Moulay Bousselham	Nador	Bou-regreg	Sebou
[1 à 10[		7,3	8,75	10,86
[10 à 20[	10	12	15 ?	17,5
[20 à 30[	18,67 23,62	20,53 23	21,5 24,22 29,74	20 25,12
[30 à 40[	30,5 35,5 37,28	37,5	35,36	34,75 39,75
[40 à 50[		40,7	43 ?	43,5 48,74
[50 à 60[				53 ?

Conclusion

De cette analyse, il ressort que *R. decussata* présente des structures démographiques propres à chacun des sites. La stratégie, en milieu lagunaire (Nador, Moulay Bousselham) est probablement de type r, c'est à dire de courte durée de vie, une forte mortalité des jeunes classes d'âge suite aux intempéries compensée par une forte fécondité, ce qui caractérise ces milieux d'instabilité. Alors qu'en milieu estuarien (surtout le Sebou) la stratégie serait de type K, soit une durée de vie plus longue, un taux de survie élevé des juvéniles, et donc des recrutements bien marquées malgré la faible fécondité donc les contraintes environnementales plus ou moins stables. Dans l'estuaire de Bou-regreg, les deux types coexisteraient, le type r en médiollitoral, et le type k en infralittoral. Si les recrutements sont plus importants à Bou-regreg et à Nador, ceci trouve son explication dans le facteur édaphique, qui est y hétérogène et grossier et nécessaire à la fixation des larves (3). Les tailles importantes au Sebou, s'expliquent par les conditions optimales de filtration particulièrement la profondeur (8 mètres), et par le substrat surtout vaseux favorable à l'élongation des coquilles.

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